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AN INQUIRY INTO DISRUPTIVE INNOVATION AND THE INNOVATIVENESS OF NEW ZEALAND BIOTECHNOLOGY

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ABSTRACT

The New Zealand biotechnology industry is a significant component of the country's knowledge economy, primarily comprising small to medium-sized enterprises. Operating on a high-risk, high-return model, the industry has a unique history marked by diverse outcomes. This research centres on the examination of disruptive innovation, a concept that has garnered considerable attention, with a specific focus on its application to the commercial aspects of the New Zealand biotechnology sector.

While previous studies have indicated that disruptive innovations often emerge in low-end segments or new markets, their relevance to the progressive biotechnology industry remains unclear. There is a need for a deeper understanding of disruptive innovation, particularly concerning its definition and the strategies that underpin its implementation by companies. Moreover, the level of innovativeness in biotechnology companies is not widely comprehended. An objective of this research is to establish a perceived innovativeness diagnostic scorecard for companies. The strategic utility of this diagnostic tool is particularly significant as it empowers decision-makers to identify areas for potential innovation, thereby enabling more informed decision-making and fostering competitive resilience within the biotechnology landscape.

The methodology utilised is a mixed-method pragmatic approach, incorporating both quantitative and qualitative methods. An online survey and structured, in-person interviews were conducted to explore the alignment between academic and practitioner perspectives on disruptive innovation and its potential theoretical foundations. Archival and data mining methods were employed to profile the New Zealand biotechnology landscape. The data underwent further analysis using a perceived innovativeness diagnostic scorecard, developed through multiple criteria decision analysis. This involved an adjusted and combined analytical hierarchy process, utilising pairwise comparisons and simple additive weighting between criteria to assess the relationship between perceived innovativeness and success.

The outcomes of the study include a purposeful definition of disruptive innovation that aligns with both practitioner and academic viewpoints. Additionally, a set of potential foundations for disruptive innovation in the biotechnology sector was identified. For the first time, the research mapped the entirety of the New Zealand biotech industry, focusing on companies founded and operated within the country. Finally, the study generated a perceived innovativeness diagnostic measure to analyse the New Zealand biotechnology landscape, revealing that companies perceived as highly innovative may be associated with unfavourable success outcomes, subject to the caveats outlined in the thesis.

TABLE OF CONTENTS

ABSTRACT	II
LIST OF TABLES.....	VI
LIST OF FIGURES.....	VII
LIST OF ABBREVIATIONS.....	IX
ATTESTATION OF AUTHORSHIP	X
ACKNOWLEDGEMENTS	XI
ETHICS APPROVAL.....	XII
1. INTRODUCTION	1
1.1 RESEARCH RATIONALE	2
1.2 RESEARCH QUESTIONS.....	5
1.3 CONTRIBUTIONS	6
1.4 OUTLINE OF THE RESEARCH	7
2. KEY CONCEPTS.....	9
2.1 INNOVATION THEORY	10
2.1.1 What is innovation?.....	10
2.1.2 The innovation process	14
2.1.3 The concept of innovation	18
2.1.4 The knowledge of innovation.....	18
2.1.5 The function of innovation	18
2.1.6 The form of innovation.....	20
2.1.7 The magnitude of innovation.....	21
2.1.8 Disruptive innovation theory.....	22
2.2 NEW ZEALAND AND BIOTECHNOLOGY	32
2.2.1 The isolated country.....	32
2.2.2 The untapped fountain.....	36
2.2.3 The colours of biotechnology.....	37
2.2.4 Global biotechnology.....	39
2.2.5 New Zealand biotechnology.....	43
2.2.6 University biotechnology commercialisation.....	45
2.2.7 A unique entity	47
2.2.8 The challenges of biotechnology	47
2.3 BIOTECH COMMERCIALISATION & INNOVATIVENESS	49
2.3.1 Biotech business models.....	49
2.3.2 Biotech strategies	51
2.3.3 Biotech tactics	53
2.3.4 Measuring innovativeness.....	54
2.3.5 Biotech success.....	60
3. METHODOLOGY.....	62
3.1 INTRODUCTION.....	62
3.2 RESEARCH QUESTIONS.....	63
3.3 RESEARCH PARADIGM.....	63
3.4 DESIGN RATIONALE	74
3.5 SURVEYING DISRUPTIVE INNOVATION	75
3.5.1 Survey	75
3.5.2 Participants	77
3.5.3 Data collection.....	78
3.5.4 Data analysis	80

3.6	SNAPSHOT INTERVIEWS.....	82
3.6.1	Interview.....	82
3.6.2	Participants.....	82
3.6.3	Data collection.....	82
3.6.4	Data analysis.....	83
3.7	NEW ZEALAND BIOTECH LANDSCAPE & PERCEIVED INNOVATIVENESS.....	84
3.7.1	New Zealand biotech battlefield.....	84
3.7.2	Datapoints.....	85
3.7.3	Selection criteria.....	87
3.7.4	Landscape analysis.....	88
3.7.5	Perceived innovativeness diagnostic scorecard.....	89
3.8	LEGITIMATION OF RESEARCH.....	95
3.8.1	Survey legitimization.....	96
3.8.2	Snapshot interview legitimization.....	96
3.8.3	New Zealand biotech battlefield and scorecard legitimization.....	97
3.9	SUMMARY.....	97
4.	DI SURVEY.....	98
4.1	DESCRIPTIVE OVERVIEW.....	98
4.2	DISRUPTIVE INNOVATION PERCEPTIONS.....	101
4.3	EDUCATION AROUND DISRUPTIVE INNOVATION.....	104
4.4	ELEMENTS OF DI IN BUSINESS SEGMENTS.....	106
4.5	RATING THE COMMERCIAL ENVIRONMENT.....	125
5.	BIOTECH SNAPSHOT.....	129
5.1	DESCRIPTIVE OVERVIEW.....	129
5.2	DI PERCEPTION.....	130
5.3	DISRUPTIVE BIOTECH.....	131
5.4	COMMERCIAL SUCCESS BARRIERS.....	132
5.5	BIOTECH FUTURE.....	133
5.6	SUMMARY.....	134
6.	NEW ZEALAND BIOTECH BATTLEFIELD.....	137
6.1	NEW ZEALAND BIOTECH INDUSTRY.....	138
6.2	NEW ZEALAND BIOTECH SECTORS.....	139
6.3	DATE OF INCEPTION.....	141
6.4	BIOTECH SUCCESS.....	143
6.5	AGE OF OPERATION.....	143
6.6	THE LIFE OF NEW ZEALAND BIOTECH SECTORS.....	146
6.7	COMMERCIAL STATUS.....	147
6.8	NEW ZEALAND UNIVERSITY INVOLVEMENT.....	148
6.9	NEW ZEALAND BIOTECH GEOGRAPHICAL DISTRIBUTION.....	151
6.10	LOST TO NEW ZEALAND.....	155
6.11	PERCEIVED INNOVATIVENESS OF NEW ZEALAND BIOTECH.....	157
6.11.1	Innovativeness of the New Zealand biotech industry.....	157
6.11.2	Innovativeness of New Zealand biotech sectors.....	158
6.11.3	Commercial and environment innovativeness.....	159
6.11.4	New Zealand university innovativeness.....	161
6.11.5	Regional location innovativeness.....	163
6.11.6	New Zealand biotech success and innovativeness perception.....	164
7.	DISCUSSION.....	169
7.1	DISRUPTIVE INNOVATION.....	170
7.2	NEW ZEALAND BIOTECHNOLOGY INDUSTRY.....	178
7.3	NEW ZEALAND BIOTECH AND INNOVATIVENESS.....	182

7.4	SUMMARY	187
7.5	CONCLUSION	188
7.5.1	Implications	189
7.5.2	Limitations	190
7.5.3	Key Points	191
7.5.4	Future directions	191
REFERENCES.....		193
APPENDICES		208
	APPENDIX A: ONLINE SURVEY PARTICIPANT INFORMATION SHEET.....	208
	APPENDIX B: QUALTRICS ONLINE SURVEY	211
	APPENDIX C: COMMERCIAL ENVIRONMENT DATA.....	228
	APPENDIX D: NEW ZEALAND BIOTECH SECTOR BREAKDOWN.....	230

LIST OF TABLES

Table 1. Key literature definitions of innovation	11
Table 2. Models of Disruptive Innovation.....	27
Table 3. OECD GDP comparison.....	34
Table 4. The colours of biotechnology.....	38
Table 5. New Zealand university technology transfer offices	46
Table 6. Biotech business models	50
Table 7. Innovativeness index and indicator % weighting.....	58
Table 8. Research paradigm summary.....	72
Table 9. Philosophical position adopted for the present research	74
Table 10. Public LinkedIn groups survey advertised.....	77
Table 11. Search terms used on Quid® database	85
Table 12. New Zealand biotech battlefield data points.....	86
Table 13. Criteria of innovativeness scorecard statement.....	91
Table 14. Pairwise logic table to determine criteria weighting for scorecard	92
Table 15. Perceived innovativeness scorecard criterion weighting.....	93
Table 16. Disruptive innovation strategies and tactics foundations.....	124
Table 17. Identified New Zealand biotech sector status breakdown.....	140
Table 18. New Zealand biotech perceived innovativeness summary	167
Table 19. Disruptive innovation strategies and tactics foundations.....	177

LIST OF FIGURES

Figure 1. The basic innovation process from idea to adoption	15
Figure 2. Proposed categorisation of innovation	17
Figure 3. Population captured comparison of Helsinki, Finland and Wellington, New Zealand	33
Figure 4. Biotechnology companies identified per country	43
Figure 5. Model of innovation measurement.....	56
Figure 6. Research philosophy process.....	64
Figure 7. Research ontology spectrum	64
Figure 8. Research epistemology positions	65
Figure 9. Theoretical perspectives of research.....	66
Figure 10. Methodologies for research	69
Figure 11. Perceived innovativeness scorecard.....	94
Figure 12. Survey participants working industries	99
Figure 13. Survey participant’s employment positions	99
Figure 14. Survey participants in geographical locations	100
Figure 15. Perceptions of disruptive innovation.....	101
Figure 16. Perception of disruptor or disrupted.....	103
Figure 17. Education required for disruptive innovation	104
Figure 18. Types of education to allow for disruptive innovation	105
Figure 19. Geographical basis of education.....	105
Figure 20. Market elements perceived to lead to a disruptive innovation.....	106
Figure 21. Heat map of market elements’ roles and location (truncated)	107
Figure 22. Network elements perceived to lead to a disruptive innovation	108
Figure 23. Heat map of network elements’ location.....	108
Figure 24. Process elements perceived to lead to a disruptive innovation	109
Figure 25. Heat map of process elements’ roles and location (truncated)	110
Figure 26. Structure elements perceived to lead to a disruptive innovation	110
Figure 27. Heat map of structure elements roles and location (truncated).....	111
Figure 28. Profit model elements perceived to lead to a disruptive innovation	112
Figure 29. Heat map of profit model elements roles and location (truncated)	113
Figure 30. Product performance elements perceived to lead to a disruptive innovation	114
Figure 31. Heat map of product performance elements roles and location (truncated).....	115
Figure 32. Product system elements perceived to lead to a disruptive innovation	115
Figure 33. Heat map of product performance elements roles and location (truncated).....	116
Figure 34. Service elements perceived to lead to a disruptive innovation.....	117
Figure 35. Heat map of service elements’ roles and location (truncated)	117
Figure 36. Channel elements perceived to lead to a disruptive innovation	118
Figure 37. Heat map of service elements’ roles and location	119
Figure 38. Brand elements perceived to lead to a disruptive innovation.....	119
Figure 39. Heat map of brand elements’ roles and location (truncated)	120
Figure 40. Customer engagement elements perceived to lead to a disruptive innovation	121
Figure 41. Heat map of customer engagement elements roles and location	122
Figure 42. Summary of disruptive innovation (DI) elements	123
Figure 43. Ranking the commercial environment for business.....	125
Figure 44. Biotech Snapshot Summary.....	136

Figure 45. New Zealand biotech companies alive and fallen from 1970 - 2020.....	138
Figure 46. Companies alive and fallen in different eras	138
Figure 47. New Zealand biotech sector breakdown.....	139
Figure 48. New Zealand biotech sub-sector breakdown.....	141
Figure 49. Year New Zealand biotech companies were incorporated	142
Figure 50. Success breakdown of alive and fallen New Zealand biotech companies.....	143
Figure 51. New Zealand biotech age.....	144
Figure 52. New Zealand biotech industry years' operating comparison	145
Figure 53. New Zealand biotech sector years' operating comparison	146
Figure 54. New Zealand biotech market stage of sectors	147
Figure 55. Biotech sectors of New Zealand university spin-outs	148
Figure 56. The founding of New Zealand university biotech spin-outs	149
Figure 57. Biotech sector count on New Zealand university research collaborations	151
Figure 58. Regional spread of the New Zealand biotech industry	152
Figure 59. New Zealand biotech regional distribution map.....	153
Figure 60. New Zealand urban or rural biotech sector focus.....	154
Figure 61. Causes of companies lost as a New Zealand biotech.....	155
Figure 62. Year New Zealand biotech company was lost	156
Figure 63. New Zealand biotech industry perceived innovativeness.....	157
Figure 64. New Zealand biotech perceived innovativeness distribution	158
Figure 65. New Zealand biotech sectors' perceived innovativeness	158
Figure 66. Perceived innovativeness spread within the New Zealand biotech sectors.....	159
Figure 67. New Zealand biotech private or public company perceived innovativeness	159
Figure 68. New Zealand biotech urban or rural company perceived innovativeness.	160
Figure 69. New Zealand biotech market stage perceived innovativeness.....	160
Figure 70. New Zealand university spin-out perceived innovativeness.....	161
Figure 71. New Zealand university proximity perceived innovativeness.....	162
Figure 72. New Zealand university association perceived innovativeness	162
Figure 73. Perceived innovativeness by region	163
Figure 74. Success status perceived innovativeness of New Zealand biotech companies.....	164
Figure 75. Perceived innovativeness success comparison	165
Figure 76. Deemed-a-success and perceived innovativeness box and whisker	165
Figure 77. Perceived innovativeness of the biotechnology sectors deemed-a-success or not.....	166
Figure 78. Perceived innovativeness scorecard.....	183

LIST OF ABBREVIATIONS

AKL	Auckland
ALL	Entire dataset (all participants)
AUT	Auckland University of Technology
AUTEC	Auckland University of Technology Ethics Committee
BAE	Board, advisors, and executives
bn	Billion
BoD	Board of directors
BOP	Bay of Plenty
CAN	Canterbury
CEO	Chief executive officer
DI	Disruptive innovation
DNA	Deoxyribonucleic acid
GDP	Gross domestic product
GII	Global innovation index
GIS	East Coast
HKB	Hawkes Bay
IP	Intellectual property
LU	Lincoln University
MU	Massey University
MWT	Manawatu-Whanganui
NTL	Northland
OECD	Organisation for Economic Co-operation and Development
OTA	Otago
PI	Perceived innovativeness
R&D	Research and development
ROW	Rest of the world
SME	Small and medium-sized enterprise
SMO	Senior, middle management and other
STL	Southland
TKI	Taranaki
TNM	Tasman, Nelson, Marlborough
UK	United Kingdom
UoA	University of Auckland
UoC	University of Canterbury
UoO	University of Otago
UoW	University of Waikato
US	United States of America
VUW	Victoria University of Wellington
WGN	Wellington
WKO	Waikato
WTC	West Coast

ATTESTATION OF AUTHORSHIP

Attestation of Authorship

I hereby declare that this submission is my work and that, to the best of my knowledge and belief. It contains no material previously published or written by another person (except where explicitly acknowledged), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed _____

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ETHICS APPROVAL

This research received approval from the Auckland University of Technology Ethics Committee (AUTEC):

Ethics approval number: 16/74

All research was conducted in keeping with the regulations and guidelines of the approval.

1. INTRODUCTION

New Zealand is a unique country, and this is mirrored in the business environment that has its quirks and nuances compared to the United States, Europe and even the often compared Israel (Statistics New Zealand, 2013). This uniqueness is often problematic for a small Pacific Ocean country. It is amplified further in specialised sectors or industries such as biotechnology, where the pool of talent is scarce and rarely available (Marsh, 2003). A concept that has been a hot topic of business in recent times is disruptive innovation, whether it is sound, flawed, genuine, or accurate, and whether it has relevance to or impact on society. Therefore, an exploration into the understanding of disruptive innovation (DI) and its theory has been undertaken. Unlike the early work of Harvard Professor Clayton Christensen (Bower & Christensen, 1995; Christensen, 1997) and, more recently, Paetz (2014), this research focuses on DI meaning, potential commercial foundations, innovativeness and their relevance and application for the New Zealand biotechnology industry comprising mainly of small and medium-sized enterprises (SMEs).

The research first explored the understanding of DI on a wide scope, conducted with a voluntary online survey. Second, audio-recorded structured interviews were conducted with biotechnology business personnel for closer inspection of the sentiment towards DI commercialisation foundations in an application for the biotechnology industry. Third, the New Zealand biotechnology industry landscape profiling and examination were undertaken through archival and data mining processes and for further analysis with the developed perceived innovativeness scorecard, as well as the relationship of success or failure and the New Zealand biotechnology innovativeness that could potentially increase knowledge towards driving successful outcomes.

1.1 RESEARCH RATIONALE

As a small country, New Zealand has some of the best economic rankings that would exceed many larger countries' expectations and is a highly desirable location to live, potentially impacted by the COVID-19 pandemic. It is, therefore, quite unusual that the business environment operating in New Zealand is somewhat subdued. According to three worldwide reports on competitiveness (Global Innovation Index), innovation (OECD Innovation Report) and the economy (World Economic Forum), New Zealand has previously ranked well on a global level. However, instead of being among similar-stature countries or where it would be desirable, New Zealand is placed somewhat down the list (OECD, 2017; World Economic Forum, 2018; World Intellectual Property Organization et al., 2018). New Zealand's rankings in all three reports have trended negatively with slow or stagnant growth or worsening in rankings whereas others have improved and increased or maintained their rankings in the world (Hong, 2013). The negative trend is a concern for a small, export-dominant economy built upon SMEs that received a relatively minor impact from the global financial crisis of 2007-2009 and has had issues around housing and poverty, most notably. Although, in recent times, up until the 2020 coronavirus pandemic, when the country was severely isolated and shut to the world, the innovation environment appeared to be on the rise in the information technology and smart devices sectors where the scene is rapidly changing (Technology Investment Network Ltd. (TIN), 2018). The pandemic has seen an assortment of outcomes, with many countries impacted substantially entering recessions and the shutdown of many companies due to travel restrictions and country-wide lockdowns.

New Zealanders are inventive as there is a relatively high output of scientific papers and many patents per capita due to a focus on a knowledge-based economy. However, when converting these outputs into successful marketable products, New Zealand has ranked relatively poorly in the Organisation for Economic Co-operation and Development (OECD) reports, compared with countries of similar size (Marsh, 2003; OECD, 2017; Raine et al., 2011). Innovation is more than ideas and patents as these may create knowledge and protect it, but implementing this new knowledge creates the essence of the global economy. An aspect of innovation involves products, services, and processes that extend the currently available range. A successful introduction to the market rewards risk-taking by creating wealth and transforming industries by growing the dynamic firms and distancing them from the slowing firms (Baldwin & Gellatly, 2004). New Zealand individuals and companies have implemented innovations that offer high value and quality as a selling point to customers, aiming at the upper end of the market. It is discussed that New Zealand's small market size and geographical isolation from significant markets present a challenge in mass commodity areas hence the targeting of high-value innovations such as biotechnology. However, this adds to the difficulty of becoming successful (Rinne, 2011).

Disruptive innovation is a term relating to a theory popularised by Bower & Christensen (Bower & Christensen, 1995) and developed in its entirety by Christensen through multiple works (Christensen, 1997, 2006). Its origins stipulate that a minor entrant introduces a product/service with lower qualities than the mainstream market needs. With enough qualities and use to meet a niche group's needs, it slowly gains market traction as it improves. The market-leading firms choose not to defend against their lower market position or fail to react, face undesirable consequences, lose market share, and in most cases, struggle for survival (Christensen, 1997; Christensen & Raynor, 2003). Since then, additional researchers have attempted to further DI by applying the theory as a magnitude of impact for users by serving as a powerful means for transforming and developing new markets while providing functionality and in turn disrupting existing market linkages (Christensen & Raynor, 2003; Govindarajan & Kopalle, 2006; Yu & Hang, 2010). It appears that these innovations often require the users to make a change in their behaviours or mindset to use or incorporate into everyday practice (Veryzer, 1998). The changes in behaviour are seen through government reforms in regulations for increasing renewable energies and ensuring there is no suppressive buyback from electricity-generating companies to make the economics less favourable (Bradshaw, 2018; McNish, 2018; Shadikhodjaev, 2018). The potential value of innovations that identify with DI may be exponentially more significant and be achieved faster than the typical business innovation cycle of sustainable development which is essential for a country like New Zealand.

Most of the literature on DI relates to understanding how large existing firms can interpret the impending threat to counteract being disrupted and, in turn, do the disrupting (or continuing with business as per usual) themselves (Christensen, 1997; Wördenweber & Weissflog, 2005). Some researchers typically align with the point of view of Christensen (1997) (Paetz, 2014; Sandström, 2010; Yu & Hang, 2010).

The power of DI appears to be vast, as large companies live in constant fear of an entrant firm disrupting their market. Today, the term has become the holy grail of boardroom buzzwords for media and businesses to create hype about their market offering or the company itself. DI is highlighted in the New Zealand media as an uncertain, fast-paced and unpredictable entity (Dann, 2014). This research will also attempt to clarify the term's vague and blurred meanings in both the mainstream and business context and present a more purposeful meaning.

Biotechnology (often truncated as "biotech"), at the most superficial level, is an ancient process of applying biological knowledge and techniques to develop products or services such as beer and bread. Modern biotechnology had its origins in the 1953 discovery of DNA (deoxyribonucleic acid), followed by the earliest official modern biotech companies founded in the early 1970s in a Stanford laboratory by

the revolutionary demonstration of DNA cloning (Cohen et al., 1973). The biotechnology industry is undergoing considerable change, and, in future years, it could be a significant contributor to many economies and industries such as seen in the 2020 coronavirus pandemic. In New Zealand, the biotech industry is emerging and potentially lucrative, contributing to the growth of jobs and the country's economy with high potential. Many biotech companies and projects from companies could have been potentially disruptive but have already failed or are not likely to reach their potential. The failures may be from the lack of understanding or structures in commercialising such products and services, constrained thinking, wrong direction, or lack of, being shelved for a later time as not a priority, or lack of capital and infrastructure in New Zealand enabling them. Being able to offer insight involving the perceived innovativeness and favoured and not favoured DI commercial aspects could positively impact the companies involved and, more importantly, the rate of commercialisation success, which could drive further success.

The New Zealand biotechnology industry is the focal point of this research. New Zealand has a well-educated knowledge society and can be an influential player in the biotech industry through its access to highly talented individuals, world-class facilities and resources as rated by the three global surveys (OECD, 2017; World Economic Forum, 2018; World Intellectual Property Organization et al., 2018). Biotech is also a high-value industry that New Zealand should target but requires high risk-taking levels and, in almost all cases, both technically and financially. With many patents ending for pharmaceutical companies in the coming years (the patent cliff), these companies will be looking towards smaller biotech companies for future developments.

The research delves into the New Zealand biotech landscape, exploring perceived innovativeness and potential factors that could enhance commercial success through strategic and tactical drivers. Previous attempts to identify and measure DI features have been somewhat broad and lacked strategic significance for businesses. Little research has focused on identifying elements in a company's environment that contribute to disruptive innovation. These elements, viewed as commercial drivers, have the potential to guide companies toward global impact. One possible strategy could involve employing identified disruptive innovation (DI) approaches to achieve global recognition and success as leaders in their respective fields.

Moving forward, the research develops a perceived innovativeness diagnostic scorecard to analyse and guide decision-making for biotech companies. The amalgamation of these elements with the perceived innovativeness diagnostic scorecard could enable companies, particularly small biotech firms, to refine and focus their innovation activities. Aligning practices, processes, procedures, and structures with the most effective commercial drivers could increase the likelihood of being highly innovative and achieving

substantial commercial returns. The primary target audience for this research is small biotech companies, given the industry's early growth stage in New Zealand and the potential for significant expansion, making them well-positioned to benefit from the research findings. This influence may be particularly impactful in guiding their business development decisions for global growth compared to larger, more established companies.

The overarching goal of the research is to formalise and integrate practitioner knowledge of disruptive innovation (DI) elements with academic insights. The initial application of the perceived innovativeness diagnostic scorecard is directed toward the biotechnology industry and is limited to a focus on the unique characteristics of the New Zealand biotechnology industry. This targeted approach aims to enhance the practical applicability of the information for industry practitioners, fostering more efficient utilisation of the insights gained from the study.

1.2 RESEARCH QUESTIONS

The design of this research is guided and explored by the following four research questions:

- 1. How aligned is the understanding of disruptive innovation between academia and industry?**
- 2. What commercial elements could set the foundations of disruptive innovation?**
- 3. What is the landscape profile of the New Zealand biotechnology industry?**
- 4. How does the perceived innovativeness of New Zealand biotech relate to success?**

The author's research followed a mixed-method research design. It is beneficial for exploring phenomena and social contexts because of the limited data available for the combination of disruptive innovation theory, the biotechnology industry, and New Zealand SMEs. The combination of both quantitative and qualitative processes did increase the chances of creating a clearer picture and creating evidence in a manner that independently conducted quantitative and qualitative studies alone cannot (Creswell, 2014).

1.3 CONTRIBUTIONS

This research makes three key contributions to innovation theory. It (1) expands the existing knowledge and theory of DI, (2) develops new insights into the foundations of DI activities, and (3) develops and demonstrates the application of a perceived innovativeness diagnostic scoring system in mixed-method research in biotechnology studies.

Expand existing knowledge and theories of disruptive innovation,

Research into DI has so far focused on large incumbent firms and the imminent attack that they will undergo and strategies for avoiding falling prey to disruptive innovation. There is a need for research that identifies industry and academic understanding of DI applications and the resulting impacts. The research provides several factors that could contribute to DI and its potential success.

Develop new insights into the foundations of disruptive innovation activities and applications to a New Zealand biotechnology context.

The literature has yet to explore the sources of information for innovative ideas and the foundations that could enhance disruptive innovation development. An exploration of these elements contributes to building theory in this area of research. Understanding the New Zealand biotechnology landscape and the focus on innovative ideas is essential, as it is one of the most critical steps in the innovation development process. Also, identifying deterrents to the innovation process can enable New Zealand biotech leaders to take steps to mitigate barriers and adverse effects and reduce their potential negative impact.

Develop and demonstrate the application of a perceived innovativeness diagnostic scorecard in mixed-method research in biotechnology studies.

This research sought to contribute to the application of mixed-method research in a biotechnology context. The research applied this approach to answer exploratory research questions using quantitative and qualitative inquiry methods. The research attempted to explore the idea that the higher the innovativeness of a company, the greater its chances of being successful, while also generating theory by investigating the factors that are analysed within the context of biotechnology companies.

This research has the potential to make two practical contributions. It could (1) enhance the innovation capabilities of the New Zealand economy in the biotechnology industry, and (2) enhance New Zealand's competitiveness as a knowledge-based economy.

Enhance the innovation capabilities of the New Zealand biotechnology industry.

This research contributes to enhancing the innovation level in New Zealand's economy, particularly the biotechnology industry, by deepening our understanding of DI elements that could be applied to biotechnology. This will help companies identify the foundations they could pursue to increase their ability to develop and implement innovations. Also, the research develops a perceived innovativeness diagnostic scorecard from a whole company perspective as most research recently has been from a single product perspective. It will allow companies to be able to assess and identify potential strengths and weaknesses that could hinder their innovation process. Thus, the research directs biotechnology leaders to essential sources of information.

Enhance New Zealand's competitiveness as a knowledge-based economy.

Due to New Zealand being a small, isolated country, the commercialisation of commodities alone would be insufficient to build the economy. Hence, the research will contribute to enhancing the knowledge-based economy where the creation of high-value or high-end products and services through technical and skilled occupations such as biotechnology.

1.4 OUTLINE OF THE RESEARCH

The organisation of the six chapters of the research is as follows:

In this chapter, the introduction of the study's rationale is presented with a brief outline of the context, study design and potential contributions.

Chapter 2 contextualises the relevant literature study through crucial concepts that underline the research topic. An extensive review is presented by delving into the depths of innovation, New Zealand and the biotechnology business environment, and business models and measuring innovativeness. The research questions are developed from the literature review and an online survey on DI, interview questions, and the critical points for data mining for the New Zealand biotech profile.

Chapter 3 is an account of the research methodology and methods. Philosophical assumptions undertaken to complete the research are first addressed, and then the approach to the selection of mixed-methods approaches is discussed. Per mixed-methods design, the chapter is divided into distinct phases and details the methods used for these phases, respectively. In each phase, the design is explained and justifications for the sampling method and research instruments are presented. The

process of developing the research instruments follows this and its appropriate measures are explained. Each phase concludes with a detailed discussion of the data collection and analysis process.

Chapter 4, the findings of the online survey are presented with a focus on disruptive innovation. A descriptive overview of the survey sample is presented, followed by the results of the DI elements and the commercial environment analysis.

Chapter 5 delivers thematic insights from the structured interviews conducted with biotechnology business professionals as a snapshot of the biotech industry's situation.

Chapter 6 presents the New Zealand biotechnology battlefield, a profile analysis of alive and fallen biotechnology companies. Beginning with a descriptive overview, the biotechnology landscape analysis results are conducted by probing various data points as well as an assessment of the perceived innovativeness of the New Zealand biotechnology industry as a whole as well as within the sectors and about the determination of success.

Chapter 7 presents a discussion based on the data collected in chapters 4, 5 and 6 to answer the developed research questions. Each research question is answered through a discussion of the outcomes of the analysis of each phase. Conclusions are drawn from the research, beginning with revisiting the rationale of the study. Finally, the limitations of the study are considered, and directions for future research are described.

2. KEY CONCEPTS

This chapter presents a review of the associated literature's key concepts: innovation, disruptive innovation (DI), New Zealand's economic standing from a biotechnology perspective, and commercialisation for biotechnology and innovativeness. These areas are the combined focus of the research and will present a theoretical basis for this research.

Many search terms involving innovation and disruption variations, biotechnology and New Zealand were searched with PubMed, Scopus, EBSCO, and Google Scholar databases to locate appropriate literature. To grasp a complete understanding and developments through time, no date restrictions were applied to the literature search. Each section presents the prior literature used in framing research necessary to meet the specific aims of the research.

First, a general overview of innovation theory is covered and further explores DI. The review is followed by an overview of New Zealand's economic standing with a focus on the biotechnology industry, followed by biotechnology commercialisation and the concept of innovativeness. Finally, research questions are presented that will guide an inquiry into understanding DI and the assessment of the innovativeness of the New Zealand biotechnology landscape.

2.1 INNOVATION THEORY

Innovation is regarded as an essential aspect of business survival in today's ever-changing economic environment. If one is not innovative, one will fall behind and become extinct - the adage: innovate or die! (Getz & Robinson, 2003). In the current global economy, innovation has become a central issue for organisations. However, despite acknowledging the importance of innovation, no single definition of innovation has reigned supreme among businesses and academics to date. The ambiguity is mainly due to the multidisciplinary approaches to innovation research where each of the disciplines has adopted varying methods, definitions and samples of innovation research (Tidd, 2001).

However, some agree that innovation is more than just a creative process and that it is necessary to distinguish between invention and innovation. While creativity and idea generation are the first steps to innovation, creating a new idea on its own is not an innovation; innovation is the utilisation and exploitation of a new idea, or in other words, the implementation of a new idea.

2.1.1 What is innovation?

To comprehend the topic at hand, disruptive innovation, the history, and the origins of this complex and ever-evolving concept of innovation are reviewed to generate a deeper understanding of innovation. The term innovation, in recent times, has been used as a contemporary buzzword, primarily used loosely by politicians and policymakers as well as business managers and many others concerning improvements or doing things more effectively and efficiently (Bernstein & Singh, 2006; Perry, 2010). Such individuals have also used it when there are high expectations of reviving, boosting, and renewing a dwindling economy. The understanding of innovation has been an area of debate for several years.

The idea of innovation has been known for centuries under a different guise and can be traced back to the Middle Ages. However, studies on the topic of innovation have only been prevalent for the last half a century (Shahady et al., 2008). The increased number of innovation studies in more recent times has meant that different authors' perspectives have led to the concept of innovation becoming a blurred area. Each time a paper on innovation is published, researchers have commented on the prior work and then added their perspective to the area. The additions have contributed to the overuse, misuse and hype of innovation so that the word has, in essence, lost its meaning over time (Keeley et al., 2013). Due to the complex nature of the topic, there appears to be no one universal definition conveyed by authors or researchers of innovation (Adams et al., 2011; Gatignon et al., 2002; Keeley et al., 2013; Thota & Munir, 2011; Utterback, 1986). However, there appear to be elements grouped under the same umbrella to be included for an innovation. The Merriam-Webster dictionary definition of innovation is

"a new idea, method, or device; the introduction of something new" (Merriam-Webster, n.d.-a). Table 1 presents the key works that have defined innovation in literature from various perspectives.

Table 1. Key literature definitions of innovation

Definition	Reference
<i>(1) The introduction of a new good...(2) the introduction of a new method or production... (3) the opening of a new market... (4) the conquest of a new source of supply or raw materials or half-manufactured goods... (5) the carrying out of a new organization of any industry</i>	(Schumpeter, 1934, p. 66)
<i>"...the function of an interaction among the motivation to innovate, the strength of obstacles against innovation, and the availability of resources for overcoming such obstacles."</i>	(Mohr, 1969, p. 111)
<i>"...an invention which has reached market introduction in the case of a new product, or first used in a production process, in the case of a process innovation."</i>	(Utterback, 1971, p. 77)
<i>"specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or different service."</i>	(Drucker, 1985, p. 17)
<i>"...the search for, and the discovery, experimentation, development, imitation, and adoption of new products, new production processes and new organisational set-ups."</i>	(Nelson et al., 1988, p. 222)
<i>"...adoption of an internally generated or purchased device, system, policy, program, process, product, or service that is new to the adopting organization."</i>	(Damanpour, 1991, p. 556)
<i>"...the transformation of knowledge into new products, processes, and services..."</i>	(Porter & Stern, 1999, p. 12)
<i>"...an idea, practice, or object that is perceived as new by an individual or another unit of adoption."</i>	(Rogers, 2003, p. 1)
<i>"Innovation represents the core renewal process in any organization. Unless it changes what it offers the world (product/service innovation) and the ways in which it creates and delivers those offerings (process innovation), it risks its survival and growth prospects."</i>	(Bessant et al., 2005, p. 1366)
<i>"...is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations."</i>	(OECD & Eurostat, 2005, p. 46)
<i>"Innovation is executing a new idea to create value."</i>	(Kastelle & Steen, 2011, p. 199)
<i>"...innovation is a process of turning opportunity into new ideas and of putting these into widely used practice."</i>	(Tidd & Bessant, 2011, p. 16)
<i>"Something different that has impact"</i>	(Anthony, 2012, p. 16)
<i>"A new idea, method, or device... The act of creating a new product or process, which includes invention and the work required to bring an idea or concept to final form."</i>	(Kahn et al., 2012, p. 454)
<i>"...a viable offering that is new to a specific context and time, creating user and provider value."</i>	(Kumar, 2013, p. 1)
<i>"The commercialization of any new product, process, or idea, or the modification and recombination of existing ones."</i>	(Rothaermel, 2013, p. 172)

The notion of "new," which could be a creative process, is almost evident in all the definitions and the most crucial aspect of innovation, is the implementation of such creativity. Thus, defining innovation

has some degree of alignment with all who study it. The disagreements and misaligned views occur as we delve deeper into the more specific elements of the topic of innovation. Benoît Godin (2017) is a historian who has focused on the intellectual history of innovation. He found that before using the term innovation, similar meanings could be traced to the Middle Ages today, where it has acquired a central place in society. Godin (2017) presents that from the 16th and 17th centuries, the idea of novelty was beginning to be seen everywhere and become a cultural value in society.

The concept of innovation began to garner attention from the work of the Austrian-American economist Joseph Alois Schumpeter, most notably through his books, *The Theory of Economic Development* in 1912, translated into English in 1934, *Business Cycles* in 1939 and *Capitalism, Socialism and Democracy* in 1942. The number of innovation studies has grown tremendously since then. An early definition extracted by Hong (2013) and Janszen (2000) from Schumpeter finds that the key points include; involving the introduction of new goods; methods of products; the opening of new markets; and new sources of supply by a new organisation in any industry (Schumpeter, 1934, 1939, 1942). The meaning could bear that new ideas or knowledge are converted into marketable products. These marketable products require constant attention as in Schumpeter's work, a similar process seen by Kondratieff waves (modelled by Nikolai Kondratieff) for some industries and economies come through emphasising business cycles with the rise and fall of technologies (Drucker, 1955, 1985). Schumpeter's theories have faced challenges from another influential innovation scholar, Peter Drucker, as they differed from the source of innovation. Schumpeter advocated that the source was production-driven, whereas Drucker details that it is demand-driven and that purchasing power is the primary source (Perry, 2010).

Hendy & Callaghan (2013) reiterate Schumpeter's point in their publications that invention and technological change (innovation) followed up with imitation are distinctly different but related. Schumpeter purports that invention deals with creating new ideas or knowledge, while innovation has a specific function of converting new ideas or knowledge into marketable products or improved processes. The idea relates to the 1966 thinking of Harvard Business School's T. Levitt, who states that the "greatest flow of newness is not innovation at all. Rather, it is imitation." Stating that imitation is the greatest form of flattery (Godin, 2017). Schumpeter's thinking leads towards a deeper aspect of innovation, creative destruction, which will be discussed in the categorisation of innovation to follow.

Drucker's view is instilled from his question in 1955 of what the purpose of a business is. Creating a customer as a business has the purpose of creating a customer and therefore reasons that it has two primary functions, marketing, and innovation. Drucker sees marketing as the distinguishing feature between what a business is and what is not (Drucker, 1985). Drucker details the second function of

innovation being "the provision of better and more economic goods and services [and] must provide better and more economic ones" (Drucker, 1955, p. 34), which means that a business does not have to grow excessively large in numbers but constantly grow better. Innovation for Drucker extends throughout the entire business at each phase, from design to the product to marketing, such as the operation of innovations, which will be touched upon further. Drucker's view adapts somewhat some years later in his 1985 book, *Innovation and Entrepreneurship*, and sees innovation as a specific tool for entrepreneurs to exploit change, viewed as a discipline that can be learned and practised (Drucker, 1985). Drucker looks at innovation systematically, a diagnostic discipline, examining areas of change that offer entrepreneurial opportunities, where he identifies seven sources for innovative opportunity. Four of these are within the enterprise (the unexpected, the incongruity, process need, industry and market structure) and three from outside (demographics, changes in perception and new knowledge) (Drucker, 1985). The view is quite different from Utterback (Utterback, 1986, 1996), who sees innovation as a complex subject and that building a broader, more holistic appreciation of the phenomena should be taken.

There have been many definitions presented throughout history about the concept of innovation. Hong (2013) located an extensive innovation study by Tinneland in 1973 that collected innovation definitions from over 180 publications and recognised that innovation could be placed into six categories from the findings. The categories were led by:

- the introduction of a new idea,
- a new idea,
- the introduction of an invention,
- an idea different from existing ideas,
- the introduction of an idea disrupting prevailing behaviour,
- an invention

These categories relate to new creations. More recently, a definition, that is more whole, and attempts to capture the many facets of innovation, is one by the OECD/Eurostat in the Oslo Manual, which contains the guidelines for measuring scientific and technological activity. It states that "innovation is the implementation of a new or significantly improved product, or process, a new marketing method, or a new organisational method in business practices, workplace organisations or external relations" (OECD & Eurostat, 2005, p. 46). There are still numerous different point-of-views as to what innovation is, as seen previously in Table 1. This definition by the OECD was updated in 2018 to reflect changes in society and the term innovation. The definition is only one example, but the 2005 OECD definition will be the core definition applied to this research:

“Innovation is the implementation of a new or significantly improved product, or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.”

(OECD & Eurostat, 2005, p. 46)

Individuals need to note that the critical components of creativity and implementation must be present, as can be seen by many definitions for something to be an innovation.

In summation, nothing created becomes an innovation until it is successfully adopted into organisations or by users' frequent use. A discovery that goes no further than the laboratory remains an invention (Garcia & Calantone, 2002; Hong, 2013; Keeley et al., 2013). Many individuals or companies invent things that receive patents for new ideas, products, and processes. However, the number of patents that turn into successful or marketable products at all is tiny in comparison (Stevens & Burley, 1997). This is why innovation has been described as a team sport by (Kelley & Littman, 2001) involving ten faces for innovation. A simple view of innovation is the successful implementation of a creative idea or invention in the marketplace (Onetti & Zucchella, 2014).

Another aspect of innovation is innovativeness, which also has multiple meanings associated with it. One such meaning is that innovativeness has a "strong emphasis on research and development, new products, new services, improved product lines and global technological improvement in the industry" (Ahmad et al., 2017, p. 117). Innovativeness will be further explored in the business models and strategies with the New Zealand biotechnology industry.

The following section presents the finer details of innovation beyond the core concept. It presents categorisation layers for innovation in the literature surrounding innovation to form a more concise understanding.

2.1.2 The innovation process

Innovation does not just happen. It is a process undertaken by an individual or group/company to progress by taking something that could be very little and transforming it into something big. The basic

process begins with an idea and finishes by being accepted by the market. The summary of the process is shown in Figure 1 as an oversimplification integrating the innovation and commercialisation process.

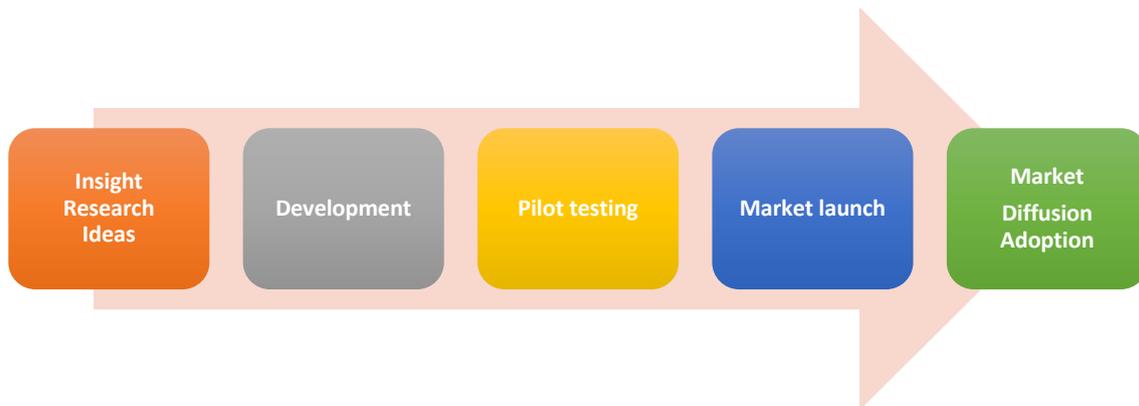


Figure 1. The basic innovation process from idea to adoption. The general basic phases involve the creation and development of novel ideas, products or technology, testing or prototyping, launching the innovation to the market and finally, that innovation being diffused and adopted by the market.

The innovation process and the commercialisation process are distinct yet interconnected stages in bringing a new idea or technology to market. Bell and Mason, as well as Klofsten, provide valuable differing insights into these processes.

The innovation process refers to the creation and development of novel ideas, products, or technologies. It involves ideation, research and development, and the generation of new concepts. This phase is characterised by creativity, experimentation, and the pursuit of groundbreaking solutions. On the other hand, the commercialisation process is focused on taking innovative ideas or technologies and turning them into viable products or services for the market. This involves activities such as market analysis, product development, marketing, and establishing distribution channels. Therefore, the innovation process is about generating new ideas and technologies, while the commercialisation process is about translating these innovations into marketable products or services. Both processes are integral to the overall innovation lifecycle.

The complex nature of these two processes can be seen within The Bell-Mason Diagnostic and/or Bell-Mason framework, and Klofsten Business Platform where they offer valuable perspectives that highlight the simultaneous nature of innovation and development on multiple fronts. These frameworks recognise that innovation involves various dimensions, such as technological advancements, market dynamics, organisational capabilities, and customer needs (Bell & Mason, 1991; Klofsten, 2005).

Further to the innovation and commercialisation processes, there are seminal theories and frameworks to elucidate the journey from early-stage adoption to mainstream success in a dynamic landscape marked by continual evolution.

In the embryonic stages of technology adoption and diffusion, a concept championed by Rogers (1962), the landscape is characterised by cautious exploration and gradual market entry. Nested within this phase are smaller S-Curves, reflecting iterative cycles of innovation and improvement. The S-Curve, popularised by scholars like Perez (1983), is a visual representation of this journey, encapsulating the initial crawl, mirroring the cautious steps of early adopters. As the innovation gains traction, both the larger and nested curves ascend, embodying the gradual ascent towards mainstream acceptance. Within this technological journey, the dichotomy between sustaining and disruptive innovations becomes apparent. Christensen (1997), in his seminal work on disruptive innovation, which is the topic of focus for this research, highlights that sustaining innovations contribute to the upward slope of the S-Curve, representing incremental improvements. In contrast, disruptive innovations, begin in niche markets and traverse a slower trajectory before catapulting ahead, challenging the status quo and established technologies.

A critical juncture in the innovation narrative is the crossing of the chasm, a concept introduced by Moore (1991). This transition from early adopters to mainstream acceptance requires navigating strategic challenges, as the needs and expectations of the broader market diverge from those of the early enthusiasts. This phase demands a delicate balance to bridge the gap successfully.

Enter the strategic realm encapsulated by the Blue Ocean Strategy, a paradigm introduced by Kim & Mauborgne (2005) offering a framework for businesses to explore untapped markets and create uncontested spaces for innovation. This approach encourages companies to move away from direct competition and instead focus on innovation that creates new demand. It aligns with the concept of crossing the chasm in technology diffusion, where companies seek to bridge the gap between early adopters and the broader market. The Strategy Canvas, another tool from the Blue Ocean Strategy, helps organizations visualize their competitive landscape and identify areas for differentiation. By strategically adjusting key factors, companies can redefine their market positioning and create a unique value proposition.

The innovation journey involves understanding the phases of technology adoption, recognising the distinctions between various forms and states of innovation such as sustaining and disruptive, strategically navigating the transition from early to mainstream adoption, and embracing frameworks like the Blue Ocean Strategy and the Strategy Canvas to create a competitive advantage in dynamic markets. Successfully managing these elements is crucial for organizations seeking to thrive in the ever-evolving landscape of technology and business.

Differing aspects are abundant in the meaning of the general process of innovation. Shahady et al. (2008) point out that innovation can be differentiated based on the purpose or type of innovation effort. The differences are seen in numerous scholarly and industry articles that the information on innovation can be organised or categorised to be able to distil the information available about innovation. A proposed categorisation of innovation is presented in Figure 2. Each innovation appears to involve all four categories: knowledge, function, form, and magnitude as they progress through categorisations. The innovation will then have a specific component of each category identified, of which further studies and reports can be produced for that aspect. For example; working down the categorisation framework, an innovation may have a knowledge basis of open innovation as opposed to closed innovation, the function of what the innovation is proposed to function as be a product, the form of the innovation concerns the spectrum of change from the industry segment the innovation is involved in such as how different components of the systems interact or link with each other as in architectural innovation, and finally, the magnitude of the innovation, in terms of the impact of change for users, an innovation may be toward the sustaining end of the spectrum with little change and effect for users. There are too many terms and classifications relating to innovation, and this contributes to the lack of focus on innovation as a topic (Abernathy & Clark, 1985; Adams et al., 2011; Brophey et al., 2013; Gatignon et al., 2002; Linton, 2002).

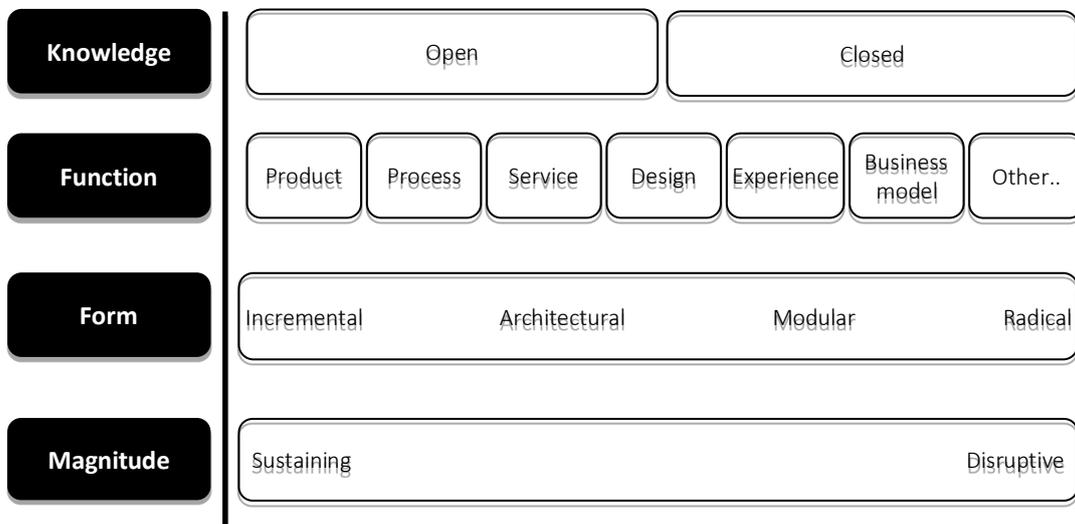


Figure 2. Proposed categorisation of innovation (Author’s diagram). There are four categories; knowledge, function, form, and magnitude in which an innovation will have a specific component from each. For example, an innovation may have knowledge that falls within open innovation, the function of the innovation may be around a product, and the form of the innovation may be around the architectural area of a form spectrum where there are changes in how different components of the systems interact or link with each other, and finally, the magnitude of the innovation and the impact of change for users, an innovation may be toward the sustaining end of the spectrum with little change and effect for users.

2.1.3 The concept of innovation

A layer categorisation sees innovation as the central overarching concept, with the end goal being implementation and adoption. The OECD/Eurostat (2005) definition of innovation covers the broadest concept as it incorporates the collaborative and iterative thinking of the best scholars. The overarching concept is followed by the knowledge of the innovation, the function for applying the innovation, the form of the innovation and finally, the magnitude of the innovation. Figure 2 depicts the proposed categorisation layers, and brief details of these layers follow.

2.1.4 The knowledge of innovation

The knowledge of the innovation relates to the source of information of a particular innovation. The information utilised towards the development and subsequent commercialisation of innovation could be termed open or closed innovation.

(a) Closed Innovation

The knowledge of innovation can be called closed innovation, which carries the adage that companies keep everything in-house and struggle internally with the lack of resources, knowledge or personnel (Herzog, 2011).

(b) Open Innovation

The knowledge of innovation can also be open innovation entailing an abundance of good ideas. No one person or company can have a monopoly on all valuable knowledge or employ all intelligent people. Therefore, information is gathered from all possible aspects or building upon already well-founded information (Chesbrough, 2006). Open innovation is a relatively new topic of discussion with intriguing research possibilities. However, it is not the focus of this research.

2.1.5 The function of innovation

The function of innovation is an ever-expanding area of innovation research (Morris, 2003). The function relates to the terms that have become common knowledge and self-explanatory, such as product innovation, service innovation, process innovation, and more recently, business model innovation relating to the function of the innovation (Chesbrough, 2010; Davenport, 1993; Teece, 2010). Additional operations have been used but have not garnered as much attention or are still in their infant stage, for

example, experience, user-centred, and design-driven innovation (Prahalad & Ramaswamy, 2003; Verganti, 2009; Von Hippel, 2009).

(a) Product Innovation

Product innovation is defined as the development of new products, changes in the design of established products, or the use of new materials or components in the manufacture of established products (Chakrabarti, 1974; Cooper & Edgett, 2009; Danneels, 2002). Examples of product innovation by a business might include a new product's invention; technical specification, and quality improvements made to a product; or the inclusion of new components, materials, or desirable functions into an existing product.

(b) Service Innovation

Service innovation is defined as a new or significantly improved service concept that is taken into practice. It can be, for example, a new customer interaction channel, a distribution system or a technological concept or a combination of them. A service innovation always includes replicable elements that can be identified and systematically reproduced in other cases or environments (Berry et al., 2006; Lusch & Nambisan, 2015; Miles, 2010; Witell et al., 2016).

(c) Process Innovation

Process innovation means implementing a new or significantly improved production or delivery method, including significant changes in techniques, equipment and/or software, and improved IT infrastructure (Davenport, 1993; Ettlé & Reza, 1992; Pisano, 1997).

(d) Design Innovation

Design innovation is a process used to create innovation. It focuses on addressing people's needs with technologically feasible and devising a viable business strategy to derive value from this market opportunity. Design Innovation is a unique blend of design thinking, computational thinking, maker culture, and business (Dong, 2015; Hsu, 2011; Mutlu & Er, 2003).

(e) Business Model Innovation

Business model innovation is the art of enhancing advantage and value creation by making simultaneous and mutually supportive changes both to an organisation's value proposition to customers and its underlying operating model. Business model innovation is developing new, unique concepts supporting an organisation's financial viability, including its mission and the processes for bringing those concepts to fruition (Amit & Zott, 2012; Chesbrough, 2007; Teece, 2010). The primary goal of business model innovation is to realise new revenue sources by improving product value and how products are delivered

to customers. Thus, a business model innovation is the conscious change of an existing business model or the creation of a new business model that satisfies the customer's needs more than existing business models. Product and service innovation is essential, but business model innovation can deliver a more lasting competitive advantage, particularly in changing times (Teece, 2010).

2.1.6 The form of innovation

The form category details what form the application of innovation takes. The form could be compared to what the innovation is replacing or introducing in a specific context. Some researchers believe that it does not matter what innovations are called, to misquote Shakespeare, "new innovations would smell as sweet by any other name" (Garcia & Calantone, 2002, p. 110). This layer of categorisation has the greatest variation between scholars. Overall, a synonymous overlap is seen in the literature. To capture the many facets introduced, simplifying the terms into a standard system is done by creating a form spectrum. The spectrum can be seen in Figure 2, ranging from incremental to radical.

(a) Incremental Innovation

Incremental innovation involves the relatively minor, simple modifications or adaption of current products, exploiting the existing design's potential (Ali, 1994; Berndt et al., 2006; Carayannis et al., 2003). Incremental innovation is the most common form of any innovation as it is in most organisations' nature. They are there to satisfy a perceived market and generally require a short time to develop and implement.

(b) Modular Innovation

Modular innovation is about changing a component without changing how a system is configured (Galunic & Eisenhardt, 2001; Magnusson et al., 2003; Utterback & Abernathy, 1975). Introduction of new component technology inserted within an essentially unchanged product architecture. An innovation that changes only the relationships between core design concepts of technology. It is an innovation that changes a core design concept without changing the product's architecture (Henderson & Clark, 1990).

(c) Architectural Innovation

Architectural innovation refers to destroying the usefulness of a company's architectural knowledge but preserving the knowledge about the firm's product's components (a physically distinct portion of a

product that represents the core design concept and performs a well-designed function). Architectural innovation refers to innovation in the architecture of a product that modifies or changes how different components of the systems interact or link with each other (Bozdogan et al., 1998; Galunic & Eisenhardt, 2001; Henderson & Clark, 1990; Jaspers et al., 2012). The system's different components may also be modified within the new architecture (smaller form factor, lighter weight, etc.); however, the key technologies at the component level remain unchanged.

(d) *Radical Innovation*

Radical innovations draw upon new technical knowledge and commercial skills to explore new technology, causing dramatic changes in processes, products, or services (Dewar & Dutton, 1986; Henderson & Clark, 1990; Junkunc, 2007; Leifer et al., 2001). Radical innovations have been put under the microscope over time when innovation is deemed a radical innovation, which is subjective to the context. The critical difference between radical and disruptive innovation is that radical innovations stem from creating new knowledge and novel products and services, which does not need to be the case for disruptive innovation (Hopp et al., 2018).

Some see incremental innovation as a way to sustain short-term financial performance, and that radical innovation is the only way to ensure competitive advantage and growth (Alexander & van Knippenberg, 2014).

2.1.7 The magnitude of innovation

This research's final categorisation and focus are interpreted to be related to the magnitude of impact experienced for the innovation. This area has piqued and stirred a debate in the scholar community since Christensen's complete introduction in 1997 (Shahady et al., 2008). Based on the studies completed, it appears that a magnitude spectrum can also be applied ranging from sustaining to disruptive innovation.

(a) *Sustaining Innovation*

Usually, when we think of innovation, we think of disruptive or breakthrough innovation, which is seen as more exciting innovation types than sustaining innovation. Sustaining innovation involves improvements in specific performance attributes. Sustaining innovation, also called routine innovation, refers to an innovation that happens on an incremental basis, often in response to customer and market demands or improvements in technology (Christensen, 1997). While a great deal of attention is given to disruptive and breakthrough innovation, sustaining innovation is where established companies

experience higher profits without changing the marketplace. A company spends much less on research and development (R&D) and on promotions to sell it, thereby improving existing products. It does not create new markets or value markets but develops existing ones to have better value, allowing companies to compete against each other's sustaining improvements (Christensen, 1997; Christensen & Raynor, 2003).

(b) Disruptive Innovation

Initially, the concept of disruptive technology was introduced, then updated to disruptive innovation as a more useful concept to capture an entire business process (Christensen, 1997, 2006; Christensen & Raynor, 2003). Disruptive innovation can be active combinations involving the business model and not just the technology that can enable and create a disruptive effect. The innovation eventually disrupts an existing market and current value network. This will be looked at in more depth in the following section.

2.1.8 Disruptive innovation theory

Disruptive innovation is one of the single most talked about business concepts today, especially in the technology sector. It permeates boardrooms, both as a strategy for innovators and as a threat to existing businesses. Technology start-ups around the world virtually all fancy themselves as disruptors (Paetz, 2014).

Breaking down the term, *Disrupt* comes from the Latin *disrumpere*, which is formed by combining *dis-* ("apart") and *rumpere* ("to break"). The Oxford English dictionary defines disrupt as "to interrupt the normal continuity of (an activity); throw into disorder" (Oxford English Dictionary, n.d.). Merriam-Webster defines disruption as "the act or process of disrupting something: a break or interruption in the ordinary course or continuation of some activity, process, etc." (Merriam-Webster, n.d.-b).

Despite the intended meaning of disrupt and disruptive, the word has seen a reasonably broad shift. It is often found in advertisements and articles as a way of simply describing upheaval in an industry. In the Harvard Business Review, 2015, Christensen and two co-authors made a note of what they felt was a semantic misapplication: "Many researchers, writers, and consultants use disruptive innovation to describe any situation in which an industry is shaken up, and previously successful incumbents stumble. But that's much too broad a usage." (Christensen et al., 2015, p. 46). While it is inevitable that some people will have a distinct influence on getting a word to change, it is also certain that they will not have

the final say on when it should stop changing. The modern sense of 'disrupt' is still working out its meaning.

Disruptive innovation or disruptive technologies, as it was initially named, is a term that was first introduced by Bower & Christensen in the 1995 article, *Disruptive Technologies: Catching the Wave*, and then secondly, in Christensen's book, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, where they attempted to make sense of why large companies at the top of the market succumb to a change in the technology. The concept appears to have similarities to Schumpeter's theory of creative destruction for business cycles, endorsing Kondratieff waves (technology cycles of prosperity) in the process. Schumpeter's theory postulates shifting profit pools, rearranging industries, and replacing established businesses (Anderson & Tushman, 1990; Croitoru, 2012; Drucker, 1955; Schumpeter, 1934, 1939). This process would occur in a dynamic fashion of new technologies (creation), interrupting the old technologies (destruction) (Hendy & Callaghan, 2013; McCraw, 2009; Schumpeter, 1934). Therefore, it could be postulated that the concept of disruptive innovation had its original foundations laid by Schumpeter.

There is a lot of buzz and attention around disruption, as it is now seen as the must-have business approach for extraordinary growth, shareholder and economic value (Ignatius, 2015). Typically, 20 times or more than the index averages, and they can in a matter of years make old business models and industry norms obsolete, going from nothing to becoming the new incumbent market leader. Today, a clearer picture of disruptive innovation is required more than ever in its history. The term has become increasingly popular in business mantras and shifted how some companies approach innovations and their business's general running. To be disruptive is the goal for many companies, and the concept is being lost in the business's everyday running.

Paetz (2014) does not sway from the definition initially applied by Christensen like many others do, citing its proven use in the real world and stating, "it doesn't help to improperly label things as disruptive that aren't" (Paetz, 2014, p. 5).

The traditional model of disruptive innovation in the modern sense, referred to as Christensen's model can be described as an "attack from below" (1997) and, more recently, the addition of a new market (2003). In both cases, the current market is unwilling to use the potentially disruptive innovation in applications they know and understand due to the different value proposition to what is previously available (Christensen, 1997). Therefore, this model presents a technology that in the beginning is not able to meet mainstream market expectations but can offer value-added ancillary performance and improve at a rapid rate, and this then invades the established markets (Christensen, 1997; Christensen

& Raynor, 2003; Utterback & Acee, 2005). Established companies are thought to ignore these progressions. This type of disruptive innovation is only used and valued in a niche or new applications and markets, which look unappealing to investment from the outset. The potential revenues from the major markets are negligible due to the inferiority of performance aspects. It is not easy to project how big a newly established market will get over the long term. A challenge is that markets that do not exist cannot be analysed (Christensen, 1997). Disruptive innovations achieve a market share in the established market as technology progresses faster than the market demands which causes an overshoot of market requirements and is generally expensive. This allows a cheaper, inferior technology that meets the market requirements to enter at the bottom or form an emerging or insignificant market. Christensen summarises that these innovations are smaller, simpler, cheaper, and more convenient to users. This, therefore, gives an impression to the majority that traditional DI assumes that disruptors start with a lower-priced, inferior alternative that chips away at the least profitable segments (Downes & Nunes, 2013).

For all its use in various mediums around the world, DI is not well understood. It is not hard today to find advertising agencies and designers calling themselves disruptive. For example, some companies that have not yet created a product and have no customers call themselves disruptive, or venture capitalists (VCs) may describe their investment strategy as disruptive. Even art festivals celebrate singer Justin Bieber as a disruptor.

This research aims to provide some guidance to companies, particularly those in New Zealand, to understand innovation and DI, possibly applying foundations and implementing their disruptive innovations and increasing their chances of success. Definitions must be outlined and review the critical aspects of innovation components such as products, services, and business models, that aim to be disruptive.

In their initial 1995 article, Bower and Christensen also introduced the term "sustaining" to cooperate with disruption and enhance existing products. With the introduction of the concept of sustaining innovation, this research speculates that, as proposed in Figure 2, a spectrum between the two terms can be formed, as some innovations can be more disruptive than others as with the level of sustaining, which could be borderline with sustaining or disruptive. Sustaining applications tend to maintain the rate of improvement; they give customers something more or better in the attributes they already have (Bower & Christensen, 1995; Christensen, 1997). The grouping of innovations into disruptive and sustaining can be fluid as these concepts' boundaries are often confounded and unclear; hence, a spectrum is used here to illustrate better the lack of boundaries (Figure 2) (Ehrnberg, 1995). A term that appears synonymous with sustaining innovation is continuous innovation, a well-known term with

industrial production, financial services, and transportation logistics. Sustaining innovation is not enough to counteract global markets' forces and is not a differentiator for those markets (Wördenweber & Weissflog, 2005). A particular standpoint has been that unlike sustaining innovation, where we take what we already have and make it more efficient, disruptive innovation aims to replace what already exists and upset the status quo (Wördenweber & Weissflog, 2005). This can also be seen as the case with a new concept, taking customers from a previously unrelated market (Hopp et al., 2018).

Bower & Christensen (1995) presented a solid starting point for DI, and there have been researchers who have adopted the definition or have challenged their theory. The disruptive innovation theory definition, collated and interpreted by multiple scholars (Christensen & Raynor, 2003; Downes & Nunes, 2013; Govindarajan & Kopalle, 2006; Paetz, 2014; Veryzer, 1998) for this research, and used for research participants to anchor a focal thinking point, was:

a product and/or market phenomenon that disrupts traditional market linkages by broadening and developing new markets and providing the functionality to potential customers

This definition will be used as the primary definition in the data collection of the study. Another perception included one by disruptive innovation thought leader, Tony Seba; who has the view that a disruptive product or service will help create a new market or network and weaken or destroy an existing product or market category (Seba, 2014). Another aspect of disruptive innovation that appears to be framed as discontinuous innovation is that the innovation may involve dramatic leaps in terms of familiarity and use, requiring behavioural changes by users to utilise the innovation (Kaplan, 1999; Veryzer, 1998). Disruptive innovations describe that the rules of the game have changed, breaking from past practices, and allowing industries and markets to emerge, transform or disappear. They can help companies rewrite industry rules or create entirely new industries (DeTienne & Koberg, 2002). Others present an interesting take on the theory as they see disruptive innovation as something that changes social practices in the way we live, work, and learn. Some innovations' capabilities can be easy to predict, but it is nearly impossible to predict how disruptive innovations will shape social practices (Hendry et al., 2003). Wördenweber & Weissflog (2005) summarise disruptive innovation neatly, as disruptions experienced today are both destructive and creative; taking opportunities away and offering new ones while undoubtedly moving us forward, looping back to Schumpeter's initial theory.

Notably, several scholars have focused on disruptive innovation from an established company's perspective (Bower & Christensen, 1995; Callaway & Hamilton, 2006; Charitou & Markides, 2003; Christensen, 1997). In many cases, disruptive technologies were first developed within established leading firms, using bootlegged resources. It was found that their current customers were not interested

in the change to their systems and that the niche market was too small for a firm of their size (Christensen, 1997). Although these large companies have substantial resources, and financial and technical, experience, an emerging entrepreneurial company usually introduces a disruptive innovation and transforms the industry. It is noteworthy that the study by Sood & Tellis (2011) identifies that contrary to extant theory, technologies introduced by Christensen's "from below" approach are introduced as frequently by incumbents as entrants cheaper than the old technologies and rarely disrupt firms. This is seen when large companies form skunkworks to focus a team on a particular technology in a pre-defined area.

Up until DI became popularised by Christensen (1997), business executives were unsure of what they were dealing with, such as the cases when Amazon Inc. and Ryanair entered their respective markets and grabbed a huge slice of the market before the incumbents knew what had occurred or how to counter the threat. As the theory has developed, other models of disruption have become apparent beyond Christensen's model. The theory was then applied by Christensen and Raynor in 2003 to 77 cases to illustrate the effect of disruptive innovation theory and how each case was affected by DI (Christensen & Raynor, 2003).

There appear to be three distinctive views on disruptive innovation that stand out as models presented in Table 2. Firstly, Christensen's model of attack from below or new niche markets as previously detailed above. Secondly, disruption from above, when superior products and services are much more capable and higher-priced than what the existing markets provide. They enter the most demanding market segment, but their technology cost curve is on a faster downward trajectory towards the mass market, as seen with the digital camera's advent (Carr, 2005). Finally, big-bang disruption, which Christensen & Raynor (2003) and Yu & Hang (2010) refer to as destructive innovation. An innovation that starts with superior performance, lower price and more customisation; a complete game-changer such as the introduction of Google Maps (Downes & Nunes, 2013). Utterback & Acee (2005) express that for Christensen only to focus on the attack from below, ignores other possible aspects that may be of equal or greater importance. Disruptive innovation's true importance does not lie only in displacing established markets but instead, as a powerful way to extend and develop markets and provide new functionality (Govindarajan & Kopalle, 2006; Yu & Hang, 2010). Perhaps, the cases of attack from below have a greater potential for explosive growth than those of attack from above, but all models present dramatic market expansion signs. Utterback (1996) describes how disruptive innovations that expand markets will come from outside the industry, for all three models. Disruptive innovations can have a devastating impact because the firms that first commercialise choose not to remain within their initial value network.

Table 2. Models of Disruptive Innovation

	Performance	Cost	Convenience	Displacement
From below ¹	-	-	+	+
From above ²	+	+	-	+
Big-bang ³	+	-	+	+

1 - (Christensen, 1997); 2 - (Schmidt & Druehl, 2008); 3 - (Downes & Nunes, 2013)

Schmidt & Druehl (2008) attempted to clear the confusion around disruptive innovation by using the alternative terms of low-end and high-end encroachment. The use of encroachment conveys, for example, that a new product takes sales away from the old product. This implies that a disruptive innovation ultimately impacts the existing market but does not necessarily displace it (Schmidt & Druehl, 2008).

There does not appear to have been any extensive research into the features of disruptive innovation to what makes a disruptive innovation. Studies involving disruptive innovation, such as the three models presented in Table 2, have typically described the characteristics presented as a definition for their study or are vague to the level of performance, price point, and convenience (Christensen, 1997; Christensen & Raynor, 2003). Charitou & Markides (2003) identify that disruptive innovation shares a couple of characteristics: the emphasis on different product or service attributes and generally introduced by small, low-margin businesses, hence why large established firms ignore them. Secondly, management recognises that they can grow to capture a large share of the market. One paper by Bloodworth (2012) examined the linguistic markers for disruptive innovation characteristics in the Information Technology industry and found comparable results to the characteristics that have been retrieved through the literature under review. This is the most related study of the proposed research but is still distant. Ali (2004) purports that for an innovation to be disruptive, it needs to have one or more of the following characteristics: create an entirely new set of performance features, improve performance by 5x or more, or significantly reduce cost (30% or more).

The studies that have been conducted that consist of headings such as characteristics of disruptive innovations do not give in-depth information on the characteristics but define that they involve a change in consumption. A pertinent aspect is that innovation could have little to do with technology. Disruptive innovation may or may not represent a technical breakthrough. Instead, it may simply involve introducing a new product or service or changing a firm's business model to capture untapped markets (Crockett et al., 2013). The extent to which an emerging customer base and not the existing customer

base perceive value in the innovation at the time of its introduction is critical. Disruptive innovations generally make it possible for the emergence of new markets (Christensen, 1997). There has been a very general approach by Keeley et al. (2013) to creating more innovative companies by encouraging everyone to innovate. This is supported by their efficient use of innovation tactic cards, which use different structures and strategies for what they describe, the Ten Types of Innovation (Keeley et al., 2013). A summary is included below as these categories and tactics cards will be utilised to provide a thinking basis for features and strategies. Many practitioners may be employing such strategies but do not know the technical or academic term that fits them.

In their groundbreaking work, Keeley et al. (2013) introduced the Ten Types of Innovation framework, a comprehensive model designed to guide organisations in systematically exploring and implementing innovation across various dimensions. This framework categorises innovations into three main groups: Configuration, Offering, and Experience, each comprising distinct types that contribute to overall organisational innovation.

The Configuration category encompasses innovations that pertain to the internal makeup and strategic positioning of a company. The Profit Model type involves reimagining revenue generation through novel pricing models, cost structures, and margin capture strategies. Network innovation focuses on external relationships, encouraging organizations to leverage partnerships and collaborations for enhanced innovation outcomes. Structure innovation delves into internal organizational dynamics, prompting shifts in processes, systems, and hierarchy to foster a culture of innovation. Process innovation seeks to optimise operations, introducing efficiencies and novel approaches.

The Offering category revolves around innovations directly related to the products and services provided by an organisation. Product Performance, within this category, emphasises improvements to core features and functionalities, ensuring superior value delivery. Product System innovation involves bundling products or integrating them into comprehensive systems to create a more holistic and differentiated offering. Service innovation centres on augmenting existing products with enhanced services, encompassing customer support and delivery mechanisms.

The Experience category addresses innovations related to how customers interact with the company and its offerings. Channel innovation examines the delivery of products and services, exploring changes in distribution channels and retail strategies. Brand innovation goes beyond visual elements, emphasising the creation of a unique and compelling identity that resonates with customers. Customer Engagement innovation focuses on improving customer interactions through innovative marketing and service touchpoints.

By systematically considering these ten types of innovation, organisations can develop a holistic and effective innovation strategy that extends beyond product-centric approaches. This framework encourages a multifaceted exploration of innovation, prompting organizations to assess various aspects of their business to foster sustained and impactful innovation outcomes (Keeley et al., 2013).

It has been speculated that the internet, biotechnology, alternative energies, and stealth technologies are disruptive because they allow their users to break away from the mainstream. These technologies also provide their users with an advantage not found elsewhere (Seba, 2014; Wördenweber & Weissflog, 2005).

Christensen's disruptive innovation theory has not been without challenges, several publications have questioned the theory that has been described in *The Economist* as one of the most influential modern business ideas (*The Economist*, 2011). While others have commented that due to the theory being so widely accepted, its predictive power is rarely questioned (Lepore, 2014). Some point out that weaknesses have been found over time in disruptive innovation research. The challenge is that the central thesis appears to be tautological. The theory is ambiguous about which domain of disruption the theory applies, technology, firm, or demand domain. It has been pointed out that there is a scarcity of empirical evidence to validate the claims of generalisability. The theory lacks the predictive ability, thereby instigating cherry-picking or luck as an alternative explanation (Danneels, 2004; Markides, 2006; Sood & Tellis, 2011). Yu & Hang (2010) purport that disruptive innovation is developed from the market perspective in contrast to the company perspective, which looks at competence enhancing and destroying factors, initially presented by Tushman & Anderson (1986). King and Baartartokh (2015) ask the question of how useful is the theory of disruptive innovation and investigated applying Christensen's original thinking to the same 77 cases listed in the 2003 book, *The Innovator's Solution*. They found that only a handful of the 77 cases listed corresponded well with Christensen's core four elements of disruptive innovation theory. The four elements that King and Baartartokh identified were (1) incumbents move along a sustaining innovation trajectory, (2) overshoot customer needs, (3) have the capability to respond to disruptive threats and (4) incumbents end up floundering as a result of being disrupted (King & Baartartogtokh, 2015). They found that sustaining innovation can be too slow to meet growing customers' needs that would appear to be insatiable. While many of the cases can respond, sometimes there are fundamental structural barriers in technology, infrastructure or laws that prevent them. King and Baartartokh do finish up by stating that they do not advocate discarding the theory of disruption but recommend using its best parts in addition to classic business strategic analysis.

Biotechnology appears to have not been a focus of DI at this stage. Sandberg (2002) examined the market proactiveness of launching what they deemed to be a disruptive innovation. They have a

relatable view on disruption to that of the from-above model, involving significant new technologies that require a considerable change in consumption patterns and the perception of markedly enhanced benefits. They found that the market is rather conservative overall towards changing its consumption habits. To increase awareness and support, opinion leaders, university professors and visionary practitioners were targeted. Another study looked at applying Christensen's principles of disruptive innovation to the medical device industry. The characteristics of over-performing, which is one of the more influential aspects of the theory were found to be negligible. Even if the technology was significantly more expensive, a physician might choose to use the expensive technology if it garnered a slightly better patient outcome (Berlin, 2011).

Several inhibitors to disruptive innovations are put forward in the study by Assink (2006) investigating why large firms often fail to develop disruptive innovations. Findings detailed that large firms could not unlearn obsolete mental models, a successful dominant design or business concept, a risk-averse corporate climate, innovation process mismanagement, lack of adequate follow-through competencies and the inability to develop mandatory internal or external infrastructure (Assink, 2006). Many great ideas are disregarded and not implemented because of the lack of understanding of where innovation fits the most profitable customer. They, indeed, initially cannot use products based on disruptive technologies (Christensen, 1997). A problem that potentially disruptive innovation companies face is that if the innovation differs too much from their current practices, it can often be "experienced as throwing a wrench into a smoothly running machine and those who are responsible for running it will not appreciate it" (Wördenweber & Weissflog, 2005, p. 37). It is suggested that a key reason for companies' failure to implement a disruptive innovation is the popular management dogma of staying too close to their current customers (Bower & Christensen, 1995; Christensen & Raynor, 2003).

Disruptive innovations create a considerable amount of uncertainty, making it difficult to distinguish what information matters (Callaway & Hamilton, 2006). Would-be disruptors need to build an organisation that is capable of serving new customers. It is essential for companies to abandon their habits with the established market and to let the new customers dictate the business model by which they can be profitably served (Gilbert, 2003). It would seem that innovation needs to add to the human experience of new pathways and only fulfils its position as a disruptor when it crosses the chasm from gimmick to the mainstream when most users accept it (Wördenweber & Weissflog, 2005). In the long term, every disruptive innovation will lose the lustre of being disruptive, and something else will take its place. However, the opening of new markets and applications for satisfying human needs and wants will have been achieved (Wördenweber & Weissflog, 2005).

As evident, there have been some studies into disruptive innovation but not much research into the features that characterise the development or implementation of disruptive innovation. The general features that have been identified have been related to the cost and overall performance of the innovation relative to the mainstream incumbent. The theory that addresses factors internal and external that may constrain or enhance a firm's ability will be handy in a dynamic and uncertain environment.

2.2 NEW ZEALAND AND BIOTECHNOLOGY

There are several reasons for studying the New Zealand biotechnology industry. While there is a large and growing international literature on biotechnology innovation's economic aspects, these studies concentrate on the United States of America (US) and Europe. Little has been written in New Zealand or similar countries that incorporate a knowledge society. Biotechnology touches nearly every aspect of our daily lives, from the clothing we wear, the fuel we use, the food we eat, and the medicines we take. As we will see, biotechnology itself "is an umbrella term that covers various techniques for using the properties of living things to make products or services" (Grace, 2006, p. 2). As a small country in the Pacific Ocean, New Zealand is recognised as an attractive country on many world scales for business and lifestyle.

2.2.1 The isolated country

New Zealand, slightly bigger than the United Kingdom, is the most isolated temperate landmass in the world (Walrond, n.d.). The closest eastern neighbour (that is not a Pacific Island country) is Chile, about 9,000 kilometres away and over 12 hours of flying. The US is the most important northeastern economy, and this is about 10,000 kilometres away. The US market accounts for approximately 12% of exports from New Zealand (Workman, 2020). To the west, it would take more than three hours of flying to reach Australia and about 2,000 kilometres. With a population of ~5 million people, some can hardly believe that New Zealand could survive on the domestic market alone and thus its entrepreneurs would immediately become globalised. This has always been a problem when trading and commercialising business interests. New Zealand has a competitive and open microeconomic environment that is reasonably free of distortion, but its relative income has declined over the last 50 years. The real per capita income has fallen from among the highest in the world in the 1950s to under the OECD average in 1970, to 20th in the OECD by 1999 and still sits below the average in 2019 (OECD, 2019).

With no significant natural resources to export, earning first-world incomes and building a vibrant economy, New Zealand must be innovative in everything it does through its difference in products and services. The New Zealand economy needs to have a global reach and not be constrained by being a small country in the southern Pacific Ocean. New Zealand is often compared in its innovative character to Ireland, Israel, and Finland as well as the Scandinavian countries, as these countries are of similarly sized populations and demographics. Figure 3 demonstrates the power of isolation New Zealand faces, by drawing an area circle with a radius of 2200 km around the capital cities of New Zealand (Wellington) and Finland (Helsinki). The Wellington centre captures approximately 5 million people. In contrast, the area centred on Helsinki captures >300 million people from 39 different economies. Critics dismiss that

this distance barrier to other markets is no longer an issue (Frederick & McIlroy, 1999). New Zealand has a similar-sized population to Ireland, Singapore, Israel, Finland, and the Scandinavian countries, but these countries have closer access to various other markets.



Figure 3. Population captured comparison of Helsinki, Finland and Wellington, New Zealand. The area around Helsinki (left) captures almost all of Europe, while the area around New Zealand (right) captures only New Zealand. Note: Topographically, the Helsinki area from the 2200km radius on the left appears oval due to the Earth's curvature compared to the area around New Zealand on the right with the same level of zoom magnification.

For a small country in the southern Pacific Ocean, remote and excluded on most world maps, New Zealand has moved first on social, economic and political issues, such as the right for women to vote, social welfare policies, nuclear-free, and neo-liberalism pushing for free-markets, of which, the latter has likely caused some economic disturbances locally and an external current account deficit and trade imbalance (Frost, 2018; Kelsey, 2015).

New Zealand has a small open economy, which has been modified by an extensive set of institutional and economic reforms, including the transformation of the national science and technology system towards a more market-driven model. The government has indicated a strong interest in fostering innovation and aims to concentrate on selected areas where New Zealand may develop a new comparative advantage. However, the record on investing in innovation and research and development (R&D) has been poor by OECD standards (Raine et al., 2011). One such area is biotechnology, which would build on New Zealand's existing competitive advantage in the primary sectors such as dairy, forestry, meat, wool and horticulture (Frederick & McIlroy, 1999; Marsh, 2000). Today, these are combined with new developments such as tourism, film production, and winemaking. New Zealand depends heavily on international trade, especially with Australia, China, the US, the United Kingdom (UK) and Japan (Statistics New Zealand, 2013). When comparing the gross domestic product (GDP) per

capita of these countries, New Zealand appears towards the wrong end, as seen in Table 3 with its important trade partners, excluding China.

Table 3. OECD GDP comparison. (OECD, 2019)

Country	GDP 2019 per capita (USD)
US	\$65,127
Australia	\$54,752
UK	\$48,092
New Zealand	\$43,746
Japan	\$42,486

The statistics surveys show that the New Zealand economy consists mainly of small enterprises, which comprise fewer than 20 employees and form approximately 97% of enterprises, making up a significant proportion of the over 11,000 companies exporting out of New Zealand (Ministry of Business, Innovation & Employment, 2017). They have found that the smaller the business, the lower the survival rate, with less than 50% of SMEs surviving more than ten years. Even fewer of these companies are reporting increases in their profitability (Statistics New Zealand, 2013). The definition of enterprise size is dependent on the specific country, although many utilise fewer than 250 employees to represent small-medium enterprises (as well as micro) (Ayyagari et al., 2007).

In the World Economic Forum 2018 report, New Zealand is ranked in the top five out of 140 countries in four economic pillars (categories). It was ranked first in institutions and macroeconomic stability, and fourth in the product market and the labour market, leading to an overall economic ranking of 18th (World Economic Forum, 2018). In the 2018 Global Innovation Index (GII) report, New Zealand is ranked 22nd out of 126 countries evaluated (World Intellectual Property Organization et al., 2018). New Zealand appears naïve at harnessing the value potential of creative endeavours in STEM (science, technology, engineering and mathematics) activities and appears to be more intent on sharing knowledge than converting knowledge to prosperity. The GI report ranks New Zealand in 63rd, behind Senegal and Bulgaria, for high-tech and medium-high-tech output.

For New Zealand, innovation and ingenuity are an integral part of the Kiwi national culture. The conditions of early settler life in New Zealand promoted a certain kind of eccentric experimentation leading to Kiwis often being highly regarded in the fields they chose to enter. Often known in New Zealand as Kiwi ingenuity, that can-do attitude, give it a go, number eight wire mentality or black magic;

New Zealanders are filled with it, summed up famously by Sir Ernest Rutherford as "We haven't the money so we must think" (Frederick, 2005; Frederick & McIlroy, 1999; Ministry for Culture and Heritage, 2021). Today, the current problem is that ideas, inventions, and innovation/ entrepreneurship are not the same things. An invention stemming from an idea is something new that has the potential of changing relationships. New Zealanders are great inventors. Nevertheless, an invention uncommercialised becomes an innovation wasted. New Zealanders are poor at translating ideas and inventions into commercial products through various means (Frederick & McIlroy, 1999).

Innovation in New Zealand is occurring, but not at the rates many, including the government, desire. Following a study of the economic position of New Zealand in 2009, it was identified that the IT industry had the highest rate of innovation but only contributed to 5% of the GDP. The second most innovative industry was manufacturing, which contributed the most to the GDP at 14%. Quite strikingly, the industry for which New Zealand is renowned, the primary industry, had one of the lowest innovation rates and only contributed to 5% of the GDP (Hong, 2013). The book, *Get Off the Grass* by Professor Shaun Hendy and Sir Paul Callaghan illustrates this point by discussing the innovation environment in New Zealand and the change in focus that needs to occur (Hendy & Callaghan, 2013). A large number of government incentives, including funding, although much lower R&D expenditure to OECD countries is provided to crown entities or other private research facilities for R&D, it has been found that R&D intensity has no significant impact on the probability of observing innovations (Hendy & Callaghan, 2013; Hong, 2013; Rinne, 2011). The total R&D expenditure for the country in 2020 totalled \$7.2bn and business-only R&D expenditure in 2021 totalled \$2.8bn (Statistics New Zealand, 2021, 2022). Hendy and Callaghan (2013) comment on the 2003 OECD Economic Surveys: New Zealand, noted, "The mystery is why a country that seems close to best practice in most policies that are regarded as the key drivers of growth is nevertheless just an average performer" (2013, p. 17). Arguably then, there is a disparity between what many New Zealanders recognise as good ideas and their ability to build them into scalable businesses, capable of being taken further afield (Hutcheson, 2015).

It could be that several factors and behaviours are leading to the underperformance of innovation efforts, which could be linked to the national culture such as the Kiwi lifestyle of the 3B's, the bach (holiday home), boat and BMW, or satisficing (Frederick et al., 2007; Smale, 2008). Other factors can include the narrow capital structure, making it difficult to fund an operation adequately, tall poppy syndrome, against the specialists and the emergence of champions. The limited-time horizon for outcomes (short-sighted), low assertiveness and negative attitudes to failure lead to a reluctance to attempt such tasks (Frederick et al., 2007; Raine et al., 2011; Rinne & Fairweather, 2011; Smale, 2008).

2.2.2 The untapped fountain

Biotechnology has become an important industry to supplement the pharmaceutical industry recently. However, many would not recognise that it is not new; biotechnology is one of the oldest forms of human technology. Breeding of certain plants and animals through selective breeding and organisms to make bread, wines, beers and cheese has occurred for thousands of years (Bhatia & Goli, 2018; Science Learning Hub, 2010). The newer methods and structures created can be immense if utilised appropriately.

Traditional biotechnology has now been distinctively reborn as modern biotechnology. As humans have harnessed traditional biotechnology such as bread, cheese, beer and winemaking, biotechnology is seen as new. Only recently has it become more frequently used in the era of modern biotechnology. In this research, the term biotechnology is used for everyday use from the OCED, (2021):

“the application of science and technology to living organisms as well as parts, products, and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.” (OECD, 2021)

France & Gilbert (2006) assert that to communicate about the appropriate use and development of biotechnology, perceptions and understandings of the nature of technology itself are required. In a review of many definitions for technology, McRobbie et al. (2000, p. 81) identified five definition aspects that lead to understanding technology:

1. a human dimension, with a purposeful activity by individuals that entrepreneurs can promote;
2. a social dimension, so that it is used and implemented by society in which it affects society;
3. a process that involves doing, making, and implementing materials, design, expertise and knowledge to solve problems;
4. it is situated, where it is conducted within contexts and constraints; and
5. leads to the development of products or artefacts.

Part of the problem is genuinely defining the biotechnology industry because technological innovation makes it more challenging to define industries within well-defined boundaries. There is a view that meta-industries are forming where technologies are cross-platforms that are transversal and pervasive, as is seen with biotechnology (Onetti & Zucchella, 2014).

The original documented term of biotechnology first appeared in literature in 1919 by Karl Ereky, a Hungarian researcher. He used the term to refer to "all the lines of work by which products are produced

from raw materials with the aid of living organisms" (Bud, 1989, p. 231). Since then, it has undergone many transformations to encapsulate a broader meaning toward recent developments. At its simplest, biotechnology is technology based on biology. From that perspective, the use of biological processes is hardly noteworthy (BIO, 2021). The use in growing crops and raising animals, making bread and cheese does not sound very exciting, so why has biotechnology garnered so much attention. In the last 40 years, biotechnology has gone from practising at a macro level to working with it at a micro level. Some have portrayed it as the practice of manipulating living organisms (Barnum, 2005). However, biotechnology has developed to be much bigger than just the manipulation of living organisms. One of the many modern definitions of biotechnology would be the use of cellular and biomolecular processes to solve problems or make useful products (BIO, 2021). The OECD developed single and multi-point definitions for biotechnology and made it deliberately broad, "the application of science and technology to living organisms as well as parts, products, and models thereof, to alter living or non-living materials for the production of knowledge, goods and services" (p.11). New Zealand utilises the definition through Statistics New Zealand (2010) and many other countries, including Australia, Ireland and Finland (France & Gilbert, 2006). There is a common theme that is delivered by many of the definitions with slight variations such as involving the use of techniques and practices using living things or their derivatives to solve problems and make products through novel items, modifications and improvements for specific uses (Ministry of Research, Science & Technology, 2003; Vereinte Nationen, 1993).

2.2.3 The colours of biotechnology

The biotechnology industry is a commonly used term. However, biotechnology refers to a collection of related scientific disciplines and branches with distinct applications in several areas such as healthcare, agriculture, and industrial processes. Biotechnology's outputs in these sectors may be physical products, intellectual property (IP) or services (Saviotti, 1998, p. 19). These applications or branches can be applied to a colour system that was developed in the early 2000s. There are three colours at the core of biotechnology, red for medical applications, green for agricultural and white for industrial (DaSilva, 2004). Looking at the broader meaning of biotechnology, an illustration of 10 colours for biotechnology is used to create the complete picture, seen as a summary in Table 4.

Table 4. The colours of biotechnology (from DaSilva (2004) and Kafarski (2012))

Colour	Area of Activity
Red	Human health, medical, diagnostics
Green	Agriculture, animal health
White	Industrial processes
Blue	Marine, aquaculture, coastal
Yellow	Food, nutrition
Grey	Classic fermentation
Gold	Bioinformatics, nanobiotechnology
Brown	Desert, arid zones
Violet	Legal, patents, publications
Black	Bioterrorism, biowarfare

Red biotechnology contains applications primarily for human health. This includes products for medicines or diagnostics that consist of or have been produced in living organisms, diagnostic tools for testing and treating genetic diseases, new and improved vaccines, research into the causes of serious diseases, new drug development, medicaments and cosmetics (DaSilva, 2004; Kafarski, 2012). This area is crucial to human well-being and quite profitable.

Green biotechnology consists primarily of applications for agricultural and animal health such as the use of environmentally friendly solutions for agriculture, horticulture and animal breeding processes, vaccines and diagnostic tests for animal diseases, identification of the source of valuable traits in animal species, confirmation of pedigree stock and plant cultivars, crops resistant to disease, research and screening of safe and effective pesticide and fertiliser products, biological control agents to manage pests and improved grape cultivars for wine production (DaSilva, 2004; Kafarski, 2012).

White biotechnology is known as industrial biotechnology and involves enzymes and microorganisms to make biobased products for chemicals, food, detergents, textiles and bioenergy (DaSilva, 2004; Kafarski, 2012).

Blue biotechnology is focused on the marine environment and organisms in molecular biological methods to marine and freshwater organisms, improving water quality, aquaculture, fish health and nutrition, aquatic animal reproduction, pests and disease control (DaSilva, 2004; Kafarski, 2012).

Yellow biotechnology encompasses food and nutrition, screening and identifying natural products for health supplements, creating new foods, nutritional science and nutraceuticals (DaSilva, 2004; Kafarski, 2012).

Grey biotechnology is seen as the classic biotechnology in fermentation in the production of wine, bread or beer (DaSilva, 2004; Kafarski, 2012).

Gold biotechnology is a relatively new and growing sector that involves bioinformatics associated with computer science, chip technology and nanotechnology (DaSilva, 2004; Kafarski, 2012).

Brown biotechnology is focused on applications involved with highly resistant and challenging conditions such as desert soils in Africa (DaSilva, 2004; Kafarski, 2012).

Violet biotechnology is described as a unique sector as it involves the legal aspects of biotechnology and the regulation and ethical implications of biotechnology (DaSilva, 2004; Kafarski, 2012).

Black biotechnology consists of the aspects related to the production of biological warfare bioterrorism, and counter-terrorism (DaSilva, 2004; Kafarski, 2012; Simon & Giovannetti, 2017).

2.2.4 Global biotechnology

The modern biotechnology industry emerged in the 1970s from the introduction of the recombinant DNA technique by Stanley Cohen of Stanford University and Herbert Boyer of the University of California, San Francisco. Recombinant DNA is a method of making proteins, such as human insulin and other therapeutics, in cultured cells under controlled manufacturing conditions. Boyer co-founded Genentech; the first biotechnology company specifically founded to commercialise biotechnology products and services (Marsh, 2003; Orsenigo, 1989, p. 37; Rabinow, 1996; Sammut, 2012). While the oldest biotech companies are approaching 50 years old, the oldest pharmaceutical and chemical company globally is Merck KGaA, 350 years old, founded in 1668. However, it is essential to note that the distinction between biotechnology and pharmaceutical companies has become blurred as the methodologies employed in discovering, characterising, and developing products, in turn, utilise modern biotechnologies. Colloquially a 'biotech company' is often used to refer to smaller, younger companies in drug development (even if they are developing chemical-based drugs) and a 'pharmaceutical company' is used to describe the larger, well-established companies. Even though most

of them now develop biological drugs and small-molecule chemical drugs (Arora et al., 2009; Dunlap-Hinkler et al., 2010; Pisano, 1994).

Being able to pinpoint consistent global data has been a question for most researchers and statisticians due to the varying definitions, and boundaries placed on biotechnology and the lack of data in the case of private biotechnology companies (Carlson, 2016; Marsh, 2003). An analysis attributed the global biotechnology industry with total revenues of ~\$420 billion (bn) in 2018, representing a compound annual growth rate of 8.5% between 2014 and 2018 and this revenue was expected to reach ~\$600bn by 2023 (MarketLine, 2019b). Another study found that biotechnology companies produced ~\$137bn in revenue in 2018 (Morrison & Lähteenmäki, 2019). The two main biotech markets are medical and agricultural. The medical segment has revenues exceeding \$240bn annually, where the division occurs and includes companies that could also be classified as pharmaceutical companies (MarketLine, 2019b). The medical segment has become more lucrative as the global population ages, adding pressure for new drugs to be researched and developed to treat old-age conditions.

There has been no clear indication of the total number of biotechnology organisations in the world. The OECD utilised surveys and key biotech indicators from various countries and found approximately 15,000 companies from 26 countries (IBISWorld, 2021; OECD, 2021). There have been attempts to extrapolate the data and estimate the number of total biotechnology companies around 25,000 (Friedman, 2007). From the publicly available data, there were 572 publicly traded companies in 2015, which grew to 671, employing over 230,000 people in 2018 (IBISWorld, 2021; Morrison & Lähteenmäki, 2016, 2019). In 2018, only 29 companies were identified as large-cap (>\$5bn) companies and were the only profitable group combined. The remaining 642 companies were spread across 86 mid-cap (\$1bn-<\$5bn), 147 small-cap (\$0.25bn-<\$1bn) and 409 micro-cap (<\$0.25bn) companies, all of which produced losses for their respective combined grouping.

The United States (US) is the largest biotech industry, accounting for greater than 48% of the total value in 2018. As a result, its performance weighs heavily on the global industry, especially in the public markets making up around 75% (Statista, 2018; Vuleta, 2021). The US application is very broad and includes healthcare, food and nutrition, agriculture, industrial, and environmental industries. It is one of the fastest-growing sciences and industries in the US and facilitates expansion and development in an unprecedented number of areas. Whilst the early to late 1970s saw the formation of approximately 20 US biotech start-ups per year, from 1980 to 1987, that number jumped to around 75 companies per year (Ernst & Young, 2006). The number of US companies varies from reports between about 2,000 to over 10,000 (Crunchbase, 2022; IBISWorld, 2022; Vuleta, 2021). US biotech sector revenue is estimated to have grown on average >10% each year over the past decade, much faster than the rest of the

economy (Carlson, 2016). The United States has by far the most dynamic financing environment for biotechnology, with a deep and experienced group of venture capital investors and a public market characterised by pools of institutional capital and investors that possess a higher risk appetite for research and development stage investments (Simon & Giovannetti, 2017).

Biotechnology is one of the most research-intensive industries in the world. The US publicly traded biotech companies spent \$27.1bn on research and development in 2006 and more recently, in 2016, spending \$38.8bn (Ernst & Young, 2006, 2017). There have been periods throughout the last 35 years when most investors said biotechnology was not delivering the expected financial returns or even acceptable returns. Even in recent times, from early 2001 through early 2003, 2005, and 2008 through early 2010, the sector has struggled. If a measure of the US biotechnology financial performance was compared against individual companies such as Merck or Pfizer's performance. It may be concluded that the industry has performed poorly from a financial perspective. The \$40bn accumulative losses highlighted in 2004 by the Wall Street Journal support this view (Burns, 2012; Hamilton, 2004). Pisano (2006) took all the financial information of the publicly listed biotech companies worldwide and compiled the information into one sheet to make one global biotech company. His analysis showed that over 20 years, the revenue grew exponentially, but the operating income was about zero or slightly negative in some years. When Amgen, the largest company at the time, was removed, the entire industry lost money over its lifespan for the public companies, which are supposed to be in better financial standing than the private biotech companies.

Spain is recognised as the second-largest player in terms of the number of identified organisations with over 2,500, followed by France with about 2,000, Korea with just under 1,000, Germany with about 750, Australia, Japan and the United Kingdom following suit with about 500 companies (OECD, 2021).

China is home to over 20% of the world's population, this area has started seeing the largest growth and development steps. As of 2004, there were about 500 biotechnology companies in China, employing more than 50,000 people. Due to the large country size, many companies may focus only on the domestic market (Frew et al., 2008; Zhenzhen et al., 2004; Zhou, 2008).

Germany has a strong biotechnology history, with over 600 dedicated biotechnology companies in 2017, with a narrow definition. According to BIO COM 2016 report, investment exceeded €650 million, employing over 25,000 people, turning over €3.5bn in sales and displaying steady growth. This is dominated by health/medicine, making up nearly 50% of the German industry, with agricultural only 3.2% and industrial 10.1% (Wirsching et al., 2016).

Until recently, Japan's biotechnology market was the second largest in the ranking (JETRO, 2007; open to export, 2016). Japan has one of the oldest and fastest-aging populations and faces an increasing number of chronic and long-term diseases (Muramatsu & Akiyama, 2011). The revenue generated by the Japanese biotech companies exceeded \$37bn in 2018, with the environmental and industrial segment accounting for nearly 40% (MarketLine, 2019a; Motohashi, 2012).

Australia is New Zealand's closest neighbour and has been developing its biotech industry steadily. Australia has around 540 biotech companies including 140 public companies, employing over 16,000 staff and includes medical device companies due to the incorporation of biosensors (Commonwealth of Australia, 2022; Herpin et al., 2005; KWM, 2019; Nogrady, 2018). The buoyancy of the Australian biotech industry lately is heavily skewed by CSL Limited's success, Australia's largest and most successful biotech company. Starting as a serum laboratory during World War I, it has adapted and taken different directions leading to its success in the life sciences area. There are 102 publicly listed Australian pharmaceutical, biotechnology and life sciences companies, with a total market cap of approx. \$150bn, of which CSL Limited accounts for \$134bn (90%) as of September 2020 (StockLight, 2020). The Australian biotech industry consists of 69% being focused on health and biomedical segments, and there have been emerging developments in agriculture and industrial applications, particularly the food segments (Commonwealth of Australia, 2022; Nogrady, 2018). However, another report by Thornton has broadened the definition to include all aspects of life sciences and indicates that there are more than 1,600 organisations and 230,000 employees. This industry is substantial, but the business sentiment is pessimistic due to government support's recent removal (AusBiotech, 2019). Australia was not a thriving biotech industry until the 2010s when a string of successful deals was made amounting to over ~\$3bn, but this was not always the case. Before these deals, only one company had successfully commercialised its drug product. A picture of the global industry is presented in Figure 4, from completed OECD surveys, therefore the actual number may be far more significant for each country (OECD, 2016).

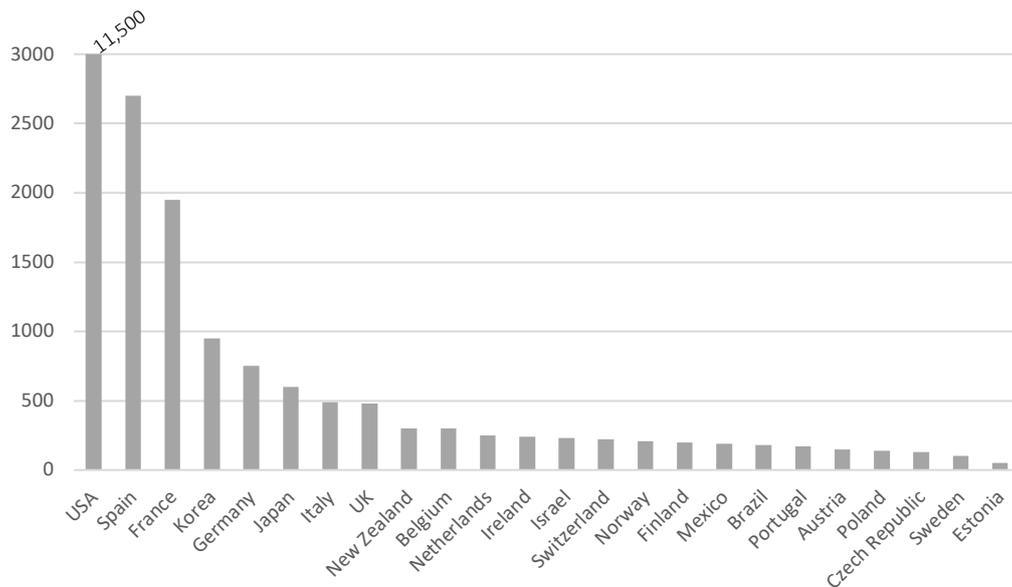


Figure 4. Biotechnology companies identified per country (adapted from OECD 2016 data)

The most prominent players in the broad sense of the biotechnology definition that intersect life-sciences and other healthcare parts are Johnson & Johnson, Roche, Novartis, Merck & Co., and Pfizer with a combined value of over \$1,354bn and doing revenue of \$290bn in 2019. In a more refined term towards dedicated biotechnology companies, the leading players are Amgen, Gilead Sciences, Bayer, Biogen and Illumina, with a combined value of \$408bn and revenues over \$111bn for 2019 (MarketLine, 2019b). These large biotech companies that cross the boundary with pharma companies are typically public companies with shareholder's eyes on them expecting revenues and growth. They also do not want to wait for an entire cycle before an innovation produces revenue, therefore, these large companies seek acquisitions of smaller biotech companies in new therapeutic areas to keep them as the market leaders (Evens & Kaitin, 2014; Salle & Thomas, 2020).

2.2.5 New Zealand biotechnology

Despite the small size of the local economy, New Zealand science has had a significant role in the biotechnology revolution. A New Zealander contributed to modern biotechnology's birth through the first description of the structure of DNA by biophysicist Dr Maurice Wilkins, who was later jointly awarded the Nobel Prize with Crick and Watson. However, this did not appear to invigorate the country to explore these avenues locally. Until the late 1980s, for six years from 1984 to 1991, New Zealand engaged in "one of the most radical market liberalisation programmes initiated anywhere in the world" (Massey, 1995, p. xii), "transforming New Zealand from the most to the least regulated economy in the OECD" (Hazledine, 1998, p. 1). Until 1999, a new Labour government had neither large-scale policy interventions designed to increase R&D spending nor major funding initiatives to promote

biotechnology. The biotechnology task force report in 2003 presented that New Zealand has significant strengths in large animal biology, as well as having world-class research teams in several areas of biomedical science and bioengineering.

The NZBio organisation (now rebranded and organised as BioTechNZ) and Statistics New Zealand produced bioscience and biotechnology surveys in 1999, 2004, 2005 and 2007, followed by a broader survey in 2009 and 2011. Marsh (2003) conducted multiple surveys to build upon the early surveys conducted, but excluded many companies from the data because these companies were not well suited to a study of innovation as they tended to exhibit low innovation rates. Marsh focused only on companies that conduct R&D. BioTechNZ carried out a data collection in 2020, published at the end of November 2020 (BioTechNZ, 2020; Statistics New Zealand, 2001, 2005, 2006, 2010, 2012). According to the most recently published data about the New Zealand biotech industry from the BioTechNZ survey, there were 211 companies identified albeit utilising the narrow definition of a core biotech firm (conducting R&D) compared to the broader definition used in the Bioscience Survey of 2011, where there were 474 organisations identified as bioscience companies or involved with aspects of bioscience or 147 core biotech companies (Statistics New Zealand, 2012). This number grew substantially compared to 2009 with only 267 organisations or 108 core biotech companies, which was also up from the 2007 survey numbers of 168 organisations dominated by agriscience-based companies (BioTechNZ, 2020; Statistics New Zealand, 2010). The identities of these companies have not been disclosed in the Statistics New Zealand surveys.

From 2011 to 2020, the predominant areas of focus have been human wellness and animal-based biosciences. This appears to have changed from the prior survey conducted in 2009, where the dominant areas were food and human nutrition and human biomedical science and drug discovery. The Auckland and Northland region had the largest number of bioscience organisations with 37% of companies, followed by Wellington with 18%, Christchurch and Dunedin with 6% each in the most recent survey and about 45% are based in regional locations (BioTechNZ, 2020). This is also evident in the size of the companies, with 67% having fewer than 10 employees and less than 10% having greater than 100 employees. Total bioscience revenue has increased to \$2.7bn in 2020 versus \$0.7bn for organisations in which bioscience was the primary focus in 2005 (Ross & Ward, 2005). There has been some significant change to the New Zealand biotech industry compared to 2005 when there were six public companies and 47 private companies, as well as 28 university and crown research institutes (Ross & Ward, 2005). It has been recognised that about 30% of surveyed companies are in the early stages of commercial and pre-revenue and most rely on self-funding to operate (BioTechNZ, 2020). Marsh (2003) considered the end-use sector on which companies are focused and found the groups to be identified as food processing, ag-bio, human health, and environmental processes and allowed international

comparisons. The recent BioTechNZ (2020) survey reported that across four sectors, companies are involved in Health 52%, Agricultural 38%, Industrial, and environmental 26% and Marine 11%.

The Scientific American Journal produced a global biotechnology scorecard in 2009 that has since been updated and maintained yearly by thinkbiotech.com. In the most recent scorecard of biotechnology excellence, New Zealand was placed 4th out of 54 analysed countries, trailing the US, Singapore and Denmark but ahead of Australia and Switzerland as progressing biotechnology (BioTechNZ, 2020; thinkBiotech, 2020). The scorecard observed seven categories towards the scoring criteria: productivity, IP protection, intensity, enterprise support, education and workforce, foundations and policy, and stability.

2.2.6 University biotechnology commercialisation

Before the 1980 enactment in the US of the Bayh-Dole Act, there had been limited university research commercialisation. This changed substantially when the Act came into effect allowing researchers to retain invention rights made during federally supported research (Freeman & Dervan, 2011). There is no legislation such as this in New Zealand, but there are patentable rights where students can own the IP, they create but the academic staff and other organisation employees do not have inherent rights to IP benefits. These are managed on an organisation basis. There appeared to be a lack of a pro-business environment, and attitudes to entrepreneurs and risk-takers (Marsh, 2003). The total number of university commercialisation in 2006 created 44 companies, and in 2012, no total number was given, and nothing has been published near 2020 (Te Pōkai Tara, 2012). There are three key players in New Zealand innovation: industry, government, and universities. Placed in this order as most innovation is undertaken by industry, often incrementally. It is the industry that is responsible for the great majority of innovations in any economy (BCA, 2006). Universities are important generators of new ideas and promoters of innovation. They all generally have industry liaisons. This liaison is identified as big business in the US (National Research Council (U.S.), 2013). The relationship is further seen when the US National Science Foundation placed the total university spending towards life-science R&D in 2016 at around \$41bn, of which, ~\$22bn from the government, ~\$10bn from local fundraising and the remainder from state governments and private foundations (Godfrey et al., 2020). The university technology transfer offices try to underwrite future research and meet the community's economic development by generating revenue through licensing of IP to existing companies or spinout companies, of which there was a 10-fold increase from 1990 to 2005 in the US.

Examples of this big business are Columbia University and their recombinant DNA technology patents returning over \$300 million and an affiliate of Harvard Medical School earning \$46 million in licensing revenues in 2003 (Pisano, 2006). In the UK, between 1998-2018, 446 healthcare university spinouts raised £7.4bn of capital (GovGrant, 2021). The New Zealand Government has not provided any specific funding for universities to undertake the commercialisation of research developed at universities. This means that universities with established technology transfer offices have done so using funds available from other sources, most usually general income. Each of New Zealand's eight universities appears to have established technology transfer offices, as seen in Table 5. Six universities operate the office through a separate company and two as units within the university. The perception of the New Zealand science community, from an online survey, is that the University of Auckland is the most effective at spinning out new companies, followed by the University of Otago, University of Waikato and Massey University (Ahn et al., 2009). Those who took part in the study also considered the crown research institutes as the most effective at commercialisation to be AgResearch, Industrial Research Ltd (now defunct), Plant & Food Research, and Scion (formerly the Forest Research Institute).

Table 5. New Zealand university technology transfer offices

University	Commercialisation Entity	Year Founded
University of Auckland (UoA)	Auckland UniServices	1988
Victoria University of Wellington (VUW)	Wellington UniVentures (formerly VicLink)	1992
University of Waikato (UoW)	WaikatoLink	1993
Lincoln University (LU)	Lincoln Research & Commercialisation	1994
University of Canterbury (UoC)	Canterbury Research & Innovation	1999
University of Otago (UoO)	Otago Innovation	2002
Massey University (MU)	Massey Ventures	2003
Auckland University of Technology (AUT)	AUT Ventures (formerly AUT Enterprises)	2005

New Zealand has several strengths in biotechnology and thus would make it an attractive location. There is excellent, robustly regulated and ethically guided science associated with the universities, which is world-class. All eight universities are ranked in the top 3% of all universities (Te Pōkai Tara, 2022). Agricultural applications are world-renowned with the best understanding of sheep breeding and dairy husbandry, and genomic research in apples, kiwifruit, sheep and deer (BioTechNZ, 2020; Te Pōkai Tara, 2022). There is cutting-edge biomedical research at the discovery end of development and a desirable site for clinical trials and some natural clustering of companies and science providers.

2.2.7 A unique entity

The biotechnology industry is an exciting place to study commercialisation strategy because the institutional, situational, and historical aspects of entrepreneurship are peculiar. Biotechnology entities can be spin-off companies based on innovative products or processes resulting from discoveries in university research (Evens & Kaitin, 2015). Such companies have long periods with little revenue and no profit; combined with high fixed costs, they must secure a high degree of capital backing. This may be difficult to obtain given a long time before any return on investment is seen and the relatively high risk that a start-up will not succeed in bringing a new product into the industry (Hamilton, 2004; Pfeffer, 2012; Vanderbyl & Kobelak, 2008).

The biotech sector has unique features, with most firms occupying a position somewhere between university-based research and large pharmaceutical companies (Powell & Owen-Smith, 1998). They typically undertake only a portion of the activities required to bring an offering to market. They rarely have the resources and capabilities that enable full product development and marketing. On top of this, there may be a high degree of technological uncertainty underlying the offering itself. The development process involves high risk, long timeframes, and massive investment. The typical time for the development of a drug is 10 to 17 years, where it can spend 3–6 years getting to the clinical trials, then 6–7 years going through the clinical phases and another 1–2 years of optimisation before officially making the market (Patzelt et al., 2008; Pfeffer, 2012; Pisano, 2006; Vuleta, 2021). The high technological risk means that only around 2–3 drugs reach regulatory approval status for every 100 drug development projects initiated and these in turn usually reflect around 10,000 compounds screened. Conversely, this means that there are 97–98 failures for every 2–3 drugs launched. The R&D cost of roughly US\$0.8–\$1bn for every product that reaches the market, around two-thirds of the cost may be attributable to failed efforts (Northrup et al., 2012; Pfeffer, 2012).

2.2.8 The challenges of biotechnology

For the last few decades, biotechnology has driven the transformation of health, food and energy and has become an essential global industry (Simon & Giovannetti, 2017). Unlike other industries, biotech has not progressed linearly due to the industry's high levels of technological uncertainty and risk. After discovering DNA, it took a further 29 years to launch the first official biotechnology product, Humulin, recombinant human insulin, licensed from Genentech to Eli Lilly (Pavlou & Reichert, 2004).

When discussing the challenges of biotechnology, several topics appear more frequently than others, including the size of the company in relation to its finances and remaining small for an extended period.

Most companies do not have sufficient funds to foster intensive R&D, upscaling and launching into the market that is years away before any proper revenue is generated (BioTechNZ, 2020; Ross & Ward, 2005). Human resources are a challenge on two fronts, as the industry's personnel is specialised, needing an assortment of technical skills as well as international managerial and marketing experience. Some countries display a gap between research-focused academics and industry (BioTechNZ, 2020; Miyata, 2012; Ross & Ward, 2005; Shimasaki, 2014a; Zhou, 2008).

Regulatory hurdles are a significant reason for the slow spread of biotechnologies in healthcare. They are the main reason drug development is expensive and takes many years. These regulatory hurdles also now apply to small molecule drugs, but the hurdles were not as considerable in the pharmaceutical industry's earlier years. A problem with this is that many countries and companies are required to acquire GMP certifications or WHO prequalifications (Zhou, 2008).

In New Zealand, these challenges can be exacerbated for many reasons. As previously stated, the New Zealand market is small, and the distance to markets is significant (Frederick & McIlroy, 1999; Walrond, n.d.). The culture tends to be critical of both entrepreneurial success and failure. There is a poor understanding of commercial and venture capital business drivers, and the culture is generally risk-averse. Difficulties in obtaining capital, as both money and talented personnel, may also constrain start-up or expanding biotech firms in New Zealand leading to a challenge to compete in the international market (BioTechNZ, 2020; Frederick, 2005; Rinne & Fairweather, 2011; Ross & Ward, 2005; Smale, 2008). However, some suggest that the lack of entrepreneurs who can build companies, rather than a shortage of money, is curtailing new companies' development (Springall, 2009). Previously, no venture capital seemed to be available for biotech, and companies relied on traditional funding methods. Recently there has been a marked increase in private-sector funding. At a 1999 venture capital conference in Auckland, one speaker concluded that New Zealand does not yet have a venture capital market. An experienced venture capitalist noted that capital was 30 times harder to raise in New Zealand than in the US (Marsh, 2003). Indeed New Zealand's venture capital and capital markets are significantly less developed than those of the global biotech centres such as San Francisco, Boston, London, Germany and Seattle (Lerner et al., 2005).

2.3 BIOTECH COMMERCIALISATION & INNOVATIVENESS

The biotechnology industry has been identified as a unique business environment compared to many other industries. Science-based companies have unique challenges and, therefore, call for different approaches (Pisano, 2006; Rajamäki, 2008). Throughout the industry's progression, there have been business models, strategies and tactics developed and implemented to commercialise projects. These approaches can also impact the innovativeness and may impact a company's desired outcomes in terms of being successful or a failure.

Although, at a basic level, aspects of a biotech business are no different from any other business, such as the need to secure capital, scarce resources of personnel, financial and intellectual rights have to be allocated to projects with uncertain payoffs (Gans & Stern, 2003b). Pisano (2006) recognises that biotech firms can either commercialise in the product market or the market for ideas. He explicitly describes the choice between vertical integration, from idea to market, and out-licensing, doing some part as a continuum, with many forms of relationships between them with the best strategy depending on the context and conditions (Pisano, 2006). The following section shapes a detailed picture of concepts of biotech commercialisation, from the business models, strategies, tactics, innovativeness, and success.

2.3.1 Biotech business models

Business models are also an area of definable debate, however, aspects are shared across the business model's plethora of perspectives relating to its logic with the way a business entity operates and how it will create value for its stakeholders (Teece, 2010). On one side is Afuah (2018), who reports that business models involve the activities performed, how well, and when it utilises resources to complete the activities to create superior customer value and gain value itself. On the other side is Winter & Szulanski (2001) who perceive the business model as not the activity but the structure connecting the firm core activity towards a specific set of goals. The business model view adopted in this thesis is;

the structure of a company provides the platform to conduct certain activities to achieve several goals, thereby creating value

There are many business model approaches for biotech that have been identified in Table 6 (Shimasaki, 2014b). They may try and take a product to market themselves or sell the idea to another firm that already has the appropriate infrastructure to launch the innovation into the product market (Gans & Stern, 2003b).

Table 6. Biotech business models (adapted from Shimasaki, 2014)

Business Model	Concept	Advantages	Disadvantages
1) Virtual	Organisation outsources most of its activities and owns or leases little, if any physical space, and possesses few full-time employees to keep overhead expenses at a minimum	Extend the time horizon of their operations Requires much less capital while product/s being developed	Typically short term
2) Research Intensive (Out licensing)	Focused only on R&D and license out all their product candidates to other organisations	Lower risk Lower costs	Require strong IPR Potential weak return
3) Drug Repositioning	Find alternate uses or finds a population in which the drug has fewer side-effects and greater efficacy	Reduced R&D timeframe Leverage previous drug safety profile Save costs	Must convince investors that they can reposition a previously failed drug
4) Enabling Technology (Platform)	Focus on a single aspect or segment of the value chain, can use it to enable or improve applications of other company's products	Minimal skill base required as a single focus	Competing companies can reduce the value of your product by providing a more relevant or more valuable product
5) Medical Device Instrument	Develops and markets content that only operates on their instruments, and cannot run on a competitor's testing platform	Captive customer base with continual reoccurring revenue streams	Need to install many devices to acquire sales Desirable content Short life-cycle
6) Clinical Laboratory Services	Perform unique and proprietary tests as a service, operating through a single company-owned clinical laboratory	Shorter timeframe Lower costs Few employees for commercialisation Alternative regulatory path	Testing services can only be performed in one laboratory Specialised employees Laboratory inspection and proficiency testing
7) Subscription	Sell information or access to information and data, that is valuable to other companies	Predictability of ongoing revenue Low revenue risk Receive revenue upfront	Competing technology companies can reduce the value of your service by providing more relevant or more valuable data
8) Fully Integrated Company (Vertically integrated)	The company performs all functions of the business, from the initial R&D drug discovery, animal testing, human clinical testing, regulatory approval, manufacturing, and marketing of all its products	Control all aspects of the development through to the marketing and commercialisation of the product	Enormous amount of: Time, Resources, Capital (and good fortune)
9) Fully Integrated Network	Modified fully integrated company by reducing downstream capabilities to base levels that can be efficiently utilised but can be outsourced beyond that capacity, and eliminating some functions in favour of using CROs	Maintain control Productivity Efficiency Outsource services in the value chain Access to complementary abilities	Required to be well connected (network) Large amount of time Potentially large resources and capital still required

A study from Ryhne (2009) presented that the ideal biotech business model would include the following aspects to lead to success; an effective and cost-efficient product, strong IP protection, product alignment with a large pharma company and a reagent/diagnostic product to provide early cash flow to allow for R&D. While Godfrey et al., (2020) find that the best strategy in terms of return and success for biotech companies especially from universities is for them to be acquired.

2.3.2 Biotech strategies

A company strategy relates to the choice of the business model through which the company will operate in the marketplace. Business strategy is the directional plan of action taken to grow and develop the business (Porter, 1980, 1985). There is an intricate relationship between innovation and strategy, where innovation generally refers to the creation and implementation of new ideas, products, processes, or services that bring about positive change. Strategy involves the formulation and execution of plans to achieve specific goals.

Innovation plays a crucial role in strategy because it enables businesses to differentiate themselves from competitors, adapt to changing market conditions, and create sustainable competitive advantages. By continuously innovating, companies can develop unique products or services that meet customer needs in new and better ways. This can help them gain a competitive edge and attract more customers.

Furthermore, innovation can also drive strategic decisions by opening new market opportunities or allowing businesses to enter new industries. It can help companies explore untapped markets, expand their customer base, and diversify their revenue streams. A well-defined strategy provides a framework for guiding and prioritising innovation efforts. It helps businesses align their innovation initiatives with their overall goals and objectives. A clear strategy ensures that innovation efforts are focused, targeted, and aligned with the organisation's long-term vision.

In short, innovation and strategy are interconnected. Innovation fuels strategic growth and differentiation, while strategy provides direction and purpose to innovation efforts. Successful businesses understand the importance of integrating innovation into their strategic planning to stay competitive and drive long-term success.

McGrath (2013) has challenged business strategy researchers of the previous era, such as those who have used Porter's five forces, Boston Consulting Group's growth-share matrix and Hamel and Prahalad's core competencies, which are all massively important but they have all been based upon a

singular focus that sustainable competitive advantage is the purpose of strategy. It is every company's Holy Grail. This contrasts with previously accepted strategy objectives, where researchers sought to understand how a company could create an enduring difference of above-normal returns (Oliver, 1999).

The company commercialisation strategy outlines what, when and how it will interact with a value chain to create value. These decisions are embodied in its business model for describing the final market offering.

Particularly in the pharmaceutical sector:

- (i) **What:** involves the therapeutic indications that regulatory agencies will seek.
- (ii) **When:** describing the point within a value chain a company decides to earn a return on its offering. The path taken can be critical in the biotech industry because product development is a long and expensive journey (Freeman & Dervan, 2011). The sunk costs and time required are strong disincentives to significant strategic direction changes.
- (iii) **How:** refers to the revenue model that the company uses to create a financial return on its innovation, such as licensing, direct-to-business, physical contact stores, technology sale, or outright sale of the company (Burns, 2012).

In most industries, entrepreneurial start-ups depend on the rapid creation of new products to gain cash flow, create legitimacy, gain early market share, and increase their survival odds (Schoonhoven et al., 1990). The same is also required for the biotech industry, however, the complexity of new product or technology development and the need for specialised assets along with the associated high costs leads most of the biotech companies to some form of collaborative alliance (Dixon, 2009).

McGrath and Nerkar (2004) found that decision-makers in the pharmaceutical sector utilise real options reasoning. A conceptual approach to strategy allocates investment considering the value derived from taking a particular option under uncertain conditions. During a drug development process, when the reduction of uncertainty occurs, the value concurrently amplifies as well as pre-defined milestones being achieved during the process. This could entail the proof of concept, Phase I, Phase II and III clinical trials being started and completed, and regulatory approval (Dixon, 2009). The ability to apply real options reasoning to commercialisation in the biotech sector is a dynamic capability. Dynamic capabilities are strategic routines by which practitioners alter their resource base, acquire and shed resources, and integrate and recombine them (Eisenhardt & Martin, 2000; McGrath & Nerkar, 2004). Dynamic capability is an essential component to be able to sense and act upon new opportunities and

reconfigure and protect knowledge assets, competencies, and complementary assets and technologies to achieve sustainable competitive advantage (Teece, 1998).

Once a company has decided to commercialise and chosen the most suited business model, strategic decisions must be made regarding the actual mechanism. Typically, the choice between selling, licensing, acquisition, joint venture or alliance depends on an analysis of the incentives to maintain control over the technology for future development versus the benefits of ownership for the company with direct control over commercialising the innovation (Gans & Stern, 2003a). Other strategies can be taken in a more practical sense, such as cost, differentiated or focus strategies (Porter, 1985). Most biotech companies have adopted a hybrid approach, which includes short-term cash-generating or bootstrapping activities to fund the long-term discovery and developmental process. These bootstrapping activities include selling services, non-core technology licensing out, selling the rights to some lead compounds, and/or developing associated medical devices that have a shorter development and regulatory path (Vitale, 2004).

The next step involves the finer details of the implementation of the desired business model and strategies through various tactics.

2.3.3 Biotech tactics

The company's tactics relate to the choices appropriate to a company by the business model and strategies it has chosen to utilise (Casadesus-Masanell & Ricart, 2010). An example is Metro Magazine, which has chosen to be ad-supported and free to readers. It can decide on the layout and number of ads per page and content and the ad rates charged in various cities, but this dictates that the magazine must be sold at zero price and prevents them from using the magazine's selling price as a tactic. The tactics employed are important in determining how much value a company can create and capture (Casadesus-Masanell & Ricart, 2010).

The literature on tactics regarding biotech companies is scarce. However, there are a few instances that have shed some light on the area. The source and amount of funding are critical for biotech companies and the perceived risk of investment by investors is highest for new companies. The availability of lending for these R&D stage companies depends greatly on the current economic climate and general sentiment towards the industry, such as currently, during a pandemic, certain technologies are certainly favoured, while at the same time, uncertainty has increased greatly (Paul et al., 2015). This is also an aspect that takes most of a new company's time and effort. A company may only raise enough capital

to take its lead product to the following scientific or clinical milestone. In this situation, companies must raise sufficient capital to reach this point, building cushions that account for potential unforeseen hurdles. It is extremely difficult and demoralising for both biotech and investors to keep going back to the well for more funding to complete the necessary research (Simon & Giovannetti, 2017).

Deeds, together with DeCarolis and Coombs (2000), looked for further tactics for new product development success, finding that geographic location, the quality of the scientific team, which was measured through several citations, and keeping the scientists out of the day-to-day running of the firm are all important factors. The right geographic location is important in gaining access to scientific talent, specialised suppliers and labour pooling (Casper & Kettler, 2001; Cooke, 2001a; Porter & Stern, 2001; Powell et al., 2002; Zucker et al., 1994).

Another tactic that is utilised is clustering where a group of companies is located within proximity, such as a research park or block of a city and are related to the other companies by research type. This has been seen in Cambridge, UK and San Francisco and Boston, US. These clusters have been well-known for clustered companies' successes in leveraging each other in terms of technology, equipment, personnel, and collaborations (Bania et al., 1993; Casper & Karamanos, 2003; Garnsey & Heffernan, 2005; Munroe & Anguiano, 2003).

On the cost side for risk management, there was a view to avoiding high fixed costs by contracting for research, development, and manufacturing until the company could afford to bring these activities in-house (Manuj & Mentzer, 2008; Rammer et al., 2009).

Several permissible tactics differentiate each company and the likelihood of its success. These could be anything from excellence in technology, the method of production, human resources division, the ability of staff and experience, choosing an appropriate partner, commercial and product management, risk management, and the kind of product or service that is being developed.

2.3.4 Measuring innovativeness

Initially, innovativeness was viewed by scholars as a concept to which an individual is an early adopter of innovation than other members of society and was a psychological and sociological trait (Midgley & Dowling, 1978). This research views innovativeness from a firm/company level. All companies rely on

innovation as described in the earlier section in this chapter 2.1.3 the concept of innovation to promote growth and sustainability to continue operating. It is a process that helps companies develop or implement new technologies (products, processes, services, etc.) which without these, they would struggle to operate (Escalfoni et al., 2009). Managing innovation, therefore, becomes more important towards their economic success.

Every company offering in history over some time will become commoditised, and when this occurs, the company loses its competitive advantage and will generally have to compete on pricing and having a global network (Betz, 1998; Thomas & Wilkinson, 2011). This demonstrates the importance of innovation and continually being innovative to maintain a competitive advantage. Companies have the capability to measure their innovativeness providing direction on where to improve and give strategic direction (Phan, 2013). Phan (2013) investigated innovation measurement in technological product innovation in technology-driven industries, presenting the innovativeness of a company based on output indicators, which are uncontrollable and unpredictable as opposed to inputs, which a company can control such as R&D expenditure. This was viewed as outputs transforming activities into economic value for the company (Morris, 2008).

Measuring innovation has garnered some attention with different methodologies and indicators. As well as indicators, at a macro level, innovation indexes have been proposed at the national level. From the number of studies conducted in this area, Potters (2009) found that different innovation activities and different innovation behaviours exist across industries. A range of studies found different input and output indicators are used to measure innovation. However, the majority of researchers emphasised that output indicators have greater importance over input indicators in doing this measurement but there is still a vast number of studies with a focus on input indicators (Gupta, 2007; Morris, 2008) Some of the output indicators included; patents, being the number of patents filed, the number of patents granted, and the number of patent citations, the number of new products, the revenue generated by products, as it is viewed that more money equates to being more successful, with total revenue, growth percentage, from new products, increase in revenue per employee, the impact on net profits from new platforms, the market share, scientific publications with bibliometrics, being broken into a total score, number of citations, the quality of papers, the number of presentations and also several honours or awards. This was also followed by the metrics and methodologies that were used to measure innovation, where many types of surveys, interviews, balanced scorecards, innovation funnels, mathematical models, and indexes and each of these has different standards applied, utilised by different countries across different industries, such as hospitality, high-tech, manufacturing, telecommunications, forestry, and eLearning (Morris, 2008; Phan, 2013; Steward et al., 2008). It has also been well established that because innovation is complex, a single indicator is deemed to not be

sufficient in measuring innovation and so a multi-dimensional approach is required to give a better measure of innovation (Glassman, 2009; Rothaermel & Hess, 2007).

Phan (2013) uses a hierarchical decision model to formulate a framework for measuring innovation. The model allows for the quantification of both quantitative and qualitative judgements, by using a process developed by Saaty for multi-criteria decision-making (Saaty, 1987; Saaty, 1977). In doing this, a pairwise comparison of the criteria was used to acquire priority importance in the hierarchy. The model used by Phan (2013) consisted of a three-level hierarchy, with the first level being the mission of identifying an innovativeness index in the semiconductor industry. Second, were the output indicators used such as the number of new products, number of awards and honours, number of patents, revenue from new products, number of publications and market share. The relative importance of this level was divided between the factors to equal one. The third level involved sub-factors to the indicators, for example, the indicator of the new product, was the new products new to the world and/or new to the company. This third level factors also had a relative importance score applied which was the sum of the score identified in the second level. A summary of Phan's (2013) model for measuring innovation is seen in Figure 5 with relative importance scores associated. The data were normalised to account for company size differences when applying the framework.

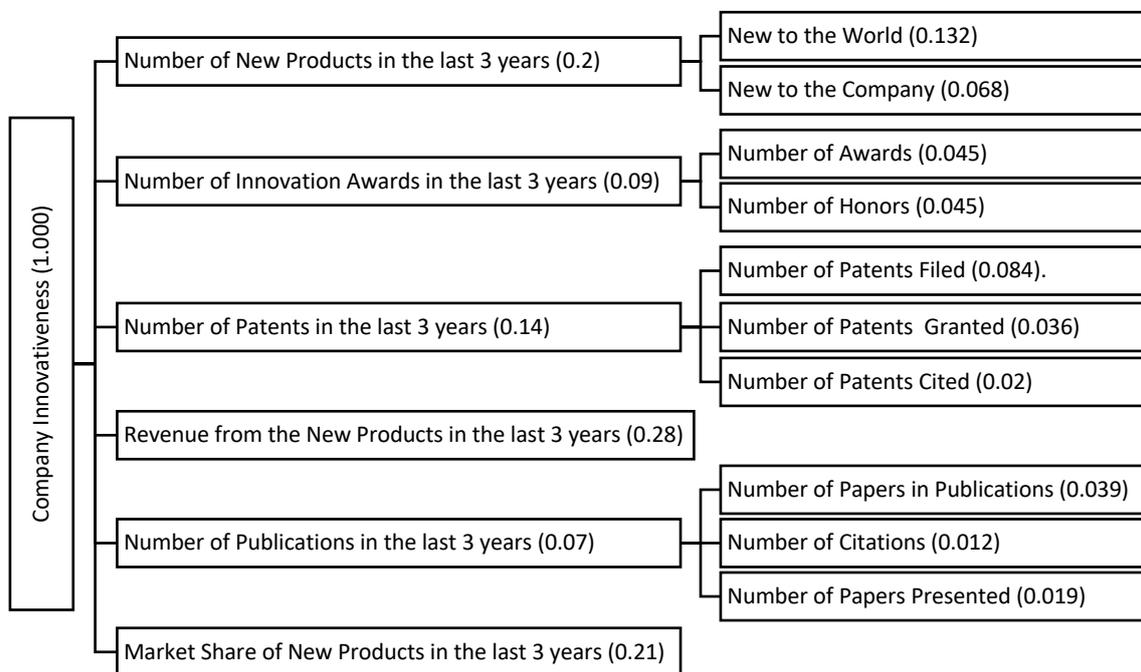


Figure 5. Model of innovation measurement. Adapted from Phan (2013) displaying the output indicators and sub-factors with their relative contribution to the innovativeness index. The first tier is the mission of finding the company's innovativeness with an importance of 1.0. The second tier consists of the output indicators which have a relative importance score applied with the sum of 1.0. This shows that an indicator such as revenue from new products in the last 3 years was the most important indicator scoring 0.28 compared to a lower relative importance of the number of publications in the last 3 years with 0.07. The third tier is a further breakdown of the output indicators into sub-factors, these are more specific factors to assist in establishing the innovativeness measurement. The number of new products in the last 3 years with a relative importance score of 0.2 is

broken down into two sub-factors, new to the world and new to the company. These are also given a relative importance score to total the parent branch score of 0.2, therefore scores of 0.132 and 0.068 are given respectively to total 0.2.

Aspects of some concepts within the framework presented by Phan (2013) were also found in the work of Savolou (2004) with product innovativeness. A compilation of summaries of all aspects of product innovativeness, such as newness to the company, newness to the sector, product uniqueness, product superiority, the degree of change in consumption patterns, the difference between new and existing products in the market, but no framework to measure is presented.

Another study completed by Lejpras and Stephan (2011) investigated the location proximity of spin-outs and their innovativeness using the partial least squares method. The innovativeness metrics used consisted of new products, new processes, number of patent applications and deployment share of R&D for a particular year. It was found that university spin-outs were more innovative than company spin-outs, with government funding thought to be a contributing factor.

In Välimäki et al. (2004), innovativeness is seen as a company's ability to develop and utilise innovations and the innovativeness is divided into the environmental and internal factors of a company. Environmental factors involving social, economic, cultural, technological, political, and physical impact the innovativeness, while internal factors such as knowledge and entrepreneurship are important towards the innovativeness indicators. This led Välimäki et al. (2004) to conduct a survey of the forestry industry in Finland to find the top indicators and was given a weighting based on perfect fit towards measuring innovativeness by experts. The developed innovativeness index consisted of 11 indicators, with six inputs and five outputs seen in Table 7 with a scaled weighting system to give a score between zero and 100.

Table 7. Innovativeness index and indicator % weighting (from Välimäki et al. (2004))

Indicator	Weighting
Company personnel dedicated to R&D work	9.51
Average share of R&D investments from total turnover of the company (%)	9.45
Co-operation with universities and other public research and expert organisations (yes/no)	9.01
Co-operative development with other companies (yes/no)	8.59
Public, venture capital and other corresponding funding and investments to the company (yes/no)	8.55
Number of development projects	8.48
Number of new products to the market	10.60
Average share of new products from the total turnover of the company (%)	9.09
Number of product improvements	9.07
Number of new production methods implemented in the company	9.07
New products/all products %	8.59
Total weighting	100.00

The analysis of innovativeness by Bell (2005) was completed with surveys to investment fund experts in Canada to respond to three statements; “this firm often leads the industry at (1) introducing new products... (2) introducing new services... (3) adopting new technologies.” Each statement was answered on a 5-point Likert scale and innovation was summed and averaged from all the respondents. The cluster locality, the managerial network the company network, the market share of assets under the company’s control and finally the age of the company. A similar approach was taken by Hurt et al. (1977) where a self-reporting survey of innovativeness with statements and selecting from a 7-point Likert scale was utilised to look at innovativeness from an adoption perspective.

The work by Danneels and Kleinschmidt (2001) presents product innovativeness from the company perspective and in doing so generated several measures. The measures related to product performance and product innovativeness (or product newness) on an 11-point Likert scale. The product performance aspects were five-question statements referring to the sales and profitability of the product (only for successful projects). Danneels and Kleinschmidt used historical data and were therefore restricted to the database provided by Cooper and Kleinschmidt’s study between 1985 – 1986, which contained 19 question-statement items to be answered with the 11-point Likert scale. The 19 items were broken into five categories of market familiarity, technological familiarity, marketing fit, technological fit and new marketing activities. The overall outcome of the study presents the different ways a product may be innovative and then about the product’s newness to the company performance outcomes from a market and technological perspective.

While the literature has extensively discussed different indicators and frameworks to measure innovativeness, it is crucial to delve into the foundational capabilities that enable a company to innovate consistently. Recognizing competencies, capacity, and cultural aspects that foster innovation is essential. One well-established concept in this realm is the Capability Maturity Model (CMM). The CMM, initially developed for software development, has been adapted to various domains, including innovation management.

The CMM emphasizes a staged approach, delineating an organisation's maturity levels in executing specific processes. In the context of innovativeness, this model can be applied to gauge a company's capability to innovate or disrupt. The model typically progresses through stages from initial or ad-hoc processes to optimized and continuous improvement.

The first stage would be to recognise the competencies of an organisation relating to the skills, knowledge, and expertise of its workforce. A mature innovativeness capability involves identifying and nurturing key competencies aligned with the company's innovation goals. This can include training programs, talent acquisition strategies, and fostering a culture that values continuous learning.

The capacity for innovation would be next and refers to the resources and infrastructure a company allocates to innovation. This encompasses financial investment, research and development facilities, and collaboration mechanisms. Assessing the maturity of a company's capacity for innovation helps determine its readiness to undertake and sustain innovative initiatives.

The cultural aspect of an organisation plays a pivotal role in fostering or hindering innovation. A mature innovativeness capability is reflected in a culture that encourages experimentation, tolerates failure as a learning opportunity, and values creative thinking. Understanding and evolving the cultural aspects conducive to innovation is integral to sustaining a competitive edge.

Incorporating the CMM into an assessment of innovativeness can provide a holistic view, going beyond measuring outputs and inputs. It enables a nuanced understanding of the underlying capabilities that drive innovation within a company. As companies mature in their innovativeness capability, they are better equipped to navigate disruptions, adapt to changing landscapes, and proactively drive innovation initiatives.

The biotechnology industry is unique, and no such measurement has been studied towards it. A framework that can assist biotech companies to focus on areas where they can improve and allow for comparisons within the industry or sector with other companies or competitors. There is a need to

measure innovativeness to be able to manage decisions into the future as well as if the level of innovativeness has effects on the outcomes of companies.

2.3.5 Biotech success

It is widely known that biotech companies and SMEs can have a low success rate (Godfrey et al., 2020; Lambert, 2003; Paul et al., 2015). The research conducted on the economic impact of university-licensed life-science start-ups across the US revealed regional differences in creating and sustaining and thus becoming successful ventures (Godfrey et al., 2020).

Success is a grey area for many involved in business, as individuals place different values on what being successful is. Success by dictionary definition is as simple as a "favourable or desired outcome" or "the fact of achieving wealth, respect, or fame" (Merriam-Webster, n.d.-c).

In general, there are many various views of what is defined as success. Financial criteria are usually considered the appropriate measure involving financial performance, turnover, profit, or investment return. However, many small business owners could have been motivated by lifestyle and personal factors, such as autonomy, job satisfaction, or balancing work and family responsibilities.

Success for biotech has also seen different measures as some see success being; securing venture capital, the completion of clinical trials, entering a collaboration, floating the company public through an initial public offering or secondary issue, or launching a product on the market as well as large amounts of stocks being purchased by an institutional investment fund (Cooke, 2001b; Godfrey et al., 2020; Greetham, 1998; Paul et al., 2015; Simpson, 1998). At times, multiple aspects must come together for success to occur, such as during drug development, having the suitable composition and character of the management team, flexibility, and the right amount of funding (Davenport et al., 1998; Hisrich, 1990).

The broad definition of success that will be applied to this thesis is:

A fair return to the owners (investors)

This definition allows the flexibility of having companies being defined as a success even if they have not launched a product into the market. The company may have been at a stage that was then acquired at

a valuation greater than the initial investment into the company and those that are profitable and can have a return on investment to the owners.

This limitation in strategic management research is revealed by the increasing disconnection between the practitioner and academic knowledge in management. There is a growing concern that academic research has become less helpful in solving practical problems (Rynes et al., 2001; Starkey & Madan, 2001; Van De Ven & Johnson, 2006). The lack of direct translation between academic-speak and practitioner-speak adds to the academy-practice divide.

The above background from the literature around innovation, disruptive innovation theory, New Zealand biotechnology and the commercialisation of biotech has set the stage for multiple questions and aims to be asked and targeted which will be detailed in the following methodology chapter.

3. METHODOLOGY

3.1 INTRODUCTION

From the literature review, it is evident that there is a basis for research to occur around the combined areas of disruptive innovation theory, New Zealand biotech landscape analysis and a framework to measure biotechnology innovativeness. The key concepts have provided a basis for developing the research questions. This chapter details the methodology undertaken from the basis of research paradigms that shape the way the research was completed, and the methods, techniques, and analyses incorporated to address the research questions.

The key definitions used in this research are:

- Innovation: the implementation of a new or significantly improved product, or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.
- Disruptive innovation: a product and/or market phenomenon that disrupts traditional market linkages by broadening and developing new markets and providing the functionality to potential customers
- Biotechnology: the application of science and technology to living organisms as well as parts, products, and models thereof, to alter living or non-living materials for the production of knowledge, goods, and services.

- Business model: the structure of a company provides the platform to conduct certain activities to achieve several goals, thereby creating value
- Success: A fair return to the owners (investors)

These definitions and key concepts of literature are critical towards framing the following research questions for this research.

3.2 RESEARCH QUESTIONS

The design of this research is guided and explored by the following five research questions:

1. **How aligned is the understanding of disruptive innovation between academia and industry?**
2. **What commercial elements could set the foundations of disruptive innovation?**
3. **What is the landscape profile of the New Zealand biotechnology industry?**
4. **How does the perceived innovativeness of New Zealand biotech relate to success?**

The questions put forward are descriptive and explorative, and require a pragmatic approach detailed in the following research paradigm. An exploratory study is valuable as it seeks new insights and assesses users' thinking in a particular field, shedding new light, which helps understand both a phenomenon and apply models in practical situations (Bryman & Bell, 2011). Concerning perceived innovativeness, this research also attempts to explore whether the higher the innovativeness of a company in the New Zealand biotechnology landscape, the greater its chances of being successful.

3.3 RESEARCH PARADIGM

The research paradigm or worldview is a set of assumptions about how things work (Creswell, 2014; Crotty, 1998; Guba, 1990; Killam, 2013). In 1962, Thomas Kuhn first talked of a research paradigm as a shared set of beliefs that informs the meaning or interpretation of data and has been the foundation for research studies (Kuhn, 1962). As at every stage of research, assumptions are made, in terms of reality, and acquisition of knowledge, that form an understanding of the research questions and aims, methods used and the analysis of the findings (Crotty, 1998; Moon & Blackman, 2014; Saunders et al., 2015). These are important as philosophical assumptions underpin the paradigm, research strategy and

the methods selected to realise them (Bryman & Bell, 2011; Crotty, 1998; Easterby-Smith et al., 2015; Moon & Blackman, 2014; Saunders et al., 2015). The collective thinking of several scholars, including Crotty (1998), Guba (1990) and Moon & Blackman (2014), describes the research philosophy framework in a logical path in Figure 6.

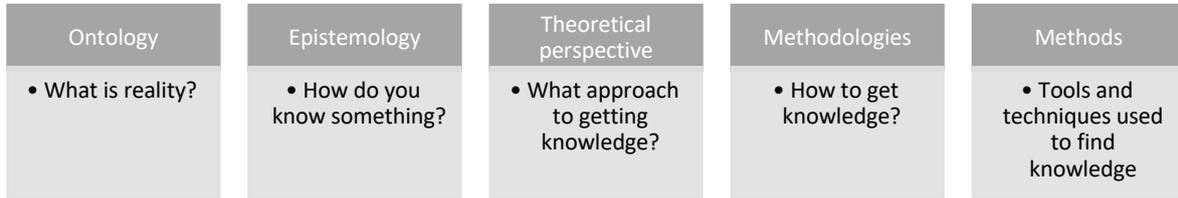


Figure 6. Research philosophy process (from Easterby-Smith et al., 2015; Guba, 1990; Saunders et al., 2015)

Figure 6 is a blended approach of two popular philosophical frameworks; the Research Onion by Saunders et al. (2015) and the Four Rings model by Easterby-Smith et al. (2015). These frameworks detail the depth linked to the research philosophy applied by researchers, particularly in business and management research, along with the work from Guba (1990), which places research in a paradigm that leads to the choice of strategy in undertaking research that has a significant impact on the style and the understanding of that research.

(a) Ontology

Ontology is the first aspect concerned with what exists in the world (Killam, 2013; Moon & Blackman, 2014). It is the basis and starting point of all philosophical assumptions about reality's nature (Saunders et al., 2015). The ontology depicted in Figure 7 is a spectrum of what exists between realism, relativism (in science) and nominalism (social sciences).



Figure 7. Research ontology spectrum. Science is aligned with realism down a spectrum to the social sciences aligned with nominalism.

Realism ontology generally holds that one single reality exists that can be studied, understood, and experienced as a truth where the reality exists independently of the mind and human experience, that what we experience through our senses portrays the world accurately (Easterby-Smith et al., 2015; Moon & Blackman, 2014; Saunders et al., 2015). Realism has little bearing on business research, as it accepts that scientific laws, once discovered, are absolute and independent of additional research, which has little connection with the dynamic socially constructed world in which organisations, individuals, and the researcher exist, which is in constant flux (Guba & Lincoln, 1994; Moon & Blackman, 2014; Saunders et al., 2015).

Relativism ontology suggests that reality is constructed within the mind and that scientific laws do not merely exist, waiting to be discovered. Therefore, no one true reality exists; instead, the reality is relative according to each individual who experiences it at a given time and place or when people create laws, such as cultural or moral aspects (Crotty, 1998; Easterby-Smith et al., 2015; Moon & Blackman, 2014). Business research, primarily interested in people's behaviour, leads to a debate concerning the appropriateness of natural sciences methods to the social sciences (Blaikie, 2007). The view of Easterby-Smith, Thorpe, & Jackson (2012) is that the appropriateness of these techniques depends on both the research topic and the researcher's preferences. Relativists accept that different researchers may have different viewpoints.

The nominalism position goes further than relativism by suggesting that the labels and names we attach to experiences and events are crucial. Social life is paradoxical and indeterminate, and argues that social reality is no more than the creation of people through language and discourse. There is no truth in this position, and the interesting questions concern how people attempt to establish different versions of the truth. Thus, the idea of social class is often used as an explanation of why some people are systematically more successful than others (Easterby-Smith et al., 2015). This position is beyond the scope of the research.

(b) Epistemology

Second in the philosophical approach is epistemology, concerned with what is seen as acceptable knowledge in a research field (Bryman & Bell, 2011; Killam, 2013; Moon & Blackman, 2014). Epistemology is important in the determination of knowledge as it influences how research is framed. Three epistemological positions depicted in Figure 8 influence research design.



Figure 8. Research epistemology positions

Objectivism epistemology takes the approach that knowledge exists as external facts, independent and outside of our mind and, therefore, beyond the reach of influence (Bryman & Bell, 2011; Moon & Blackman, 2014). Objectivism looks at discovering an empirically verifiable truth, valid, generalisable and free of social thought, thereby remaining separate from subjects and their viewpoints to bias the knowledge generated (Crotty, 1998; Moon & Blackman, 2014; Pratt, 1998). The value of objectivism is external validity and reliability, which relate to the applicability and consistency of results obtained from another context, that could then be transferable to similar situations (Moon & Blackman, 2014).

Constructionism epistemology does not agree with the objectivism approach of knowledge being present, waiting to be discovered. Instead, knowledge comes into existence from the engagement with the world's realities as a social phenomenon that is continually being reconstructed by social engagement and the interpretation of the world (Bryman & Bell, 2011; Crotty, 1998; Moon & Blackman, 2014). Constructionism, therefore, takes the same object or phenomenon, and different individuals construct its meaning in different ways that are influenced by how an individual engages with and understands the world based on their own social, cultural and historical perspectives where meaning arises from the interactions (Creswell, 2014; Crotty, 1998; Moon & Blackman, 2014). This is more the direction of the current research.

An epistemology closely related to constructionism is subjectivism, which depends on how people perceive and understand reality and that knowledge is expressed in multiple ways and purposes to which it makes sense for them (Crotty, 1998; Moon & Blackman, 2014; Pratt, 1998). The focus is on the individual from a specific place of purpose and interest. It attempts to understand the individual's knowledge, values, experiences and the meanings of one's actions as necessary as the action itself, collectively (Moon & Blackman, 2014).

(c) Theoretical perspectives

The ontology and epistemology positions direct the research theory perspective, of which each contains its own set of approaches, strategies, methods, and data analyses. The theoretical perspective's grouping will pay homage to the researcher's paradigm of the study (Creswell, 2014; Guba, 1990; Guba & Lincoln, 1994; Moon & Blackman, 2014). The theoretical perspective is closely linked with epistemology and is commonly presented as the same by many business and management research (Easterby-Smith et al., 2015; Saunders et al., 2015). The most common perspectives in business research are seen in Figure 9.

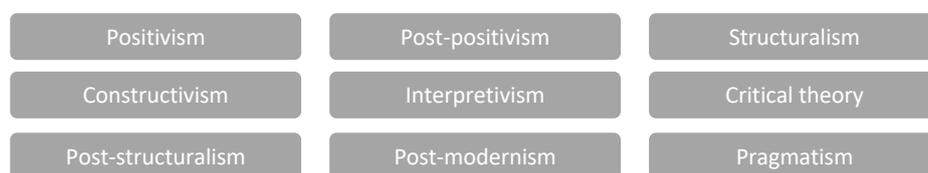


Figure 9. Theoretical perspectives of research (adapted from Moon & Blackman, 2014)

Positivism has developed into a distinct paradigm over the last 150 years that researchers adopt; positivism, post-positivism and the rarely used modernism. Positivism aims to explain and predict phenomena in an objective world, which is assumed to exist independently of the context and the observer. In taking a positivist stance, the researcher and the phenomenon are separate, and the

phenomenon does not alter as it is being observed. It is a way of exploring unique, common realities using objective research methods (Bryman & Bell, 2011; Crotty, 1998; Easterby-Smith et al., 2015). Positivist studies aim to identify truths that can be translated into generalisable laws (Greetham, 2006; Saunders et al., 2015).

Post-positivism, the gold standard for scientific research, adopts a deterministic philosophy in which causes determine outcomes or effects. The knowledge developed through a post-positivist approach is built on developing numeric measures or observations (Creswell, 2014). Post-positivism believes that some laws or theories govern phenomena and that these need to be tested to understand the world. In the scientific method, the accepted approach to an enquiry for post-positivists, a researcher embarks on the research process with a theory, collects data that supports or refutes (null-hypothesis) the theory before carrying out additional tests (Creswell, 2014; Crotty, 1998). The positivism paradigm underlies quantitative methods methodologies and cannot capture all the intricacies of social engagement and will not be suitable for the research at hand (Tashakkori & Teddlie, 1998).

In contrast to positivism, interpretivism or constructivism view the social world as not being subjected to the same methods as the natural sciences by respecting the differences between people and objects of the natural sciences (Bryman & Bell, 2011; Wahyuni, 2012). Instead of seeking the laws that explain certain behaviours, interpretivism attempts to understand an individual basis containing biases and perspectives of the research to trace the development of the phenomenon (Crotty, 1998). The three branches of interpretivism are; phenomenology, based upon the individual's experiences of a concept on a phenomenon (Easterby-Smith et al., 2012; Saunders et al., 2015; Wahyuni, 2012). Hermeneutics, based on the cultural context of the conversation by exploring the interpretations of speech, and symbolic interactionism, is based upon the researcher assuming that self, meaning, and interaction are all social products (Wahyuni, 2012). Interpretivism also contains feminism, a focus on the complexities of gender as a social and relational construction (Maruska, 2017). This paradigm underlies qualitative methods' methodologies; these are identified as more appropriate for the research being undertaken in combination with the positivist perspectives (Tashakkori & Teddlie, 1998).

Pragmatism emerged as an alternative to positivist and interpretivist positions (Wicks & Freeman, 1998). Pragmatism is often seen as a philosophical perspective for mixed methods (Creswell, 2014; Patton, 2002; Tashakkori & Teddlie, 2010), as it draws attention to the problems at hand in a social science manner, allowing for a mix of methods to be utilised to develop knowledge about the problem. This is due to the approach seeking a compromise between empiricism and rationalism. The value of knowledge is judged by how well it serves a human purpose as it comes from individuals' lived experiences (Easterby-Smith et al., 2012). In pragmatism, the research should be contextually situated

without being committed to one philosophical position. Instead, the concern is with solutions to problems (Patton, 2002); truth claims, cultural values and ideas are explored in terms of their consequences (Creswell, 2014; Crotty, 1998). Johnson & Onwuegbuzie (2004) advocate the use of pragmatism for its practicality and outcome-orientation and its provision of an immediate middle position between the purist approaches of positivism and interpretivism. By making allowances for combining different methodological approaches, pragmatism also offers researchers the opportunity to tailor their research approach to better answer research questions. The pragmatic paradigm usually considers that a single paradigm should serve as the foundation for mixed methods research (Saunders et al., 2012; Tashakkori & Teddlie, 1998). Pragmatism was identified as the best course of action for the research reported in this thesis.

Another paradigm is critical theory, which aims to challenge, reveal conflict and bring about change (Crotty, 1998). The foundations of this perspective were laid in Marxism of the capitalist economic relations in the early 1900s and have developed into the critical theory known today (Bohman, 2005). The researchers who have utilised this approach believe it is necessary to understand real people's lived experiences in a context that will dictate how the framework will direct the data collection and interpretation (Patton, 2002).

(d) Methodologies

The methodologies refer to the rationale by which the research is approached within the context of a particular paradigm. Each philosophical position leads to a methodology that comprises an underlying set of beliefs that guide researchers to choose one method (Håkansson, 2013; Killam, 2013; Wahyuni, 2012). Methodologies are divided into qualitative and quantitative approaches used to inquire about a specific situation for specific data seen in Figure 10. The two positions are not mutually exclusive; however, they are also not interchangeable. This then also positions the research at different time points as undertaking the following approaches: (i) deductive theory testing or (ii) inductive theory generation (or the combination of both): (iii) abductive theory testing and generation (Bryman & Bell, 2011; Newman et al., 1998; Saunders et al., 2015). The abductive approach is applied in the present research due to the pragmatic stance towards the research with mixed methods.

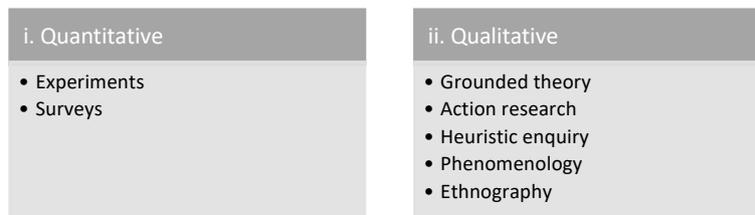


Figure 10. Methodologies for research. Two distinct approaches are generally taken: quantitative or qualitative depending on the nature of the research.

(i) Quantitative

The quantitative approach is used when a theory or hypothesis is created and is then tested for the confirmation or negation of that hypothesis (Newman et al., 1998). There are many approaches to test the hypothesis or theory, including experiments, quasi-experiments, pre-test and post-test designs and others. The control of variables, randomisation and valid and reliable measures are required and where generalisability from the sample to the population is the aim (Newman et al., 1998; Saunders et al., 2015). A quantitative approach was considered necessary for the study as empirical research may provide evidence for explaining a particular phenomenon in combination with qualitative methods.

Experiments are the original methodology of research applied directly to the physical sciences. The experimental method for business involves the random assignment of study participants to either an experimental or a control group. The conditions are manipulated for the experimental group to assess their effectiveness compared with members of the control group who are receiving no unusual conditions to help identify cause-and-effect relationships (Easterby-Smith et al., 2015; Saunders et al., 2015; Sreejesh et al., 2014). However, in business and social research, the disadvantages of experimental research influence the research's understanding quite heavily.

In survey research, there are three main types: factual, inferential, and exploratory studies. These look at opinions, markets, establishing relationships between concepts and looking at the big picture, such as taking a set of principles and measuring it against any culture to predict behaviour by looking for patterns in the data (Easterby-Smith et al., 2015). This research utilises the survey approach.

(ii) Qualitative

The qualitative approach is used when observing and interpreting reality to develop a theory that will explain what was experienced (Newman et al., 1998). Qualitative research is generally considered under the heading ethnography. Other methodologies include case studies, field studies, grounded theory, document studies, observational studies, interview studies and descriptive studies. These approaches stem from traditions in anthropology and sociology where there is an emphasis on the phenomenological basis of a study, the elaborate description of the meaning of the phenomenon for

the people or culture under examination, such as human behaviour (Newman et al., 1998; Saunders et al., 2015).

Grounded theory was initially discussed in 1967 by Glaser & Strauss (2017). They have described grounded theory as a methodology for developing a theory grounded in data systematically gathered and then analysed (Easterby-Smith et al., 2015; Strauss & Corbin, 1994). It is a good approach when theory is not available to explain a process. The theory evolves during actual research, and it does this through a continuous interplay between analysis through coding (categorisation) and data collection. Theory may be generated or grounded initially from the data from participants who have experienced the process and can be compared and modified with existing grounded theories (Strauss & Corbin, 1997).

Action research is an approach where the researcher is often actively part of the research process studied and assumes the social phenomenon is continually changing rather than static (Easterby-Smith et al., 2012).

A heuristic inquiry is a research process that has a question or problem that is a personal challenge and seeks answers. It is a search to understand through internal searching to understand the world, discovering the nature and meaning of important human experiences (Moustakas, 1990). The heuristic inquiry also extends to texts, speeches and letters from soldiers in battle to families for the continual interpretation and reinterpretation of texts and experiences, knowing that meanings can change over time and be different for different cultural areas around the world (Bernard, 2017). This will not be the focus of this research but will take some learnings from this approach as concepts can be different to individuals.

Phenomenology emphasises the direct experience of phenomena to determine the essences that make them what they are. The foundations were developed by Edmund Husserl, who presented that experimental scientific methods were not appropriate for the study of human thoughts and experiences (Bernard, 2017). In a phenomenological study, the research attempts to see reality through another person's eyes, through the meanings people give to that reality. The aim is to try to produce convincing descriptions of what they experience rather than explanations and causes. This is a core aspect of this research due to the experiences individuals have with business and commercial success.

Ethnography holds the stance that immersion and becoming part of the situation to understand the meanings that people give to specific behaviours (Easterby-Smith et al., 2015). The research is often interested in examining shared patterns, and the analysis is extensive, with more than 20 or so

individuals in a grounded theory approach. The focus is on an entire cultural group, describing and interpreting the shared and learned patterns of values, behaviours, beliefs, and languages. Aspects of ethnography are important to this research, although total immersion is not required.

(e) *Methods and techniques*

The methodologies described all consist of variable methods and techniques. These are the specific procedures, tools, and techniques used to gather and analyse the research data (Saunders et al., 2015; Wahyuni, 2012). The methods and techniques utilised to collect data are independent of methodologies and paradigms and are a practical application of doing the research compared to the methodologies and paradigms, which are the theoretical foundations of the method (Wahyuni, 2012).

The methods and techniques allow data to be collected as primary and secondary. The researcher generally collects primary data, while secondary data is publicly available regarding the topic (Wahyuni, 2012). There are many types of methods and techniques that can be used to gather data. Some examples are; sampling and scaling, statistical analysis, questionnaires, or surveys, focus groups, interviews, case studies, narrative, observation (participant and non-participant), life history, document analysis, content analysis, data mining and many others. This research utilised various techniques to gather data such as surveys, interviews, document analysis, content analysis and data mining.

(f) *Summary of philosophical paradigms*

A summary of the different research paradigms is seen in Table 8, with each stage of philosophical values, beliefs and experiences influencing the decision and stance taken.

Table 8. Research paradigm summary. (Adapted from Crotty (1998), Patel (2015) & Moon & Blackman (2014))

Research paradigm	Ontology <i>What is reality?</i>	Epistemology <i>How do you know something?</i>	Theoretical perspective <i>What approach to getting knowledge?</i>	Methodologies <i>How to get knowledge?</i>	Methods <i>Tools & techniques to find knowledge?</i>
Positivism (scientific)	Realism, one truth	Reality can be measured and needs reliable and valid tools to obtain (objective)	Positivism Post-positivism Modernism	Experiments Surveys	<i>Quantitative:</i> - Sampling - Measurement & scaling - Statistical analysis - Questionnaire - Focus group - Interviews
Constructionist / Interpretivism	Relativism, created by individuals in groups	Reality needs to be interpreted or constructed	Postmodernism Feminism Interpretivism: - Phenomenology - Symbolic-interactions - Hermeneutics	Ethnography Grounded theory Phenomenology Heuristic enquiry Action research Discourse analysis	<i>Qualitative:</i> - Qualitative interview - Observation - Participant - Non-participant - Case study - Life history - Narrative
Pragmatism	Constantly negotiated considering its usefulness	The best method is one that solves problems	Research through design	Mixed methods Design-basis Action research	Combination of any of the above and more: - Data mining - Usability testing - Physical prototype
Critical Theory	Socially constructed realities under the constant influence	Reality and knowledge are socially constructed and influenced by power relations from within society	Marxism Queer theory Feminism Emancipatory Advocacy	Critical discourse-analysis Critical ethnography Action research Ideology critique	- Ideological review - Civil actions - Open-ended interviews - Questionnaires - Observations - Focus groups - Journals

Table 9 presents a summary of the philosophical research paradigms and those used in this research. In shaping the methodological framework for this research, a careful examination of ontological and epistemological perspectives guided the selection of a theoretical approach that integrates relativist ontology, constructionist epistemology, pragmatism, and phenomenology. Unlike grounded theory, which was considered but ultimately set aside, this study embraces a diverse methodological landscape through the application of mixed methods.

The choice of a relativist ontology reflects the acknowledgment that reality is multifaceted and context-dependent, allowing for an exploration of diverse perspectives within the research context. This ontological stance is complemented by a constructionist epistemology, emphasising the socially

constructed nature of knowledge. Recognising the dynamic interplay between individuals and their social environments, this approach aligns with the overarching goal of understanding the subjective experiences and meanings attributed to phenomena under investigation.

Pragmatism serves as a unifying philosophical stance, emphasising the practical implications and utility of research findings. By adopting a pragmatic perspective, the study seeks not only to uncover theoretical insights but also to provide actionable recommendations for real-world applications.

In lieu of grounded theory, the theoretical framework incorporates phenomenology, reflecting a commitment to exploring and interpreting the lived experiences of participants. Phenomenology's emphasis on understanding the essence of phenomena aligns seamlessly with the research objectives, providing a rich and nuanced exploration of subjective realities. Whereas a grounded theory approach aims to develop theories grounded in empirical data, involving systematically collecting and analysing data to generate concepts and theories that emerge from the data itself. The research did not set out explicitly to develop a new theory as the theory phenomenon was in existence already.

The integration of mixed methods further enhances the methodological rigour of this research. Interviews offer a qualitative depth, allowing participants to express their experiences in their own words, while surveys provide a quantitative dimension, facilitating the gathering of broader patterns and trends. Observation adds a contextual layer, capturing behaviour in real-time, and data mining offers a computational lens, extracting valuable insights from large datasets.

This methodological synthesis, rooted in relativist ontology, constructionist epistemology, pragmatism, and phenomenology, underscores the comprehensive and inclusive nature of the research design. By leveraging mixed methods, including interviews, surveys, observation, and data mining, the study aims to triangulate findings, providing a holistic understanding of the research phenomena. This approach not only responds to the complexities of the research questions but also aligns with the overarching goal of generating meaningful and applicable knowledge within the chosen theoretical framework.

Table 9. Philosophical position adopted for the present research

Aspect	Relation to research
Ontology	Relativist, different researchers have different viewpoints, and the literature review supports this assumption.
Epistemology	Constructionism, is socially constructed developing patterns or theories of meaning through the study.
Theoretical perspective	Pragmatism, focusing on real-world, practice-oriented research problems.
Methodologies	Mixed methods through survey research and phenomenological research, utilising quantitative and qualitative approaches.
Methods	Tools utilised were surveys, interviews, observations and data mining. The analysis phase focused predominantly on text analysis.

3.4 DESIGN RATIONALE

As the DI research basis is relatively undeveloped, the knowledge, experience and literature for hypothesis generation are complex. Therefore, the research design is based on pragmatism, which will direct the approach of a mixed-method throughout. Pragmatism research does not take one philosophical stance, such as positivist or interpretivist, but instead finds the research and research questions' placement at the centre of the research (Wilson, 2014). As business research does not exist in a vacuum, its nature may weigh more towards the interpretivist stance. It is appreciated that people experience management processes and many intellectual traditions that shape social sciences differently and are therefore concerned with understanding the lived experience. This is more subjective than the positivist stance that uses precise, objective measures (Bryman & Bell, 2011; Saunders et al., 2015).

A sequential, exploratory, iterative mixed method design is used, where the research is conducted using both quantitative and qualitative methodologies and approaches in a single study (Johnson & Onwuegbuzie, 2004; Tashakkori & Creswell, 2007; Tashakkori & Teddlie, 2010). The research is sequential as it allows one phase to inform the next phase for deeper exploration. The exploratory design is prevalent as there are different dimensions to be tested and can also lead to the discovery of generalisations and understanding of phenomena that have received some attention (Morgan, 1998). There are two main reasons for combining quantitative and qualitative approaches. First, to achieve triangulation, the convergence of findings from different methods that examine the same phenomenon in a meaningful manner that could not be achieved by one method alone (Creswell, 2014). The second is complementarity by using one method's strengths to enhance the other (Morgan, 1998). A significant advantage of using mixed methods is that it enables confirmatory and exploratory questions, allowing

the verification and generation of theory in a single study (Tashakkori & Teddlie, 2010; Teddlie & Yu, 2007).

This approach was most suited for addressing the research questions as there was limited evidence informing the industry perceptions of disruptive innovation and the innovativeness of the New Zealand biotechnology industry. This supported the need for explorative qualitative work to describe a blurred phenomenon, especially in a unique contextual setting, such as biotechnology in New Zealand. New Zealand is often seen as a testbed for implementing new technologies for the world due to its small size compared to large industrial nations. Moreover, because of its ethnic and social diversity and modern city structures, it provides a society that can be a valid sample for the world. This mixed method research design of a survey, anonymous snapshot industry interviews, data-mining and complimentary archival research is utilised, playing on each strategy's strengths in a harmonising manner (Tashakkori & Teddlie, 2010). This allows the rich conceptualisation of DI perceptions, barriers and commercial drivers, and the development of the perceived innovativeness scorecard contributing to the potential success that can be applied to the New Zealand biotech industry through an iterative approach, weaving back and forth between data and theory.

3.5 SURVEYING DISRUPTIVE INNOVATION

This research consists of several sequential data inputs; literature analysis, survey, snapshot interviews, data mining and application. The first stage's goal was to utilise a quantitative-qualitative approach using empirical research by way of a survey to identify and explain the phenomenon of disruptive innovation in the collection of numerical data as a standard and generic understanding, which could inform the development of the perceived innovativeness scorecard. This structured nature allows broad conclusions to be made and some form of generalisation towards the population.

3.5.1 Survey

To address the research questions, the survey is considered one of the leading means of data collection approaches in the social sciences with large populations (Blaikie, 2009). A survey builds on the previous work that has established theories and principles. The approach does have potential limitations with risks of lack of responses, and response bias (Creswell, 2014). An online survey was selected as the medium over other forms such as mail-out surveys and telephone surveys as it allowed for rapid data collection. The process saves time by having no printing and postal issues of delivery and recovery of

surveys, as well as being recorded in real-time to allow the researcher to gauge a picture of the incoming responses (Bryman & Bell, 2011; Creswell, 2014). This medium also allows participants to receive and complete the survey at a time and place of convenience providing more willingness to participate in a time-poor era.

The online anonymous, voluntary survey was conducted on a university-licensed software, Qualtrics^{XM} which allows users to build surveys, distribute surveys for access on any web browser or operating system and analyse responses from one convenient online location (*Qualtrics, 2017*). The survey created was designed to explore the perceptions of disruptive innovation and commercial applications. The survey sought to distinguish between academic understanding and the real-world understanding of disruptive innovation as well as the application of tools to implement said innovations to the world using The Ten Types of Innovation (Keeley et al., 2013) as a framework. The survey attempts to capture honest opinions without the respondents having to think too deeply. Pilot testing was performed by business friends and colleagues before the survey was made live and modifications were made based on feedback from the pilot participants. This is important as it helps confirm whether the language used is clear, understandable, and free from errors and if adequate measures are in place to collect data. All pre-tested surveys were conducted online; in the same way that the live survey would be completed. None of the data from the pilot tests was included in the final data collection. The wording in the questions was tested to ensure that the language was clear, simple and to the point for the sought-after answer. The length of the survey was also addressed attempting to keep the length of time required to complete the survey between 15 and 20 minutes as recommended for online surveys (Rea & Parker, 2005).

All participants of the survey were required to grant consent to start with the survey questions. Those who declined this were redirected to the end of the survey and thanked for their time. Participants did have the capability of returning to previous questions. They could also stop the survey where they were and re-enter at the same point by using the same link and browser. Participants could have completed the survey multiple times, however, this could be identified by name, email address and IP address location. If these were different, it could not be identified if they completed the survey more than once. No such multiple attempt occurrences were observed.

The online survey looked at locating information across five areas; demography, disruptive innovation understanding, education, disruptive innovation elements, and commercial environment to provide insight towards the research questions. Throughout the survey, variables can be measured as nominal (different from one another), ordinal (logically ranked-ordered), interval (rank-ordered and equal distance between) or a ratio (all the qualities of nominal, ordinal and interval and based on a true zero

point) (Babbie, 2010). The research survey was a mix of nominal, ordinal, and ratio measures when categorising activities.

3.5.2 Participants

The online survey attained ethical approval from the Auckland University of Technology Ethics Committee (AUTEC #16/74) to survey the public (Appendix A and B). However, due to the more general nature of the online survey, AUTEC mandated that no persons could be directly contacted to participate in the survey in case it would be seen as coercion to participate. The survey was therefore advertised in an untargeted manner into a public forum via the researcher's network of about 450 contacts on the business social media website, LinkedIn, and it was advertised on numerous LinkedIn business groups in Table 10, which provided approximately 10⁶ exposure to potential participants.

Table 10. Public LinkedIn groups survey advertised

Groups	
AI, Deep Learning, Machine Learning	I Love Disruptive Tech
Board of Innovation	Innovation and Entrepreneurship Network
Branding, Brand Management, Brand Design	Innovation Excellence
Change Consultancy	Innovation Management Group
Digital Marketing	Insight Innovation Forum (Market Research Group)
Disruptive Innovation	New Zealand Business & Professional Network
Entrepreneur & Small Business Forum	New Zealand SME Business Network
Front End Innovation	On Start-Ups – The community for entrepreneurs
Future Reality (VR/AR)	Spurting Innovation – Ikigai
Harvard Business Review	TED – Ideas Worth Spreading
Human Resources (HR) & Talent Management	The Business & Data Analyst Forum

The survey sought participants who were business professionals or particularly knowledgeable or involved in many business practices. The survey attracted 115 respondents, however, only 100% of completed surveys were used in the data analysis and this constituted 43 completed surveys' through to the end to be used in the data analysis.

3.5.3 Data collection

The majority of the questions in the survey were developed as closed-ended questions. These were used as opposed to open-ended questions for several reasons: (i) they generally reduce the time and effort required from a respondent to answer questions; (ii) the pre-set answers are uniform and facilitate comparisons between respondents; (iii) responses can be directed with a fixed list to limit irrelevant responses; (iv) list responses help make the questions clearer to the respondents and the categorisation of questions may help remind respondents of alternatives they have forgotten (Rea & Parker, 2005; Sue & Ritter, 2012).

The survey was made active for a total of six months between July - December 2016. It was originally anticipated to require only three months of collection, however, this was extended to six months to allow for more respondents to the survey who were following public posts of the LinkedIn groups. The data was collected to Qualtrics which has analysis tools and filters embedded into the software (Qualtrics, 2017). The data was also transferred to Microsoft Excel for further analysis (Microsoft Excel, 2018).

A detailed breakdown of the reasoning behind each of the survey questions is explained below, detailing why each question was asked and what the question was attempting to find. The questions are shown exactly in the survey in bold with the reasoning following. These are only the questions and the reasoning, not the available selections of answers, which were viewable on the Qualtrics website and can be seen in Appendix B.

(a) Demography

What industry are you working in?

The respondents were to select one industry in which they work and this became the basis for answering the remaining questions in the survey. This can allow for cross-comparison in responses between industries.

What position(s) do/have you held in the last 15 years?

Respondents were to select from a list of managerial positions the positions that they have held within the last 15 years. This can allow for analysis between the various positions and the thinking applied to innovation and in particular, disruptive innovation.

(b) Disruptive innovation

What do you understand by the term disruptive innovation to mean?

Respondents were to select or add to a list of predefined academic and media influenced opinions of disruptive innovation, leading to their understanding of disruptive innovation. It is useful to identify what participants from various regions in the world, managerial positions and industries understand as being a disruptive innovation.

Have your own products been directly affected by disruptive innovation?

To see if the respondents perceived that they experienced disruptive innovation against their company products. This allows for identifying if respondents believe that in their industry, they have faced disruption and the percentage of those that believe they have encountered it.

Was your company responsible for disruptive innovation?

On the other side to the previous question, instead of being affected by disruptive innovation, have the respondents themselves been on the delivery end of disruptive innovation. Identifying the percentage that believes they have created a disruptive innovation based on the generalised definition applied for this section to all respondents.

(c) Education

Does the marketplace need to be educated about a disruptive innovation before the market will adopt it?

To see the opinion of respondents about the education requirements towards disruptive innovation and adoption by the market. Do they believe the majority of the population understands the concept enough to accept the concept or is education required to grasp it and its commercial applications.

How would or should this education occur?

Do the respondents have a preference on how education should be approached in one or more of the following ways. This is to identify if there are mechanisms available to educate the public or the future business people on the ways of disruptive innovation and the thinking behind it.

In the early stages of research and development for a product, does an autonomous unit need to be created to do disruptive innovation?

The opinion of respondents regarding research & development (R&D) for specific purposes such as disruptive innovation. This is seen as a litmus test for comparing with the popular disruption model by Christensen (1997), where he believes it must be an autonomous unit to be able to achieve a disruptive innovation, especially in large organisations or if respondents understand this concept.

(d) Disruptive elements

What are three critical [commercial concept] aspects that can lead to achieving a disruptive innovation?

These questions make up the majority of the survey and cover a range of business commercial aspects relating to various elements of a company that respondents identify as being essential for leading companies towards disruptive innovation. The answers to each of the categories will allow a framework to be developed based on the responses for characteristics identified by business professionals through the experiences they have encountered.

(e) Commercial environment

In what country are you CURRENTLY based/working predominantly?

This will provide a demographic aspect for the survey and of the current situation for the following question relating to that country's specific aspects and allow for geographical comparisons regarding the responses.

Rate the commercial environment of the country named above in enabling innovation from the following aspects.

The respondent's opinion of the commercial environment for their stated country to enable certain innovation activities. These answers are based on their own opinion of what is available and how the respective countries are supporting the commercial environment. This can be used for comparison reasoning and detail why some countries are doing better than others.

The responses to the questions were then collated and analysed, described in the next section.

3.5.4 Data analysis

All the survey data was collated in the Qualtrics software program to output the results from each question. Data from the survey was also entered into Microsoft Excel where each aspect was converted for analysis using numerical information (*Microsoft Excel*, 2018). Quantitative data analysis was initially descriptive as seen in the findings chapter. Statistics including means, percentages, medians, ranges, and variances were calculated, as appropriate for all questions and variables. This allowed the researcher to develop an initial framework for the data collected in the survey.

Various approaches were then used to further shape and analyse the data. These included;

- (i) the data as one overall collective,
- (ii) broken down into various employee positions,
- (iii) geographical location and,
- (iv) the working position of 'other' was removed from the data, to investigate if it had an influence of disturbing the data as these may not be seen as managerial or decision-maker positions.

The data was presented in several ways as well, with "All" answers being identified and then, filtered into the respondent's self-selected positions of management arranged in seniority and company influence from the Board of Directors to other. This allowed for visualization and comparisons or trends to be seen by job level or company influence. The responses were also arranged by geographical location as New Zealand-based (NZ-based) or overseas-based (ROW = rest of world) to allow for geographical comparisons.

Another approach utilised was that of heat mapping, as the numerous aspects being explored meant that multi-dimensional could be extracted from the collected data. In Microsoft Excel, heat map parameters were selected based on the percentage of respondents for a particular answer; Green (50%), Yellow (35%), and Red (20%). Framed differently, the same answers that received greater than 50% selection by respondents were coded green and deemed important and/or favourable, answers that received between 20–35% selections by respondents were coded yellow and were deemed sometimes important and finally, answers that received less than 20% selections were coded red and were deemed as not important and/or not favourable by the respondents. These colour selections created a colour spectrum of a traffic light system for the researcher to be able to visualise the similarities and differences in the answers. The heat maps were arranged using the same hierarchy of position seniority for each of the questions. Finally, the presentation of this data was arranged by the highest to lowest percentage of responses based on the overall unfiltered responses, denoted as "ALL."

The survey analysis findings were used to inform the understanding of disruptive innovation and the development of the perceived innovativeness scorecard and the prior literature and the following data collection.

3.6 SNAPSHOT INTERVIEWS

During the AusBiotech 2016 Conference in Melbourne, a series of anonymous informal structured interviews were completed with fellow attendees. The aim was to ask questions to get a brief picture of biotech in Australasia and the perception of disruptive innovation that could supplement the online survey.

3.6.1 Interview

The interview was seen as an additional method to acquire data on the perceptions from a pure biotechnology industry perspective compared to the more general online survey, allowing for the triangulation of data from the various collection points. The interview was conducted with only five questions, which totalled five minutes.

3.6.2 Participants

The snapshot interview participants were fellow attendees at the AusBiotech Conference in professional positions (not students) who were approached by the researcher and asked if they would participate in a quick interview involving questions about disruptive innovation and the biotechnology industry. It was initially identified by the researcher, that the potential participant was in a business role within a biotechnology company and not a student. Once this was confirmed, the interview questions were conducted. A total of 10 interviews were conducted, and each participant remained anonymous throughout the interview. No personal information was retained.

3.6.3 Data collection

The interview was recorded with an audio recording device with the permission of the participants who were informed that no identifying information would be used and was only used to accurately detail the perceptions from the asked questions for the analysis phase. Each participant was asked the same five questions, and a time limit was set at five minutes. The recording was transcribed and redacted of any identifying aspects for each participant and then further analysed.

The questions that were asked of the participants were based on the following and the reasoning behind the relevant question:

What is your current position and business?

The question was asked to establish the validity of the participant in answering the remaining questions relating them to the biotech industry. This question and responses were redacted in the transcripts to remove any identifying aspects of the respondents and the recordings were deleted following transcribing.

How do you view disruptive innovation? What it means to you?

To identify the respondent's personal view from their own experiences regarding disruptive innovation without a pre-defined list of options compared to the survey and a purely biotech perspective.

Do you think that biotechnology is disruptive?

To see the opinion of the respondents about the nature of biotechnology towards the global environment and relevant thoughts that build upon this question.

What are some barriers to the commercial success for a biotech company?

To identify what the respondents view as the barriers and problems they have faced in their own experiences during the commercialisation of their biotechnology products and services.

What are some things you would like to see occur in the future for the benefit of the biotech?

To identify what the respondents view as potential changes in a positive manner or reduce certain negative aspects that could help them towards the goal of successful commercialisation.

3.6.4 Data analysis

The transcripts from each participant were further grouped in response to the respective questions. From this, each question was analysed for any similar themes and any outliers in the perceptions by way of coding. This coding analysis is helpful for the development of DI about the biotech industry and in the development of the biotech innovativeness scorecard.

3.7 NEW ZEALAND BIOTECH LANDSCAPE & PERCEIVED INNOVATIVENESS

The New Zealand biotech landscape was profiled out of necessity as a broad brush of companies involved in biotechnology, bioscience, or the life science arena, as this compiled information is not readily available in New Zealand business reports or highly visible to the public. This information relates to the development and presentation of the New Zealand biotechnology industry landscape for this research is known as the New Zealand biotech battlefield.

Caveat: Although the data presented as the New Zealand Biotech Battlefield is an extensive presentation of the New Zealand Biotech Industry as of December 2020. It is to be understood that it is not complete in its entirety due to limited resources and time available including computer records, quality of historical internet information and activeness of companies that have influenced the visibility of the industry. Therefore, some companies and some data may have been omitted from the profiling.

3.7.1 New Zealand biotech battlefield

The New Zealand biotech battlefield was developed to depict New Zealand's efforts in the biotechnology era starting from the genesis of recombinant DNA in the early 1970s (Swazey et al., 1977; Yi, 2008). The aim was to profile the numerous New Zealand companies that were originally founded and remained in New Zealand in the world of biotechnology if they are currently operating, have been successful, are out of business or operating but not active. Being able to profile the entire industry is important to the future approaches for the industry and analysing the innovativeness and its impact and effect on outcomes for the companies.

Descriptions of battlefields often capture the chaos, fear, and heroism experienced by individuals on the front lines. The terms "fallen," "wounded," and "alive" carry significant emotional and thematic weight, especially in the context of battlefields. In the corporate landscape, analogous terms—"fallen," "wounded," and "alive"—carry profound implications, mirroring the dynamic nature of business as a battlefield. Within the literary and strategic dimensions of corporate literature, authors often explore the emotional and psychological aspects of corporate warfare, capturing the chaos, fear, and resilience experienced by individuals in the competitive arena. The term "fallen" in this context can signify companies that have succumbed to market pressures or operational challenges, evoking a sense of sacrifice and highlighting the sobering realities of the business battlefield. The "wounded," reflecting businesses that have weathered setbacks or financial injuries, but are still operating in a reduced capacity. Literature and films about business struggles illuminate the resilience and struggles of companies that endure challenges. Conversely, the term "alive" denotes thriving companies that

navigate industry challenges. Survivor narratives within corporate literature explore the psychological and emotional toll of competition and the enduring impact on organizations. Descriptions of recovery and rehabilitation in a corporate context signify the strategic and operational adjustments required for companies to return to strength after facing challenges, shaping perspectives on business conflicts and influencing how industries remember and honour the journeys of companies that have navigated the corporate battlefield.

Multiple sources of information and groundwork were used to compile this New Zealand biotech industry landscape. The latest known publication of any New Zealand biotech company list was the New Zealand Biotechnology Directory in 2000. Other sources utilised were the companies registered to NZBIO (renamed BioTechNZ) with a recent 2020 publication, biotech.org.nz, communication with the biotech industry lead from Callaghan Innovation and data mining through library resources, articles and internet searches and various databases. This research also attempted to use a web-based data program called Quid® to identify relevant companies but this was not ideal for this particular sector and was still a beta version in development at the time of use (Quid, 2018). The following search terms in Table 11 were used on Quid® as well as internet searches for New Zealand companies:

Table 11. Search terms used on Quid® database

Quid search terms	
Agriculture / Animal Health	Industrial
Biofuel / Biomass	Life sciences / Genetics
Biotech / Biotechnology / Bio / Biology	Marine / Aquaculture
Cosmetics / Cosmeceuticals	Medical devices / Med-tech
Diagnostics	Pharma / Pharmaceuticals / Therapeutics
Food / Nutraceutical / Nutraceutical / Supplements	Plants / Horticulture
Health / Health tech	

3.7.2 Datapoints

The collation of information regarding New Zealand biotech companies required multiple variables to be identified, therefore a diverse range of data points (Table 12) was selected to be investigated for each of the identified companies. The information gathered to fulfil the data points were conducted by archival research methods, where the data already exists in the public domain (Easterby-Smith et al., 2015). The records were collected from company websites, web reports, newspapers, journal articles, databases, and interviews. The information was used to analyse the respective companies to provide

insights into biotech in New Zealand such as; type of company, regional locations, proximity to universities, the market stage during this research if a company was a university spin-out or has university associations as well as a few identifiers to ensure accuracy of reporting.

Table 12. New Zealand biotech battlefield data points

Aspect	Description
Name	The name of the biotechnology entity.
Sector	The biotech sector (Health, Medical Devices, AgBio, Nutrition, Marine, Industrial), and the companies' primary focus were identified.
Sub-sector	The sub-sector within the respective sector the company specifically operates.
Incorporated	The year the company was listed as a New Zealand company on the NZ companies register (founded).
Year lost	The year the company ceased operations or were no longer an NZ-owned company.
Age	The total number of years in operation from the year incorporated to the year ended or lost or still in operation.
Status	Whether the company is active (alive) or inactive (fallen/holding).
Listing	The company is private or public.
Company Stage	The company can be the original entity, merged or acquired (M&A) or no longer in operation and out of business.
Commercial	The current market stage of the company is either pre-market, market, post-market, or a service company. This was evaluated by identifying products on offer.
NZ University Spin-out	The company was a spin-out of one of the eight New Zealand Universities.
NZ University Ties	The company has or had ties such as research projects or heavy involvement from one of the eight New Zealand Universities.
Region	The regional location where the company is registered for service is allocated to one of the 14 regional geographies of NZ using ISO 3166-2:NZ nomenclature.
Environment	Is the company located in an urban setting (greater than 100,000 people) or a rural setting.
Potential Loss Reason	What reason is the company is no longer a New Zealand-owned organisation.
Perceived Innovativeness Score	Scoring the innovativeness on a developed perceived innovativeness scorecard.
Perceived Success	Determining if the company was a success or not by returning substantial outcomes to the shareholders.
Employees	The number of employees working at the company.
Website	The website of the company.
Previous Names	Company previous names were identified to avoid duplicates of the same company.
NZ Companies Office Company Number	The New Zealand company number assigned to the company for evidence of being a registered NZ company.
Address	The registered address of operations for the entity.
Description	What the company does as part of its operations.

3.7.3 Selection criteria

To create the New Zealand biotech battlefield, there were numerous criteria utilised for the inclusion or exclusion of the data set as well as the potential to miss some companies from the profiling.

(a) Inclusion

The selection for companies into the New Zealand biotech battlefield was based on the criteria that they had all five aspects below:

1. Founded and/or the main place of business is conducted in New Zealand
2. A registered company in the New Zealand Companies Office
3. Products or services that utilise biotechnology components and/or processes
4. Self-identify (through media/websites, etc) as being a biotechnology company
5. Able to be placed into at least one of the six biotech sectors (AgBio, Health, Medical Device, Nutrition, Industrial and Marine)

This strategy should capture most of the New Zealand biotech companies to be mapped and analysed to a certain degree.

(b) Exclusion

Approximately 4,000 companies met the inclusion criteria, however, some companies were excluded due to the nature of their business. The exclusions were predominantly based on traditional primary industries and the processing of natural products directly to packaging for sale such as:

(i) Baking (bread)

The Baking Industry Association of New Zealand (BIANZ) contains a membership of 267 organisations, upon evaluation of some of these organisations, it was determined that the classic principles utilising biotechnology towards bread would be excluded from the New Zealand biotech battlefield due to the lack of differentiation from traditional biotech (Shewry et al., 1995).

(ii) Alcohol (beer and wine)

There are approximately 220 beer breweries and 1400 wine producers in New Zealand (Bamforth, 2000; National Research Council (US) Panel on the Applications of Biotechnology to Traditional Fermented Foods, 1992; Shaw, 2019; wine-searcher.com, 2021), of these, a vast number are foreign-owned through acquisition and are New Zealand-based subsidiaries.

(iii) Dairy (cheese and milk)

Many dairy farms in New Zealand have joined under co-operatives, and the processes involved with dairy such as cheese and milk products have been excluded from the study.

(iv) Honey

There were 7,814 beekeeping enterprises in 2017, of which, beekeepers with 1-50 hives are considered hobbyists (accounting for 6,654 enterprises), leaving the remaining 1,160 enterprises as commercial entities (Ministry for Primary Industries, 2018). Due to the vast number of enterprises, a selection of some of these companies were evaluated. It was difficult to go through each company individually to examine the biotechnology processes involved. Therefore, a blanket approach was taken to exclude honey companies due to the uncertainty of the additional processes applied by different organisations beyond processing honey from hives to packages for sale.

(v) Foreign-owned

All companies that were founded outside of New Zealand or whose main operations and headquarters were not in New Zealand and/ or were a local New Zealand subsidiary setup from a large foreign company were excluded.

(c) Missed

In the process of generating the New Zealand biotech battlefield, probably, some companies that meet the inclusion criteria were inadvertently missed. This can be due to several factors such as; lack of publicity, a lack of web presence, being founded and ended before the internet age became dominant, and not being part of any industry organisation that has published industry reports online or physically.

3.7.4 Landscape analysis

The collected company information and respective data points were input to a Microsoft Excel datasheet and uploaded to Quid® or IBM SPSS Statistics for analysis and interpretation where possible. Much of the analysis was conducted through Excel, as Quid® was limited in its use, although generated some graphics, allowing for some insightful analysis.

The New Zealand biotech battlefield was completed by data sorting, an approach in which the researcher collected data relating to certain search terms with the internet and Quid® searches and by defined parameters in Table 12, collected the information and relevant criteria to fulfil the identification

of the New Zealand biotech industry and its various sectors. During this stage, the collected data that applied to the analysis of all identifiable biotechnology companies in New Zealand.

Companies were allocated into categories that were recognisable in the biotechnology industry sectors and varying descriptive and explorative statistics and analyses were conducted to create a clearer picture of the industry in New Zealand.

3.7.5 Perceived innovativeness diagnostic scorecard

A vital aspect of the New Zealand biotechnology battlefield was the development of a scoring system that could evaluate/diagnose a company at a certain time and determine its overall perceived innovativeness concerning its organisational configuration, offering/s, and market aspects. The scorecard developed by the author was applied to all the identified New Zealand biotech industry companies. The scorecard was developed through an iterative approach utilising data collected from the literature review, online survey, and interviews to identify what was believed were essential towards the complete innovativeness of a company. The scorecard aims to be able to capture the core foundations towards creating a competitive, potentially disruptive company and offering to the market.

The framework attempts to be simple to use and calculates the perceived innovativeness score of a company as a whole number between 0 and 100. This value indicates the perceived innovativeness of the company that the framework is being applied to versus other companies in the same context with zero being not considered innovative compared to 100, being highly innovative. The developed scorecard was applied to all identified active companies that were in the New Zealand biotech landscape.

The following section details the development of the perceived innovativeness scorecard.

(a) *Innovativeness Scorecard Development*

The research used a subjective approach to formulate the framework for measuring innovativeness. The process was iterative, involving the back-and-forth applications and review of the data. The development processes underwent multiple stages and growth to come to the final scorecard used for the analysis of the New Zealand biotechnology industry. Initially, a minimal number of factors such as technology and regulatory difficulty, involve the degree of change, newness and novelty of the technology and the respective regulations required to bring technology to the market. After the application of this process, it was deemed that the two factors of technology and regulatory difficulty

were not expansive enough to give a complete picture of the respective company's innovativeness. Two additional aspects were included, intellectual property (IP) and societal impact. These related to whether the company had IP around their core technology such as patents or trademarks. While societal impact examined what type of influence the technology would have on society. While these additional two factors increased the scope of determining a company's innovativeness, it was found that it still did not capture a complete picture.

The perceived biotech innovativeness scorecard was re-evaluated after further analysis of the scored data and literature and was developed further to utilise a broader range of aspects involving the entire company and its offerings. The scorecard utilised parts of The Ten Types of Innovation (Keeley et al., 2013) to help construct the base outline of the model along with concepts involved in the Balanced Scorecard (Kaplan & Norton, 1992). The Ten Types of Innovation concepts guided with the structural components needed while the Balanced Scorecard guided with the performance aspects for the company analysis. This meant that the developing innovativeness scorecard would encompass the complete operations and foundations of a company. Initially, 15 factors were identified and evaluated, and these factors were consolidated into the final nine factors due to overlapping features.

The nine factors were presented as a statement that would be assessed with a 4-point non-Likert rating scale utilising: none or not identifiable (x), little (★), some (★★), or substantial (★★★). The 4-point non-Likert scale is a forced Likert scale where the user is forced to form an opinion. There is no safe neutral option. This makes it a good rating scale for market researchers to get specific responses. In certain cases, in which a specific user opinion is essential, the 4-point scale is ideal. Best for recording opinions on services/products that the user has used/experienced. The individual nine criteria along with the statement can be seen in Table 13.

Table 13. Criteria of innovativeness scorecard statement

Criterion	Statement
Intellectual Property	Amount of intellectual property
Industry Newness	Amount of newness / change within the industry
Consumer Behaviour	Amount of consumer behaviour change required
Infrastructure	Level of business operating structures in place
Competitiveness	Level of competitiveness
Meaningfulness	Amount of potential societal impact
Strategy	Degree of value chain involvement
Translation	Stage of the market process
Sub-sector Rating	Sub-sector rating difficulty

The scorecard tested whether a simple score could be applied, however, it was understood after evaluation that there were some criteria that were more important than others and weighed more heavily towards the innovativeness of a company.

The model applied to develop the innovativeness framework consisted of multiple criteria decision analysis, utilising an adjusted and combined analytical hierarchy process using a pairwise comparison and simple additive weighting between the criteria (Saaty, 1977, 1990). This was selected due to being able to handle both qualitative and quantitative objectives. The criterion is based on expert opinion but also could undergo a Delphi method and be sent out to numerous experts in specific fields to gain an average of the responses to ensure the criteria are appropriate for the fields of study. In this development, first, the problem is presented, and the objective is to develop a framework for an innovativeness scorecard. Second, the relevance and importance of each criterion are evaluated to be included in the framework of the scorecard, and finally, a decision is to be made about which option is selected (Saaty, 1977, 1990; Velasquez & Hester, 2013).

Once all the criteria were selected, they underwent a process of an adjusted pairwise comparison. In this process, two criteria were compared with one another, with one criterion being judged more important than the other criteria with a tick (✓) and given a score of one or a cross (x) and given a score of zero, or if they were deemed the same or equal with an equal symbol (=) and counted as a score of 0.5 (1000minds, 2022). This was done for each criterion against one another resulting in 36 pairwise comparisons being completed. The summary of the results is presented in Table 14 with a logical total score being found for each criterion.

Table 14. Pairwise logic table to determine criteria weighting for scorecard

<u>Criterion</u>	Intellectual Property	Industry Newness	Consumer Behaviour	Infrastructure	Competitiveness	Meaningfulness	Strategy	Translation	Sub-sector Rating	Logic Total
Intellectual Property		x	x	✓	✓	✓	=	✓	✓	5.5
Industry Newness	✓		✓	✓	✓	✓	✓	✓	✓	8
Consumer Behaviour	✓	x		✓	✓	✓	✓	✓	✓	7
Infrastructure	x	x	x		x	x	=	=	=	1.5
Competitiveness	x	x	x	✓		=	=	=	=	3
Meaningfulness	x	x	x	✓	=		=	✓	=	3.5
Strategy	=	x	x	=	=	=		=	✓	3.5
Translation	x	x	x	=	=	x	=		=	2
Sub-sector Rating	x	x	x	=	=	=	x	=		2

Once the logic score for each criterion was found, the weighting of each criterion was sought as a ratio that would equate to 100 from the total criteria combinations to find the weighting each criterion had. Therefore, the total score of one was used and the equation below was created to solve for x as each criteria logic was a multiple of x .

$$\text{Weighting factor} = 100 = 8x + 7x + 5.5x + 3.5x + 3x + 2.5x + 2x + 2x + 1.5x$$

$$100 = 36x$$

$$x = 2.777'$$

The solving for x provided the weight to be multiplied by each criterion logic score by 2.777'. The final weighting for each criterion can be seen in Table 15 where the logical total is multiplied by the single weight factor of 2.777'.

Table 15. Perceived innovativeness scorecard criterion weighting

Criterion	Logic total	Weight
Industry Newness	8x	22.2
Consumer Behaviour	7x	19.4
Intellectual Property	5.5x	15.3
Strategy	3.5x	9.7
Meaningfulness	3.5x	9.7
Competitiveness	3x	8.3
Translation	2x	5.6
Sub-sector rating	2x	5.6
Infrastructure	1.5x	4.2
		100.0

Following the completion of the criteria weighting, this allowed for the completion of the perceived innovativeness scorecard. The scorecard is considered the subjective judgment of a user when assessing a company's innovativeness. Where the 4-point non-Likert scale is applied using star-ratings to assess the factors with none or not identifiable (x), little (★), some (★★), or substantial (★★★), each representing the numerical number of stars as the applied score. The score for each star rating has been multiplied by the located criteria weighting in Table 15. Due to the 4-point Likert rating being used, the highest score possible by scoring the highest in each criterion and range with the weighting scale would be three. Therefore, each criterion scoring possibility was divided by three to allow for an individual scoring criterion score seen in the final Perceived Innovativeness Scorecard in Figure 11.

$$\text{Criteria Score} = \frac{\text{Criteria Star Rating} \times \text{Weighting}}{\text{Score Range}}$$

An example of the scoring using the intellectual property criteria variable with a 2-star rating multiplied by the weighting of 15.3 and divided by the score range of three, would score 10.2.

$$\text{Intellectual Property Criteria Score} = \frac{2 \times 15.3}{3} = 10.2$$

This process was completed for each criterion until the perceived innovativeness scorecard was filled with the weighted score values for the respective star-ratings as seen in Figure 11.

Perceived Innovativeness Scorecard				
	None ×	Little ★	Some ★★	Substantial ★★★
Intellectual Property	0.0	5.1	10.2	15.3
Industry Newness	0.0	7.4	14.8	22.2
Consumer Behaviour	0.0	6.5	13.0	19.4
Infrastructure	0.0	1.4	2.8	4.2
Competitiveness	0.0	2.8	5.6	8.3
Meaningfulness	0.0	3.2	6.5	9.7
Strategy	0.0	3.2	6.5	9.7
Translation	0.0	1.9	3.7	5.6
Sub-sector Rating	0.0	1.9	3.7	5.6

Figure 11. Perceived innovativeness scorecard. The scorecard is used when assessing the perceived innovativeness of a company at a particular point in time. The company is scored on the nine criteria labelled down the left side column and each criterion is assessed as none (no star), little (★), some (★★), or substantial (★★★). This will provide a weighted scoring value for each criterion, of which, the sum of the criteria will provide the perceived innovativeness score for each company.

Once the star-ratings for each criterion was completed, each criterion score was then added together utilising a simple additive weighting method to give a total score as a normalised score of perceived innovativeness with zero being the lowest score and 100 being the highest score and most innovativeness perception.

$$PIS = \sum \text{Weighted Criterion Score}$$

The scorecard was applied against every identified alive New Zealand biotechnology company in the landscape. This required the user of the scorecard to pose the criterion statement to the company and make a judgement of where the company would fit between none (no star = zero) and substantial (3-star) from the perceived innovativeness scorecard seen in Figure 11.

An example of a hypothetical ABC company would be if the sum of weighted scores is combined as 70.8, which is rounded to the nearest whole number giving a PI score of 71.

3.8 LEGITIMATION OF RESEARCH

When assessing the methodologies, methods, and techniques of research, two important aspects are validity and reliability. The two terms are frequently cited and accepted as being common in quantitative research and are concerned with whether the findings are really about what it claims to measure (Onwuegbuzie & Johnson, 2006; Roberts & Priest, 2006; Saunders et al., 2015) and the possibility of being able to replicate the study respectively (Roberts & Priest, 2006; Yin, 1994). There are two broad approaches to validity that are considered, internal validity; concerned with the relevance of items that are set out to be measured, and external validity; which addresses the confidence of the study findings to other people and other situations such as the generalisability (Roberts & Priest, 2006; Yin, 1994). While reliability, when used for research tools, should produce the same or near information if it was used by different people or at different times (Roberts & Priest, 2006).

Compared to the qualitative approaches that have been previously mentioned with a focus on researchers to capture the lived experiences of people and linguistics. Qualitative researchers were often found rejecting the notions of the quantitative terms regarding validity and reliability and have generally been replaced with the trustworthiness of the research due to the subjective nature of interpretation and are worth paying attention to (Lincoln & Guba, 1985; Onwuegbuzie & Johnson, 2006). The core concepts were also reconceptualised into four concepts;

1. Credibility as a replacement for internal validity, dealing with the accuracy of the findings relating to what it set out to test.
2. Transferability, as a replacement for external validity relating to its level of applicability or generalisability to other situations.
3. Dependability, as a replacement for reliability, promoting the repeatability of the study.
4. Confirmability as a replacement to objectivity, which is inherent in the quantitative approach and the findings can be confirmed by others demonstrating the participants' understanding (Bryman & Bell, 2011; Lincoln & Guba, 1985, 1990; Wahyuni, 2012).

As the research's fundamental principle is the combining of quantitative and qualitative approaches that will have complementary strengths and non-overlapping weaknesses, the concepts around validity and reliability have on occasion become troublesome due to the different thinking behind the approaches. However, an approach that has been put forward by Tashakkori & Teddlie (2003) and Onwuegbuzie & Johnson (2006) is the use of a bilingual nomenclature that both quantitative and qualitative researchers can accept mixed methods as, 'legitimation' of the process and should take place at each stage of the research process. Due to the sequential nature of the employed research, the legitimation of the methodology of each data collection will be detailed with traditional terminology.

3.8.1 Survey legitimization

As a typical quantitative tool, the survey was developed with a focus on the responses generated by the respondents. The survey was issued in a public forum, thereby preventing any coercion from the researcher; however, it did mean that the respondents were self-selected as those who would complete a survey by choice. The questions were developed over a period and underwent many iterations before being tested as a pilot study. This helped with the wording used for clarity, where, to ensure replicability and generalisability, definitions were inserted alongside the questions, to align the respondent to group definitions that would allow for the comparison of responses from respondents in different professions and areas of the world (Wahyuni, 2012). The choice of answer selections was seen as important or not important and then converted into numerical percentages, and heat mapping was applied to create an understanding of the perceptions of DI. The questions' relevance was of a general nature that could be applied to any sample, and the same or similar outcomes would be expected.

3.8.2 Snapshot interview legitimization

Due to the socially influenced and constructed component of the qualitative approach of discussions, the research's legitimization is concerned with the trustworthiness of the findings (Lincoln & Guba, 1985) and is judged by credibility, transferability, dependability and confirmability.

Credibility deals with whether the research findings are appropriate to what they initially set out to achieve. The research concerns a complex and understudied topic, and the combination of the disruptive innovation phenomena requires an in-depth approach such as utilising interviews. The use of interviews enabled research themes to be explored by shaping questions that would draw out responses addressing these themes.

The transferability relates to the extent the findings can be generalised to other situations, where the interviews were noted, recorded, transcribed, and reviewed with the questioning starting broad to more specific questions, allowing for the cross-testing with theory to reach conclusions that are more general to be applied to other situations (Wahyuni, 2012). Of course, the researcher's involvement is inherent in this type of approach, but being aware of the assumptions and viewpoints may reduce the influence on the data collected, assisting in generalisability (Rettke et al., 2018).

The dependability of the research promotes its repeatability and consistency. This has been completed by outlining the completed process to acquire the data from the design, collection, coding, and analysis. The participants could not review the audio recording of the discussions with accompanying notes and the ensuing transcriptions due to their anonymous nature. The transparency of the methodological

process, which included the researcher's inherent involvement, reflexivity, and a process of self-critique, was maintained throughout the interview and data collection phase of the project (Darawsheh, 2014; Easterby-Smith et al., 2015; Saunders et al., 2015). This is essential towards the final aspect of confirmability as the two intertwine so that others reading the methodology approach, data, and analysis can confirm the same or similar understandings from the discussions.

3.8.3 New Zealand biotech battlefield and scorecard legitimisation

The use of archival data was instrumental towards increasing the validity and reliability of the overall research as this data is concrete and not freely open to interpretation by any user of the information. The data points collected regarding the New Zealand biotech industry were selected to provide an expansive and open view of the landscape and offer some insight into the relationships that may or may not be prevalent regarding universities and the regions they are located. The collected data also allowed triangulation to occur as it was collected from numerous sources that would also feed into the next stage of data collection regarding the biotech discussions and the previous surveying. This technique and data collection process are highly replicable and can be generalised to any industry. Regarding the perceived innovativeness scorecard, the validity was tested through numerous iterations with the removal of individual criteria or several criteria to the point where no logical or sensible possibilities were applicable and then tested for intercorrelation dependencies. However, a Delphi method with a group of experts could also add to the validity of its development. The data points allocated were tested through IBM SPSS Statistics for reliability and multicollinearity to see if aspects were redundant.

3.9 SUMMARY

This chapter has presented the thinking and decisions made for the research approach regarding the philosophical research stance, and mixed-method approach involving quantitative and qualitative techniques. The outline of the three data stages presented that were required to fulfil the research questions as the data collected could not be interpreted solely by one of the stages. Thus, the integration of three stages involving the survey, interviews and archival analysis development proved suitable to create a comprehensible understanding of disruptive innovation, the New Zealand biotech landscape and innovativeness in relation to successful outcomes. The following chapter presents the findings of the data analyses undertaken.

4. DI SURVEY

This chapter presents the findings from the online survey advertised publicly in the LinkedIn online forums pages and conducted in 2016 through the internet web browser and phone/tablet app, Qualtrics. The survey aimed to examine and gain an understanding of the perception of disruptive innovation theory.

4.1 DESCRIPTIVE OVERVIEW

The data for this study was collected using an online web-based survey program called Qualtrics. The survey achieved 43 completed, useable responses. There were over 100 attempted or started surveys but they were not completed surveys. As this survey was not sent directly or targeted to any individual, the survey could not record a no-response metric due to advertising to the public in online forums, such as LinkedIn business and research groups, therefore avoiding researcher coercion for participation. Once the data collection period ended, the data were analysed in the web browser software of Qualtrics, and the raw data was transferred to Microsoft Excel and were ranked in the order of greatest selection to lowest selection by the respondents from the overall responses.

(a) Demographics of the respondents

The industries, roles and geographical prominence of respondents were seeking to allow for comparisons of different metrics. The respondents were identified from a range of industries seen in Figure 12, so no one industry dominated the results.

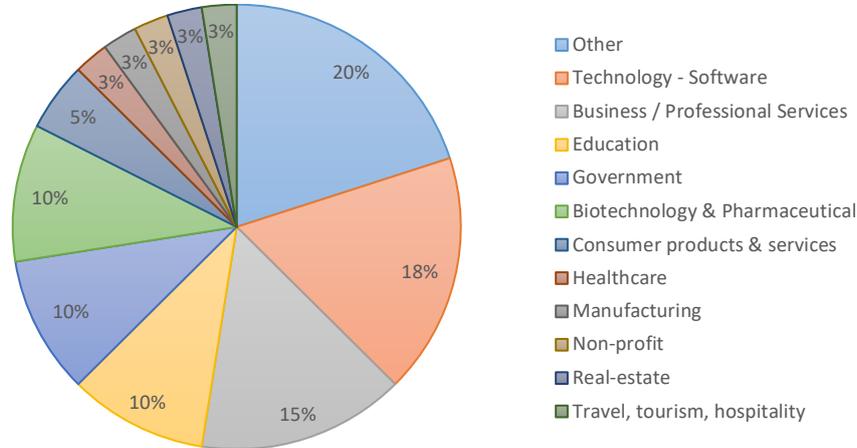


Figure 12. Survey participants working industries

The technology-software industry was the most prominent of the respondents, although the wide selection of industries meant that this was not as large as could be expected. This wide range of industries was sufficient to represent a population that would potentially encounter disruptive innovation theory.

The roles within a business implied the influence that respondents had on company decisions and directions were recorded. It was found that the respondents were from diverse backgrounds and depth of roles seen in Figure 13. The role that was the most selected was that of Senior Management (19%) compared to Executives (excluding the chief executive officer - CEO), which is the least selected with 8%. There was a near-equal divide between the remaining categories between 14% and 11%.

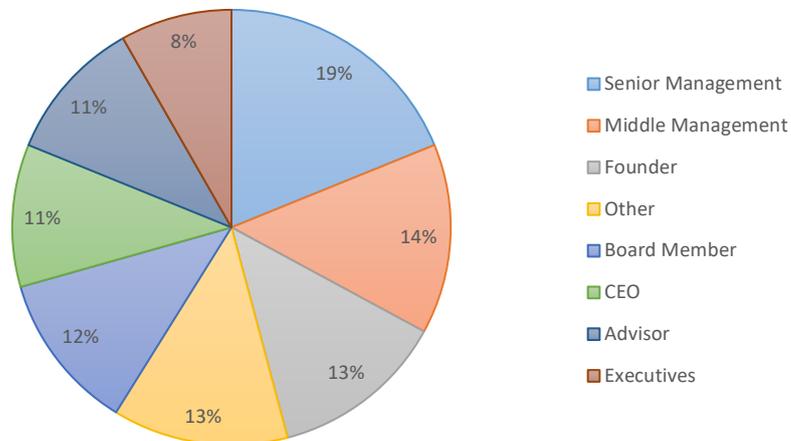


Figure 13. Survey participant's employment positions

The respondents were from a mix of geographical areas seen in Figure 14, depicted by large geographical catchments. The responses were predominantly from a mix of European countries (such as the UK, Germany, Italy, Spain, and Portugal), New Zealand and North America and a few from Asia, which could also be due to the platforms used to advertise the survey. An aspect of the research analysed the data from a perspective of NZ-based versus the rest of the world (ROW) based respondents, representing NZ = 19%, ROW = 81%.

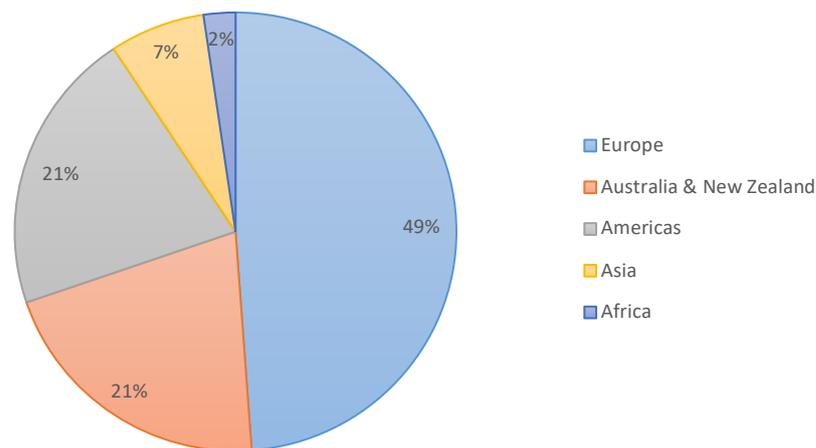


Figure 14. Survey participants in geographical locations

(b) Assessing non-response bias

Non-response bias refers to a bias in survey results that occurs when the population of respondents who do not participate in a survey is not randomly distributed (Berg, 2005). Assessing non-response bias is important because if the population of non-respondents differs significantly from the population of respondents to a survey, the results will not allow one to make generalised statements for the entire study sample (Berg, 2005). Non-response is not seen as an issue for this survey as it was released as a voluntary, anonymous online survey which was not directly sent to any individuals. The respondent sample is from various industries, roles, and locations, which is a better representative of the population. However, there is potentially the case of selection bias with participants self-selecting themselves to complete the survey.

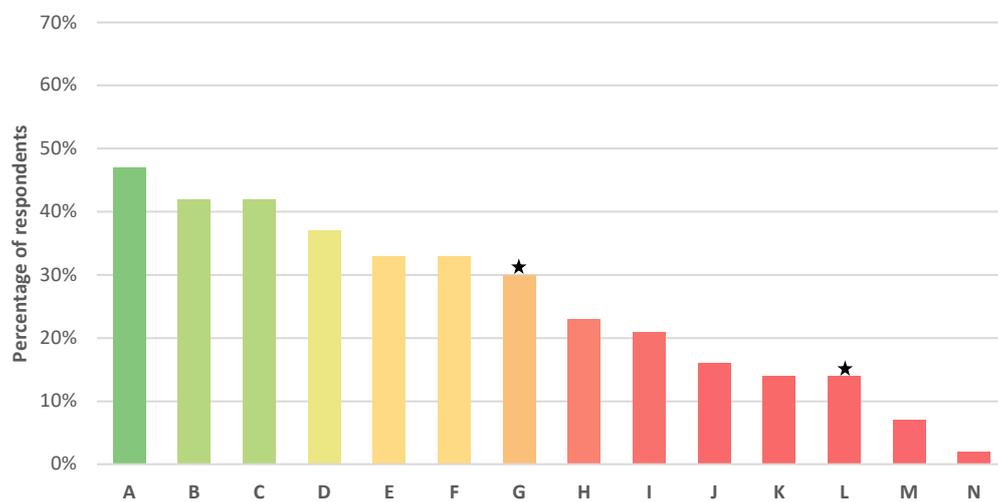
(c) Dealing with missing data

Of the 115 responses received, 43 responses were usable for data analysis. This is because participants started the survey but failed to complete the survey or were identified as spam. Therefore, the information was regarded as not acceptable or useable to the findings as there were high levels of missing data on critical aspects. Thus, these responses were excluded from the analysis. The missing data and incomplete surveys may influence the survey's overall response; therefore, it was decided that all data related to incomplete survey responses should be removed.

The number of participants was sufficient to be able to provide representative data, where Roscoe proposed a rule of thumb that sample sizes larger than 30 and less than 500 are appropriate for most research. If they are broken into sub-sample, then 30 is the minimum size for each category (Sekaran, 2003).

4.2 DISRUPTIVE INNOVATION PERCEPTIONS

To position for DI, it is necessary to find how the term DI is understood. The survey asked participants to select at least one predetermined definition to best align with their perception of DI to understand how the term is portrayed and applied in the real world. The understanding of disruptive innovation is not entirely understood due to the responses spread seen in Figure 15.



A	Disorder to the current environment by introducing something new
B	Rapid growth, creating own market, displacing other product(s)
C	Breaks traditional markets by providing functionality thereby broadening and developing markets
D	Changes the bases of competition by changing the performance metrics along which firms compete
E	New product that causes chaos to existing markets
F	The transformation of existing markets and development of new markets
G	★ Markets appear as if from nowhere, creating massive new sources of wealth, tends to have roots in technological breakthroughs
H	Placed at the edge of markets, that eventually rapidly grows, broadening and developing its own market
I	A product that makes a big impact
J	Something new and exciting
K	Utilisation requires a mind shift in customer thinking
L	★ Smaller, cheaper, reliable and convenient products that moves up a market, eventually displacing established competitors
M	Other
N	There is no definition, it is indefinable

Figure 15. Perceptions of disruptive innovation. A steady decline in selections, three categories were selected by greater than 40% of the participants (A, B and C). Most participants believed that there was a definition as the least selected option was that there is no definition; it is indefinable. ★ is the original definition/s aligned with Christensen (1997).

More than 50% of the correspondents selected none of the predetermined definitions derived from previous literature and recent media coverage. Due to the length of the original modern definition by Christensen (1997), the definition was split into the two concepts it contained and received surprisingly low responses of 30% and 14%, as seen in Figure 15 as (G) and (L) respectively indicated by the star.

This raises the question of how well-known disruptive innovation is when the original modern-day premise and meaning are not well aligned or perceived by respondents. This divergence suggests a potential gap between academic conceptions and practical applications in the business world, prompting further exploration into how well-established theoretical frameworks align with real-world perceptions. The most popular choice from the respondents receiving just under 50% of the selection was, 'disorder to the current environment by introducing something new.' Three choices were selected more favourably than the rest: (A) disorder to the current environment by introducing something new, (B) rapid growth, creating own market, displacing other product(s) and (C) breaks traditional markets by providing functionality, thereby broadening, and developing markets. The three choices, although distinctively different, carry a similar theme amongst them, which involves the breaking of the traditional sense and rapidly creating its market.

Part of the modern definition, the choice of "smaller, cheaper, reliable and more convenient products that moves up a market, eventually displacing established competitors," was not seen as pertinent for disruptive innovation as it was the least selected of all available choices except for "Other" and "There is no definition, it is indefinable" that were selected the least. There was an indiscernible difference when the responses were filtered by role or geographic location compared to the overall responses seen above in Figure 15.

The wide spread of responses in Figure 15 highlights the rich tapestry of perceptions regarding disruptive innovation within the surveyed population. The absence of a single dominant definition suggests a diversity reflective of the multifaceted nature of disruptive innovation. This diversity warrants further exploration to identify potential patterns based on industry context, organizational culture, or individual experiences.

Disrupted or disruptor?

The participants were asked if they perceived being disrupted and if they identify as the disruptor, the responses were collated in Figure 16. Greater than half of the respondents perceived that they had not undergone a disruption in their line of work although the divide is close to half with 54% No, they have not been disrupted to 44% Yes, they were disrupted.

		(2) IDENTIFY AS A DISRUPTOR			
		Yes	No	Maybe	TOTAL
(1) PERCEPTION OF BEING DISRUPTED	Yes	27%	12%	5%	44%
	No	15%	27%	12%	54%
	DK	-	2%	-	2%
	TOTAL	42%	41%	17%	

Figure 16. Perception of disruptor or disrupted. Percentage of respondents that perceived that they have faced a disruptive innovation (1) or were the cause of a disruption (2). A near-equal divide between the two categories, although more respondents were unsure if they were the cause of a disruption. Note: DK = Don't Know.

When the question was turned around, respondents were asked if they were responsible for disruptive innovation. The response was near-equal between Yes and No (42% and 41% respectively), and an increased number of participants were not sure (17% Maybe). Looking at the differences in the responses to the two separate questions, those that initially selected Yes or No first for the (1) perception of being disrupted were also likely to respond the same way for the (2) question identifying as a disruptor. However, there was also a greater proportion that selected No and was unsure if they were a disruptor. The near-equal divide between those perceiving being disrupted and those identifying as disruptors underscores the complexity of individuals' experiences with disruptive innovation. The close percentages indicate that individuals view their roles in the disruptive landscape in nuanced ways, with some acknowledging disruption and others uncertain or denying its impact.

When looking specifically between the respondents' roles, it appeared that the higher the position of an individual, the higher the chance that they perceived that they had been impacted by disruptive innovation. Greater than half of the Board of Directors (BoD) and Chairman, Founder, CEO (the largest perception of being disrupted at 67%), Advisors and Other Execs perceived this compared to the Middle, Senior Management and Other roles. This trend was also seen with identifying as a disruptor, with the higher positioned and greater influencers of the company responding quite differently again to the Middle and Senior Management, particularly with these two segments being quite strong in perceiving that this disruption had not occurred. The variations in perceptions based on roles and geographical locations highlight the contextual nature of disruptive innovation experiences. Senior management roles and individuals in specific geographic locations exhibit distinct perspectives on being disrupted or being disruptors, indicating that the impact and understanding of disruptive innovation are not universally homogeneous.

Geographically, the NZ-based group were more inclined to believe that they have not been the cause of disruptive innovation. In contrast, the ROW group offered a mixed opinion similar to the overall outcome, as seen in Figure 16.

4.3 EDUCATION AROUND DISRUPTIVE INNOVATION

The responses around the need for education for disruptive innovation present uncertainty about the concept in Figure 17 suggests a nuanced landscape. Nearly half of the respondents think that 'maybe' education is required about disruptive innovations before the marketplace will adopt them. Nearly one-third favoured education being required while just under one-quarter did not think it was necessary.

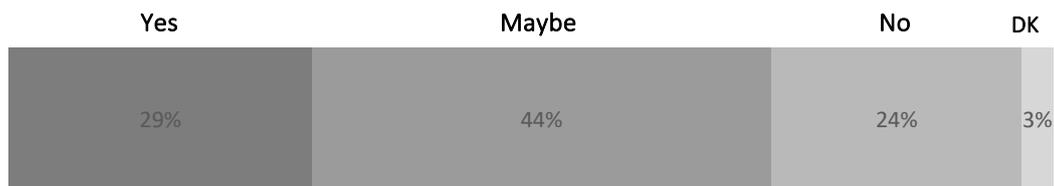


Figure 17. Education required for disruptive innovation. The largest group of respondents were that maybe education is required for disruptive innovation. Of the respondents that were of a sure response, there was a near equal divide between Yes (29%) and No (24%). Note: DK = Don't know.

Looking into the specific respondent roles, the Middle and Senior Management are evenly divided across the three choices compared to the other roles who appeared more inclined to favour one of the choices such as the C-suite group (CEO and Other Execs) who were the most in favour of education being needed.

Continuing the topic around education, it can be seen in Figure 18; there is no single form of favoured education to understand or learn disruptive innovation. There was a slightly higher selection for "Other", which included suggestions such as social media groups predominantly being the way to educate. The typical means of education for business professionals of conferences, online tutorials, advertising, and universities were not too far behind, while workplace training days were not desirable. Multiple education choices could be made, and 47% chose two or more education choices, while 47% selected only one, with the remainder not selecting any. The diversity in preferred forms of education suggests that traditional educational channels may not be perceived as the primary means for understanding disruptive innovation. This finding indicates a need for more unconventional and personalised educational approaches aligned with respondents' preferences.

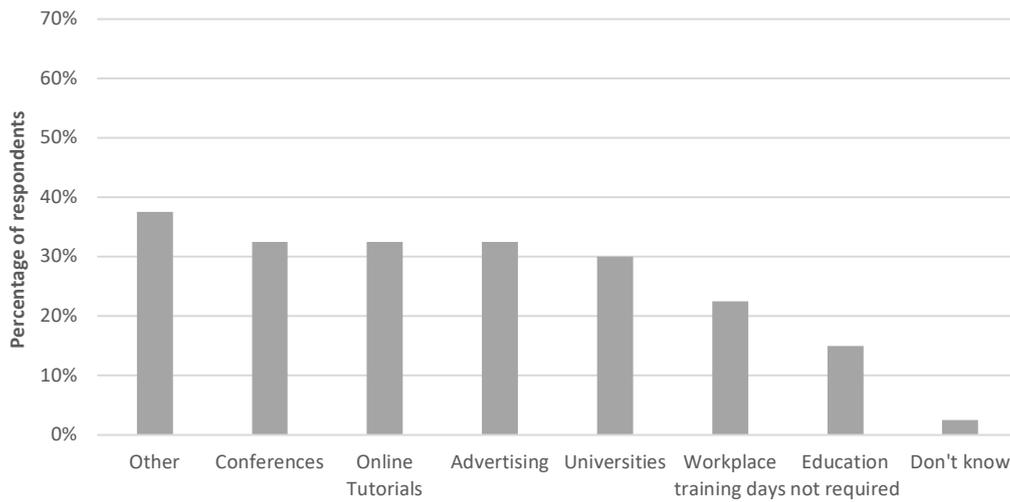


Figure 18. Types of education to allow for disruptive innovation. The typical forms of education were not seen as the primary path for disruptive innovation to be educated by, Other being the highest selection.

Senior Management was the most diverse in their selection of education, spread across all options, and one-quarter selected that education is not required towards disruptive innovations and their understandings. The C-suite group were the most in favour, with greater than half to two-thirds opting for online tutorials as the form for this to occur. Geographically there were some differences between the NZ-based and ROW groups in Figure 19. ROW was relatively evenly spread across six categories than the NZ-based group, who were highly favourable for other and online tutorials and not as favourable towards conferences.

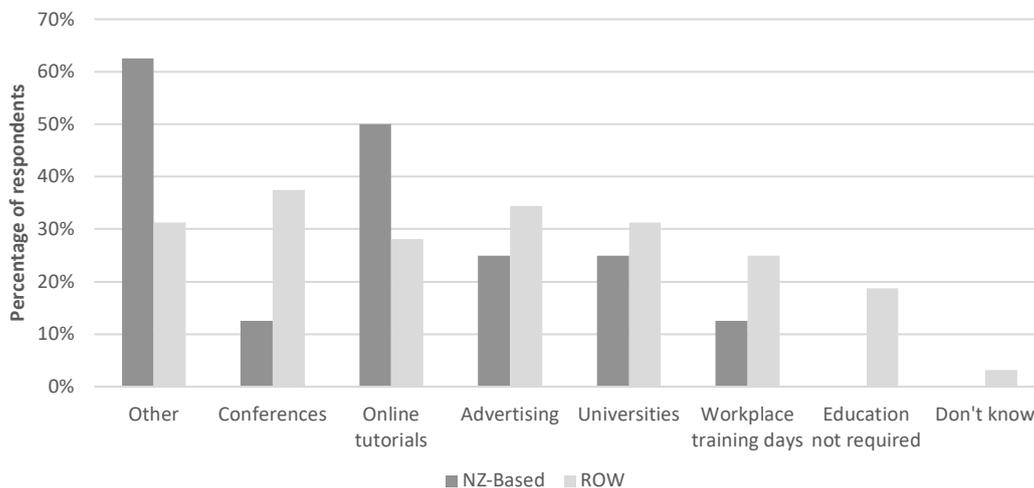


Figure 19. Geographical basis of education. The NZ-based group was more inclined to look beyond traditional education than the ROW group which had a near-equal division between all forms of education.

4.4 ELEMENTS OF DI IN BUSINESS SEGMENTS

The following section required the respondents to select their top three choices, which they believe will lead to disruptive innovation. The components utilised within each section were derived from The Ten Types of Innovation by Keeley et al. (2013) through the Dublin Company and some additional aspects were added to each relevant section. The results are presented in the order they appeared to respondents in the survey. The responses have been ranked based on the greatest selected to the least selected within each category.

(a) Market elements

First, the market elements of how a company or individual aims to deliver their offering (product or service) were presented. From the respondents, the top selections were (A) Open New Markets and (B) Intuitive Adoption, which both were selected most favourably by over 40% of the respondents seen in Figure 20. There were two distinct groupings from the overall results, with five selections that jumped out as the more favourable, acquiring more than a third of the selections including the top two previously mentioned as well as (C) Timing, (D) Behaviour Change Required and (E) Social Media. This was then followed by the second grouping that was not as favourably selected and could be perceived to have a lesser effect towards establishing a disruptive innovation, with (P) Classic Advertising being the least favourable selection of the market elements. This can suggest an acknowledgment of the importance of innovative market entry strategies.

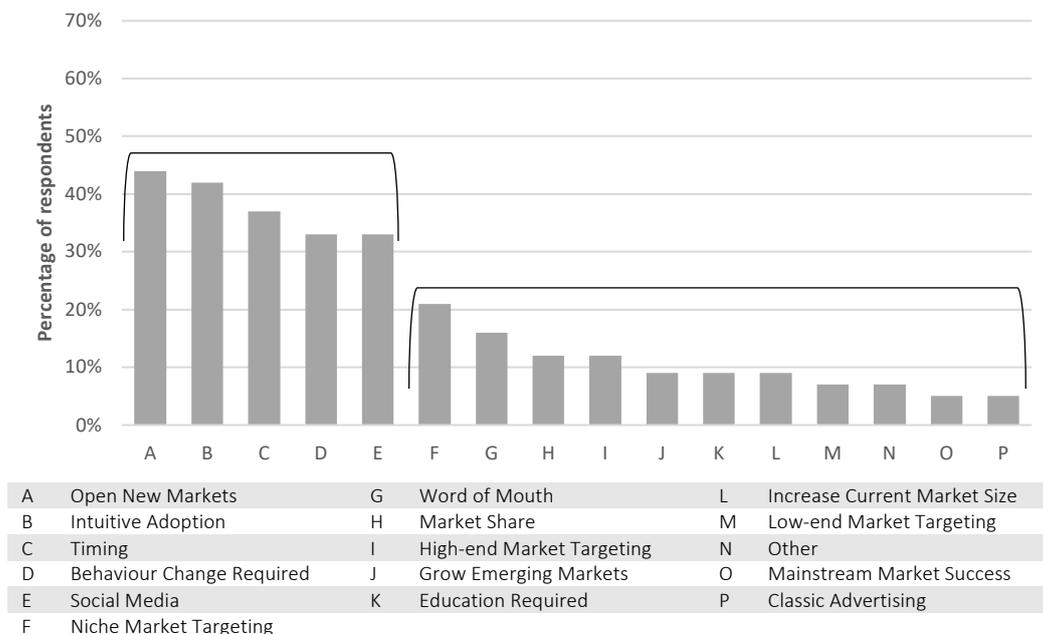


Figure 20. Market elements perceived to lead to a disruptive innovation. There were two groups identified with five highly favourable (A-E) selections for the choices available, followed by a less favourable group (F-P) with (P) Classic Advertising seen as the least favourable regarding the market elements.

A deeper examination of the participant selections based on their role of influence and regional location is seen in the heat-map figures, where the numbers indicate the percentage of respondents for that position or location. Although (G) Word of Mouth was not a top-five selection overall, it was a highly favourable selection for the NZ-based group compared to the ROW group as well as for the positions of the Board and the C-suite as seen in the truncated heat map showing the percentage of selections in Figure 21. This was not seen as favourable by Advisors and the ROW. The highest individual selection came from the Founder group that saw (C) Timing as pertinent for the market elements. Interestingly, (K) Education Required was not favourable in the respondents' perception of the market elements being the equal eighth ranked-choice and less than 10% of the selection.

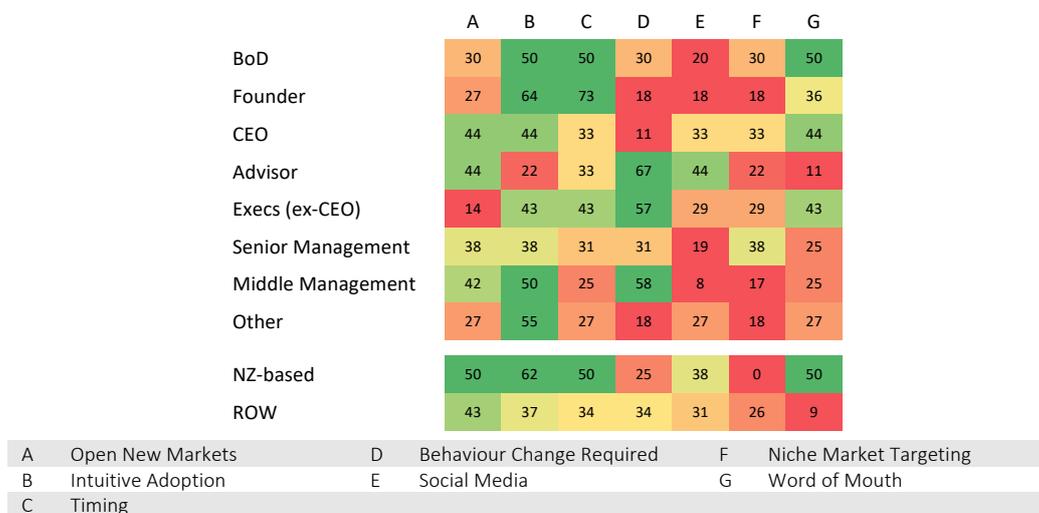


Figure 21. Heat map of market elements' roles and location (truncated). The most significant selections of the market elements from the individual roles and geographical location display the inside differences between various roles and locations, with colour spectrum being the percentage of selections from the respondents and the colours correlating to green (>50%), yellow (35%), and red (<20%). The founder had the highest overall selection for (C) Timing with 73% in favour, while (G) word of mouth did not make the favourable group in Figure 21, it was highly selected by the Board, C-Suite, and NZ-based groups.

(b) Network elements

The network elements dealt with how respondents viewed the connection with others to create value for disruptive innovation. There were two highly favourable elements from the responses acquiring over 50% each; (A) Collaboration and (B) Open Innovation, as seen in Figure 22. The overwhelming preference for Collaboration and Open Innovation underscores the perceived significance of cooperative strategies in fostering disruptive innovation. The close link between these choices suggests a holistic approach to network elements, where one cannot operate without the other being present in some form. These two choices stood out above the rest, followed by the remaining selections dwindling from adequately selected by about one-third of respondents to not favourable at all for the network component towards disruptive innovation.

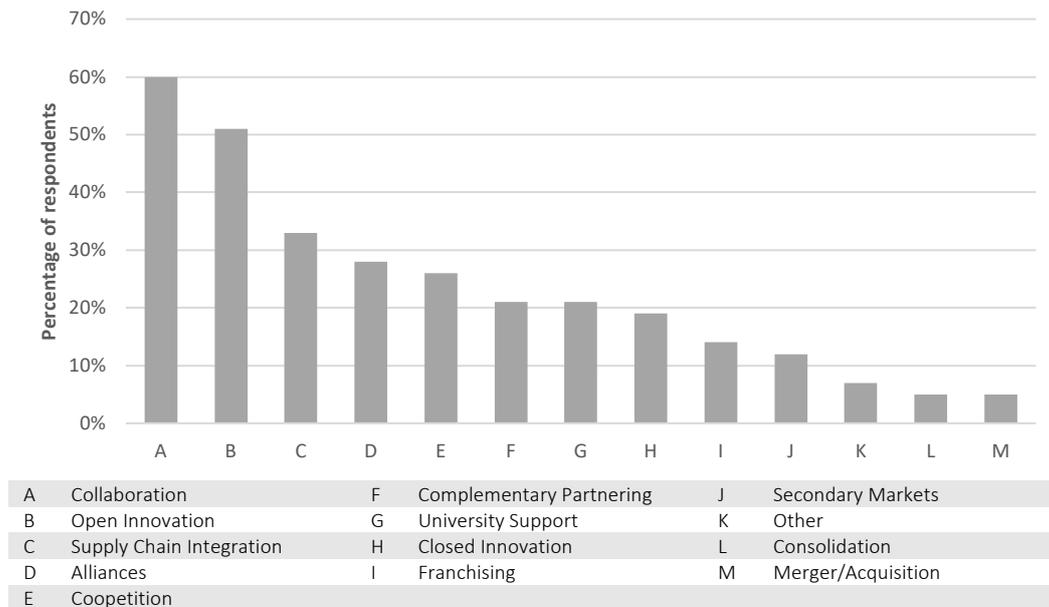


Figure 22. Network elements perceived to lead to a disruptive innovation. Collaboration and open innovation were favourable of the selections compared with consolidation and merger/acquisition being the least favourable.

Three categories showed an adequate selection preference, being chosen by 25-35% of respondents, (C) Supply Chain Integration, (D) Alliances and (E) Coopetition. Whereas (M) Merger/Acquisition was the least favourable and (L) Consolidation received less than 5%. When comparing the geographical location for network elements in Figure 23, NZ-based were in strong favour of the top two selections (A) and (B), receiving 75% for each. This was followed by (F) Complementary Partnering being ranked third out of the selections compared to the ROW, which followed closely with the overall selections, where it was ranked eighth out of the selections. Strong regional preferences for Collaboration and Open Innovation suggest a potential regional inclination towards cooperative strategies.

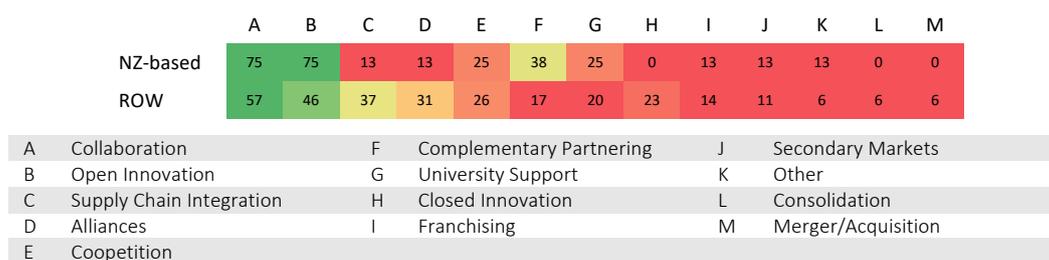


Figure 23. Heat map of network elements' location. ROW responses are similar to the responses in Figure 22, while NZ-based appear to be greatly favourable towards (A) and (B), followed by (F).

(c) Process elements

The process elements involved the proprietary processes that add value and how companies use their signature or superior methods to do their work. The responses presented in Figure 24 identify three groupings. Two answers stood out in the most favourable group compared with the other selections, with (A) Strategic Design and (B) User Generated processes acquiring greater than 40% of the selection. The prominence of these two selection processes signifies the perceived importance of strategic

planning and customer involvement in disruptive innovation. The second grouping of four was selected by more than one-quarter of the respondents; (C) Process Efficiency, (D) Flexible Manufacturing, (E) Predictive Analysis and (F) Intellectual Property/Patent(s). They were followed by the remaining choices that were not as favoured by the respondents. Surprisingly, (O) Lean Production was the least favourable, alongside (N) On-Demand Production, closely related and topical in the age of e-commerce.

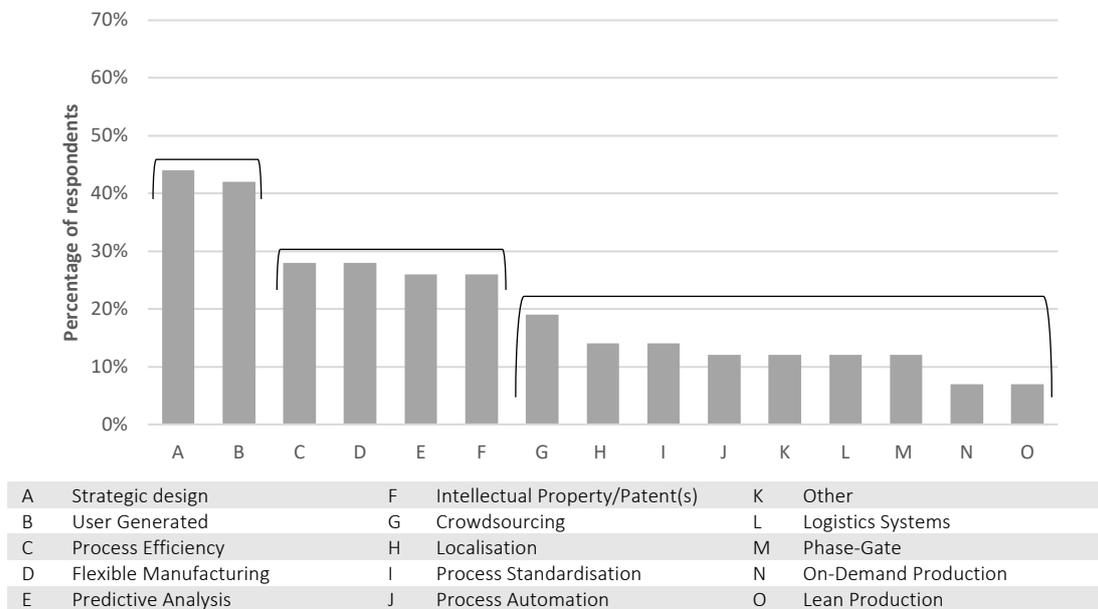


Figure 24. Process elements perceived to lead to a disruptive innovation. There were three groups identified with a highly favourable group (A-B), a moderately favourable group (C-F) and a less favourable group (G-O). (A) Strategic Design and (B) User Generated processes were the most favourable selections compared to (M) Phase-Gate, (N) On-Demand and (O) Lean Production being the least favourable.

A deeper analysis of the data, in the process elements heat map of Figure 25, shows that although positioned fifth in the overall results, Predictive Analysis (E) was first equal in selection by the C-Suite and Advisor group. Also, the Execs, Senior and Middle Management and Other did not favour the selection of (B) User Generated processes compared to the top four roles. Interestingly, when observing the geographical difference in responses, (F) Intellectual Property/Patents received zero selections from the NZ-based group compared to one-third of the ROW group.

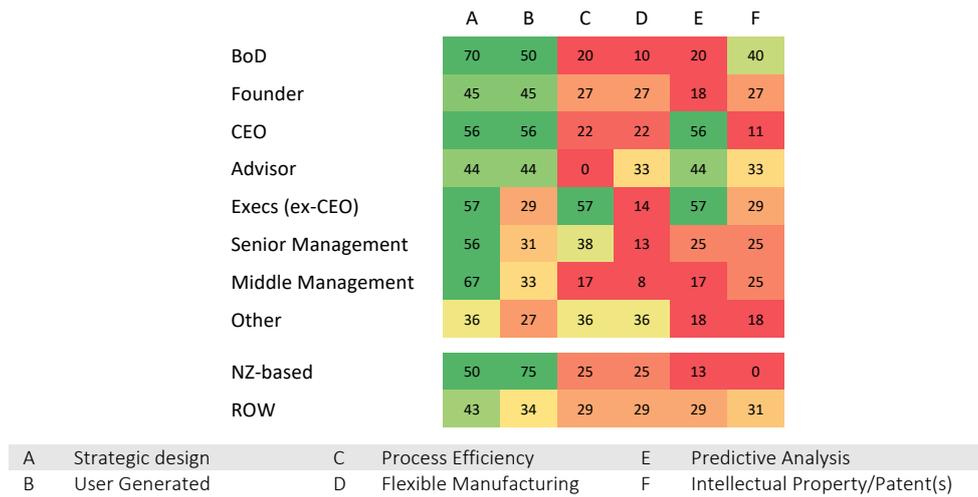


Figure 25. Heat map of process elements’ roles and location (truncated). The most significant selections from the individual roles and geographical location displays the internal differences between various roles and locations. Overall strong selection for (A) Strategic Design from all roles and locations. C-Suite and Advisors were strongly in favour of (E) Predictive Analysis, although ranked fifth overall. NZ-Based recorded zero selections for (F) Intellectual Property/Patents compared with one-third of the ROW-based group.

(d) Structure elements

The structure elements investigated how respondents viewed the organisation and the alignment of their talent and assets. There was quite a spread over the selections, which could be separated into three groupings. The most favourable option, receiving greater than one-third of the respondent's selections as seen in Figure 26; is (A) Organisational Design, (B) Decentralised Management, (C) Small Team and (D) Competency Centre. The somewhat favourable, a grouping of six (E-J), received between 14-28% of selections and finally, the least favourable towards the structural elements, a grouping of six (K-P) received the lowest selections in Figure 26.

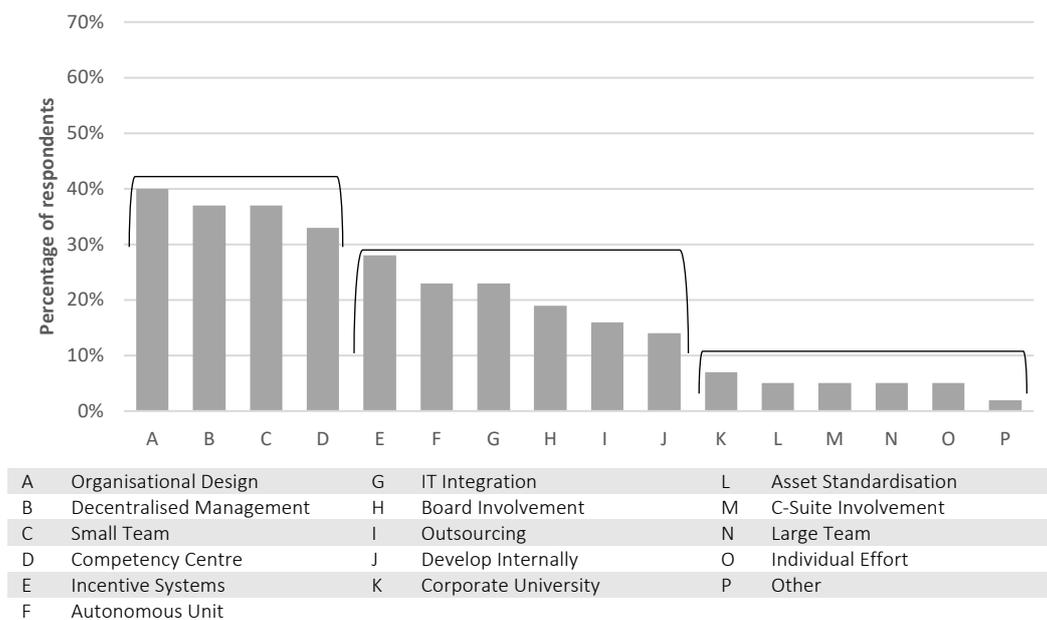


Figure 26. Structure elements perceived to lead to a disruptive innovation. There were three groups identified, with selects (A-D) being the most favourable, receiving greater than 30% of selections each, followed by (E-J) being somewhat favourable and finally (K-P) being the least favourable with the lowest selections.

The analysis by role in Figure 27 shows that CEOs were in the greatest favour for (E) Incentive Systems along with (A) Organisational Design with nearly half selecting it compared to all the other positions, and more significantly so for Middle Management who had zero selection for (E). Two distinct groupings were apparent regarding incorporating a (D) Competency Centre where the Board, Founder, CEO, and Other were less inclined to this structure than Advisors, Other Execs, and Senior and Middle Management, the latter group being much more in favour of a competency centre. The formation and implementation of an (F) Autonomous Unit were in favour of Middle Management compared to every other role. Geographically, the NZ-based group were focused on three selections, (A) Organisational Design, (B) Decentralised Management and (D) Competency Centre, much more heavily than the ROW group which was more spread across several selections. Nearly half the participants of the ROW group were in favour of a (C) Small Team, but this was favoured by none of the NZ-based group.

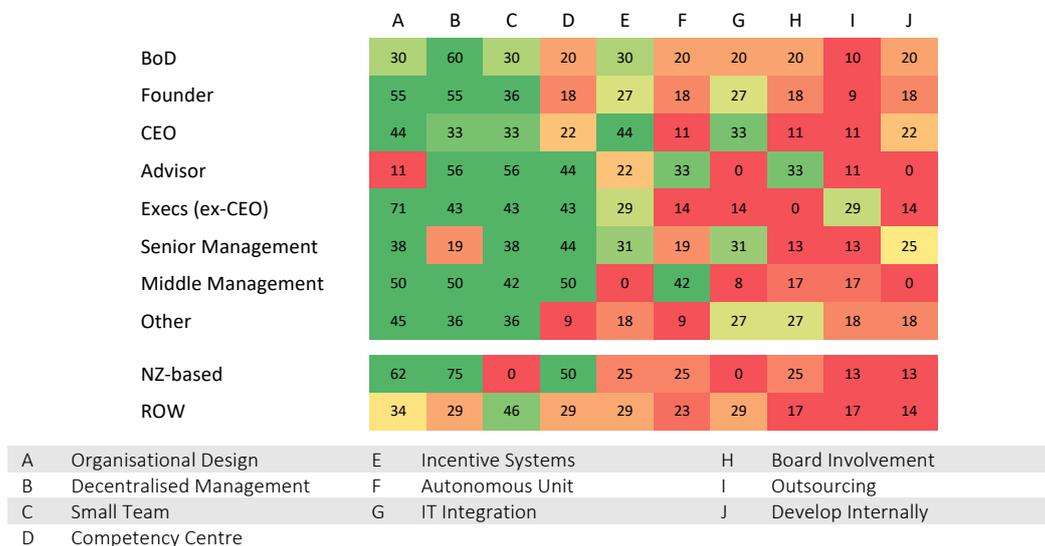


Figure 27. Heat map of structure elements roles and location (truncated). Overall, a strong selection from the various roles for A-D; however, a division for (D) Competency Centre saw BoD, Founder, CEO and Other not as favourable in the selection. CEO was highly favourable towards fifth-ranked (E) Incentive Systems compared to other roles. NZ-Based recorded zero selections for (C) Small Team compared with nearly half of the ROW-based group.

(e) Profit model elements

The profit model elements viewed how respondents perceived how money is made in the best way for disruptive innovations. From the large range of profit model choices offered, there were no clear standouts for the profit model, as only one concept received greater than 30% of selections, (A) Freemium (basic service for free, while charging a premium for advanced or special features), as seen in Figure 28, but not reaching a dominant position, while (U) Float and (V) Switchboard received the least selections from the respondents overall. The weak overall selection suggests a complex landscape, emphasizing the need for a tailored approach based on organisational and regional specifics.

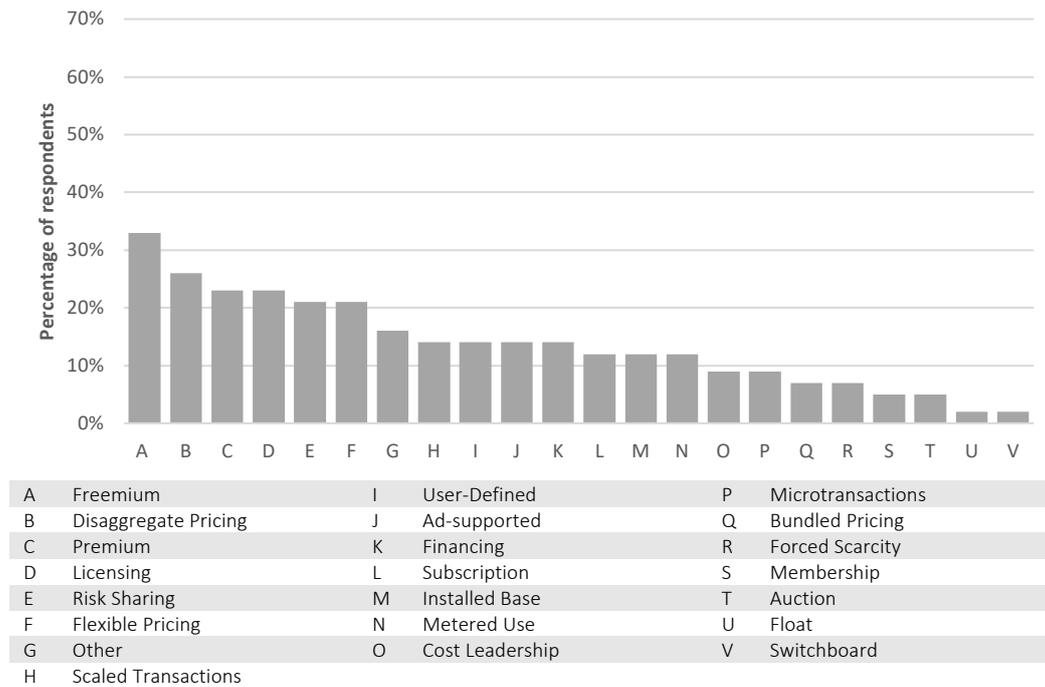


Figure 28. Profit model elements perceived to lead to a disruptive innovation. A wide variety in the selections with the Freemium (A) profit model being the highest selected by the respondents compared to membership modelling which was not as favourable.

There was a spread of varying perceptions based on the job role and the geographical location in Figure 29. The majority of the options were selected by fewer than 20% of respondents and remained red on the heat map. Only eight selections managed to be green, receiving greater than 43% of selections for a particular role or location. Noteworthy variations exist across job roles, where CEOs show a diverse preference for models such as (C) Premium, (K) Financing, and (L) Subscription.

The top selection for both NZ-based and ROW groups was (A) Freemium. Also, in equal first based on the ROW group's selections was (D) Licensing compared to being fifth-equal for the NZ-based group, which is zero selections. Of the job roles, (A) Freemium was greatly favoured by the Founders, Advisors and Middle Management with half of the selections, while Other recorded no selections. The Advisors were also in favour of (E) Risk Sharing compared to all the other positions, but in association with other Execs, were also in favour of (D) Licensing. At the same time, the Other Execs also favoured (P) Microtransactions. The CEO's equal top selections were (C) Premium, (K) Financing and (L) Subscription models.

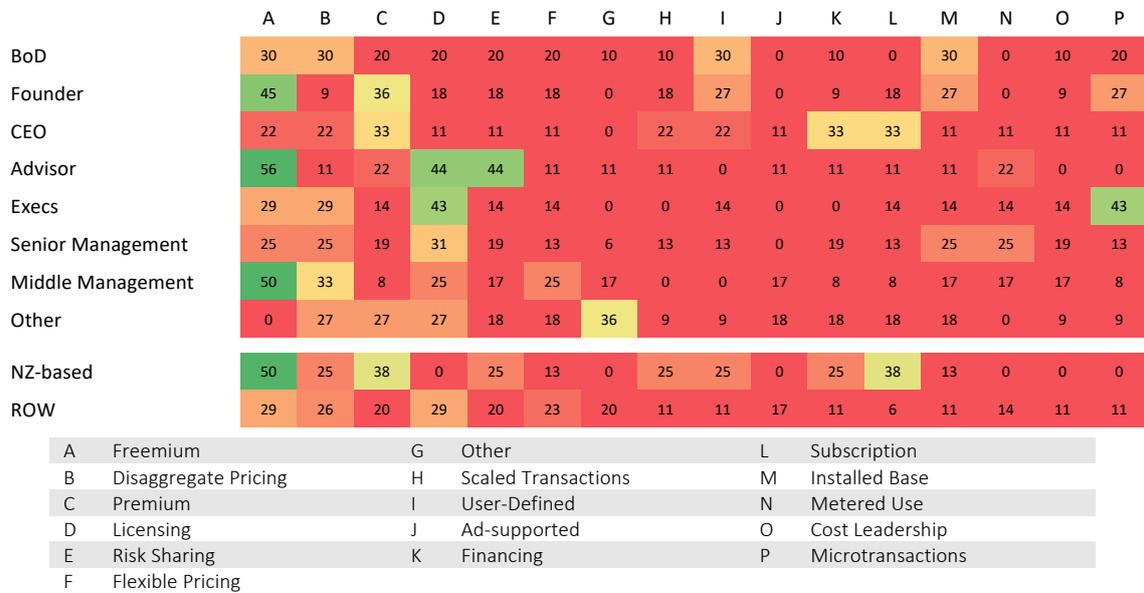


Figure 29. Heat map of profit model elements roles and location (truncated). Overall, a weak selection of the profit model where no strong consensus was formed from the various roles or locations. (A) Freemium was the most selected by four different groups but also saw some have zero selections for it. The Execs favoured the low-ranked item (P) Microtransactions compared to all the other groups. The NZ-based group was in favour of (A) Freemium, (C) Premium and (L) Subscription compared to the ROW group, who leaned more towards (A) Freemium and (D) Licensing, while the NZ-based had no selections for Licensing.

(f) Product performance elements

The product performance elements investigated how the participants develop distinguishing features and functionality for their products. From Figure 30, there were two favoured selections from the options, (A) Ease of Use and (B) Superior Product, with greater than half of all the respondents selecting them. This was followed by a second pairing of (C) Performance Simplification and (D) Engaging Functionality and a third grouping of the not-so-favourable among the respondents regarding product performance.

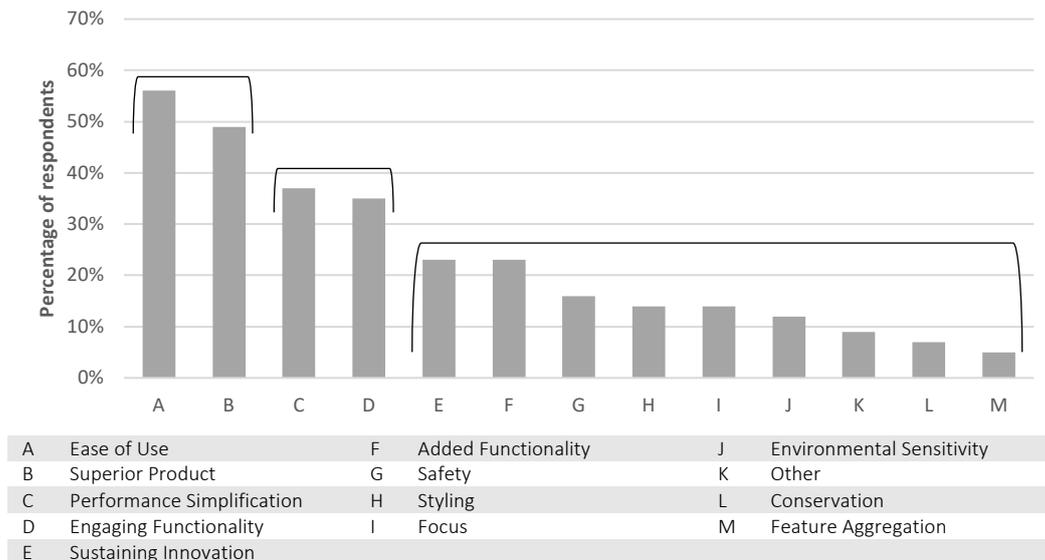


Figure 30. Product performance elements perceived to lead to a disruptive innovation. There were three groups identified with (A) and (B) being most favourable, receiving nearly 50% of selections each, followed by (C) and (D) being somewhat favourable with ~35% of selections and finally, the least favourable group from (E-M).

Looking closer at the responses by the roles, the Other Exec’s equal first selection with (A) Ease of Use was (F) Added Functionality. This stood out compared to all job role selections which were more aligned with (A), (B) and (C), while also at the other end of the spectrum, the overall second pick of (B) Superior Product was weakly selected by Other Execs. The same can be said for Advisors with the selection of (I) Focus being favourably selected as their second-highest choice, quite distinct to the other job roles and being the seventh choice overall. Safety (G) was raised by the Board and Senior Management as a consideration. Geographically, the (A) Ease of Use selection was heavily favoured by the NZ-based group and (D) Engaging Functionality compared to the ROW group which aligned more closely with the overall findings in Figure 31.

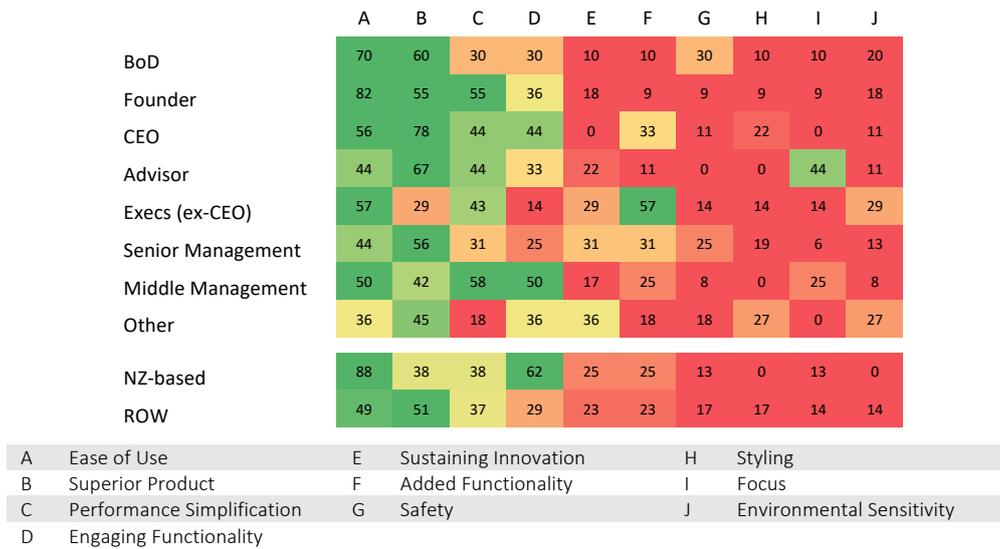


Figure 31. Heat map of product performance elements roles and location (truncated). Overall, a strong consensus for options (A) and (B), with the only exception being Other Execs who were somewhat favourable for it and instead more favourable towards (F). Advisors were aligned with the overall responses except for (I), where they were the only group favouring it. The NZ-based group were strongly in favour of (A) as well as (D) compared to the ROW group, which were more in favour of (B).

(g) Product system elements

The product system elements looked at how participants create complementary products and services for disruptive innovation. From Figure 32, it is evident that there was a favoured selection with (A) Radical Innovation attaining nearly two-thirds of the selections suggesting unanimous acknowledgment of its significance. This is followed by four selections that received greater than one-third of the selections, and finally, the remaining five choices were not as favourable. The lowest named (except other) choice overall was (I) Product Bundling.

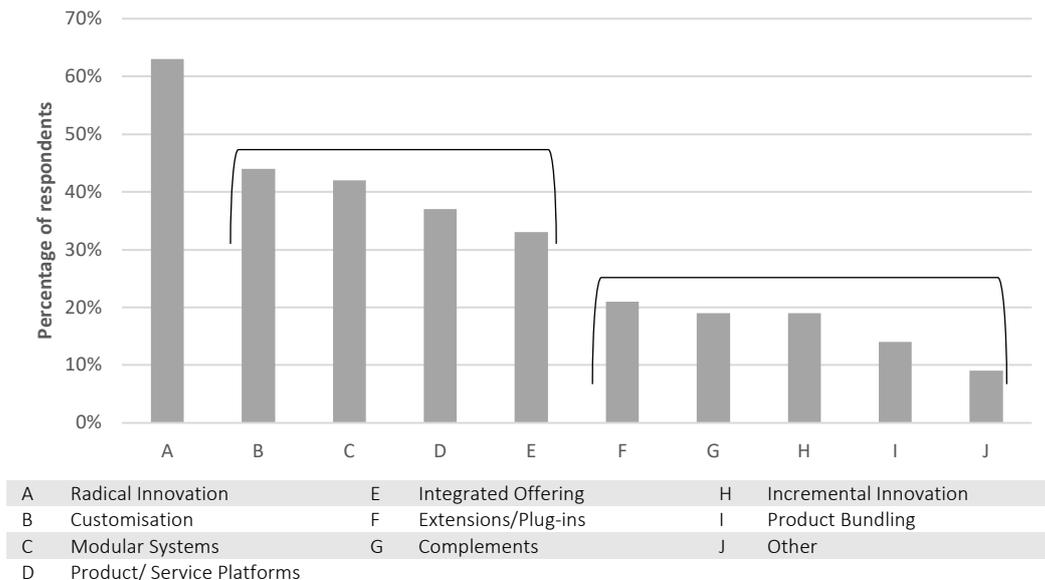


Figure 32. Product system elements perceived to lead to a disruptive innovation. Three groups identified with (A) Radical Innovation were perceived to be the most favourable regarding the product system. A second group that was somewhat favourable (B-E) was followed by the least favourable group (F-J) with (I) Product Bundling as the least favourable named choice.

Looking at the positions within the company in Figure 33, there were heat-map groupings for certain selections. Customisation (B) was identified as favourable for Other Execs, Senior and Middle Management and Other with greater than half selecting it compared to a much lower portion of selections from the Board, Founder, CEO and Advisors. The same is seen concerning the ROW group compared to the NZ-based group. All positions were well-selected modular Systems (C) except for Other Execs where there were no selections for the option. Instead, surprisingly was more favourable towards (H) Incremental Innovation compared to all other roles and locations. The favouring of (B) Customisation and varying attitudes towards (H) Incremental Innovation, highlight the need for tailored strategies. The C-Suites were less inclined to favour (B) Customisation and (C) Modular Systems, in favour of (D) Product/Service Platforms and (E) Integrated Offerings compared to the Senior and Middle Management. Founders and CEOs were in favour of (F) Extensions/Plug-ins compared to all the other positions.

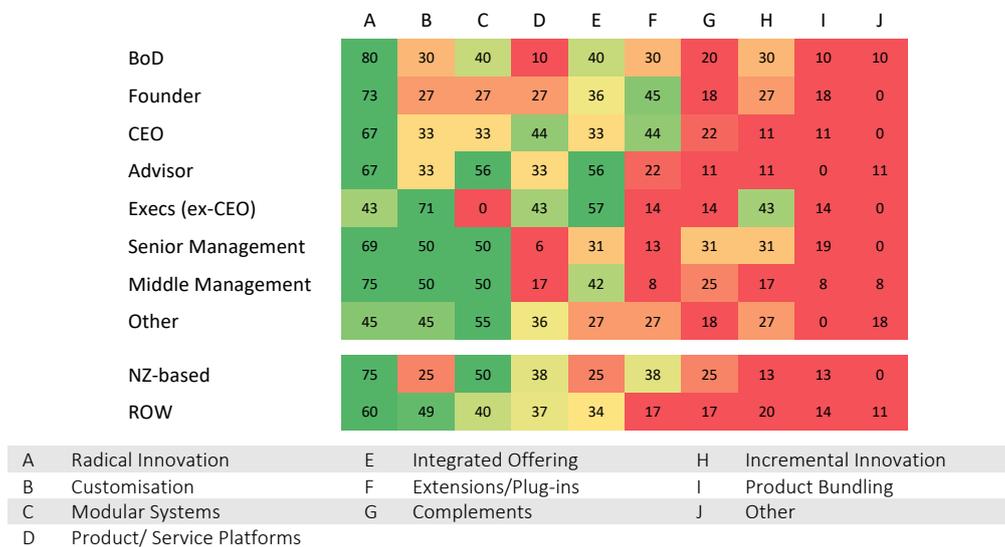
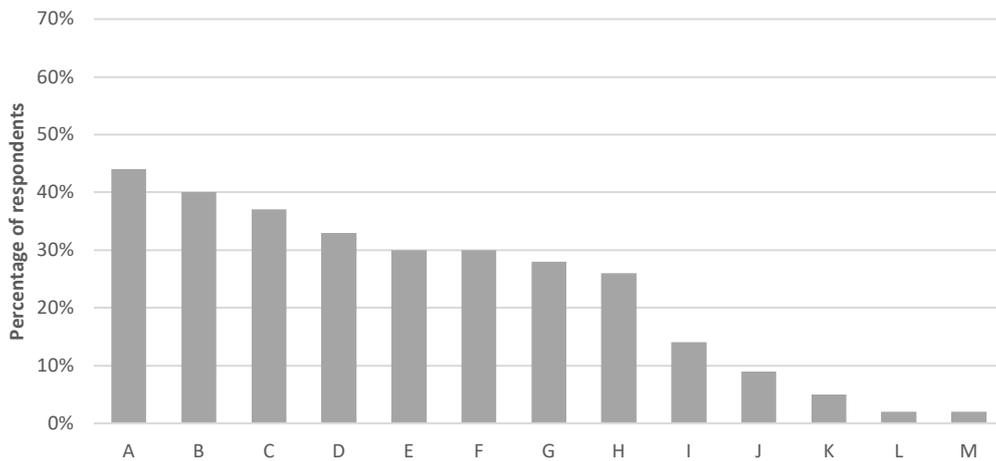


Figure 33. Heat map of product performance elements roles and location (truncated). Overall, a strong consensus for (A) Radical Innovation. The top 4 roles were less inclined to select (B) customisation than the bottom four roles. Other Execs had zero selections for (C) Modular Systems than all other groups that were somewhat favourable; instead, they were more favourable towards (H) Incremental Innovation. The ROW group were more in favour of (B) Customisation compared to the NZ-based group.

(h) Service elements

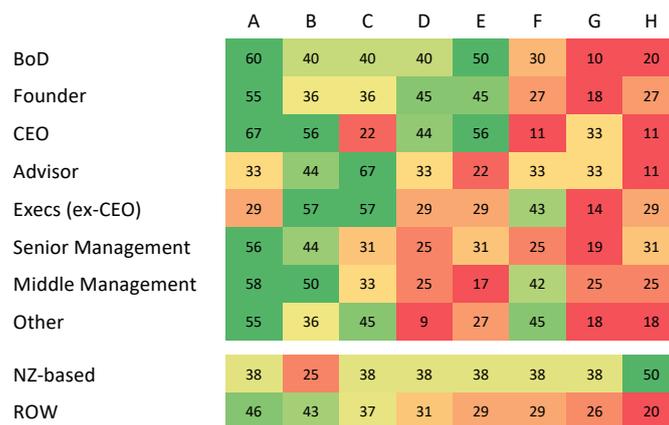
The service elements looked at how participants support and amplify the value of their offerings. Once again, there was a grouping of favourable selections in an almost linear decline for the top eight selections in Figure 34. Superior Service (A) topped the selections, with nearly half of the respondents selecting it. Loyalty programs (I), which are campaigned by companies worldwide, were ranked lowly in the service elements' survey responses.



A	Superior Service	F	Added Value	J	Concierge
B	Total Experience Management	G	User Communities/ Support Systems	K	Other
C	Try Before You Buy	H	Self-Service	L	Supplementary Service
D	Personalised Service	I	Loyalty Programs	M	Lease or Loan
E	Guarantee				

Figure 34. Service elements perceived to lead to a disruptive innovation. There is quite an even distribution for the top selections, with (A) Superior Service being the most favourable while (L) Supplementary Service and (M) Lease or Loan were seen as the least favourable selections.

When analysing by role and location, for the NZ-based group, (H) Self-Service was seen as the most favourable being ranked first, followed by an equal selection for the next six choices as seen in Figure 35. Simultaneously, the ROW group followed the same trend as the overall group with a steady decline from the top selection down to the lowest. By role, the Board, Founder and CEO were more in favour of (D) Personalised Service and (E) Guarantee compared to the rest. While other Execs, Middle Management and Others were more in favour of (F) Added Value compared to the rest of the roles.



A	Superior Service	D	Personalised Service	G	User Communities/ Support Systems
B	Total Experience Management	E	Guarantee	H	Self-Service
C	Try Before You Buy	F	Added Value		

Figure 35. Heat map of service elements' roles and location (truncated). Overall, a strong consensus for (A) Superior Service except for Advisors and Execs that were somewhat favourable towards it. The BoD, Founder and CEO were more favourable towards (D) and (E) than the other roles. At the same time, Execs, Middle Management and Other were more favourable towards (F) Added Value compared to the other roles. The NZ-based group selected (H) Self-Service as the most favourable selection, while this was ranked eighth for the ROW group, which followed the overall findings.

(i) Channel elements

The channel elements looked at how the offerings are delivered to customers and users. From the results, three selections stood out compared to the rest as being most favourable for the channel elements in Figure 36. The highest selected were (A) Go Direct, (B) On-Demand and (C) Non-Traditional Channels. Surprisingly, the bottom three named choices of (I) Indirect Distribution, (J) Flagship Store and (L) Pop-up Presence that received the lowest selections are topical in the growing world of e-commerce, with the reduction of brick-and-mortar businesses.

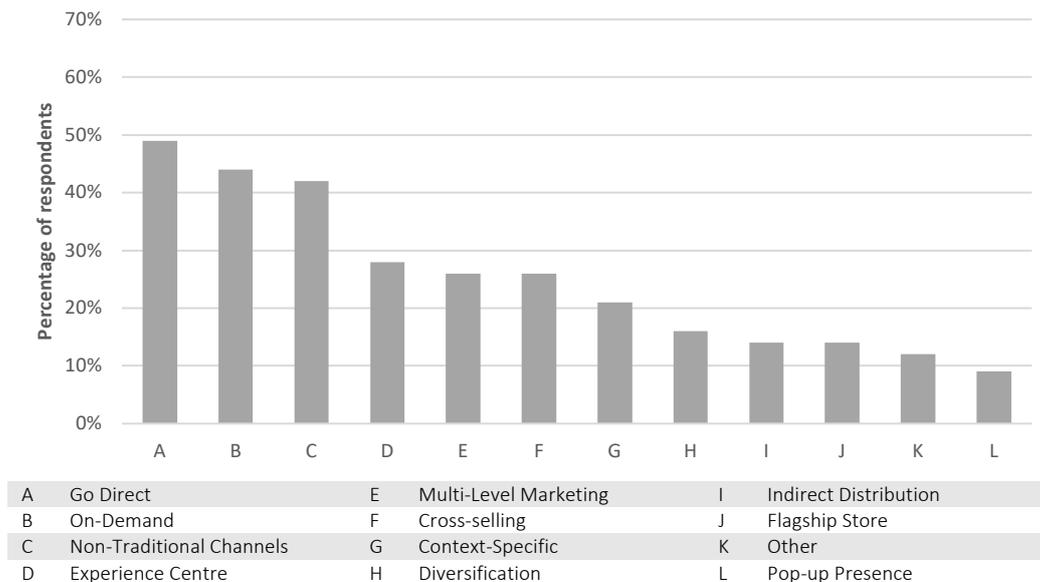


Figure 36. Channel elements perceived to lead to a disruptive innovation. Go direct, on-demand and non-traditional channels were strongly favoured compared to having a pop-up presence regarding the channel elements.

Looking closer at the roles and location of groups in Figure 37, the overall group was favourable towards (A) Go Direct and (B) On-Demand except for Other, where this was only somewhat favourable. The influential members from BoD down to Execs selected these two choices very strongly compared to the Senior, Middle Management and Other. A similar trend was seen with the NZ-based group versus the ROW group for the top three selections. Although only the eighth choice, (I) Indirect Distribution, gathered some attention from Founders, CEOs, Other Execs and Senior Management compared to the other positions. The Other group were somewhat favourable in selecting (E) Multi-Level Marketing compared to low selections from almost all other roles.

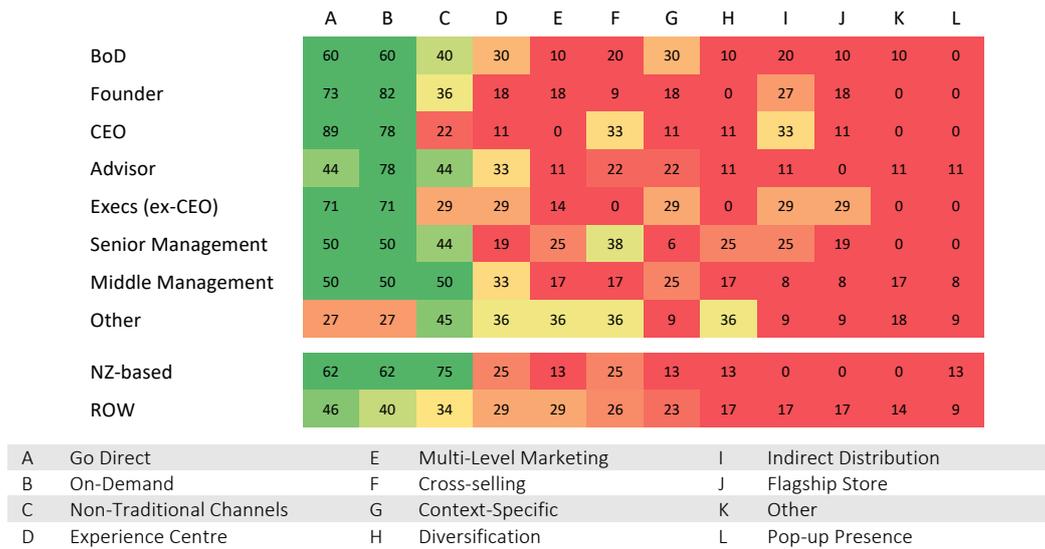


Figure 37. Heat map of service elements’ roles and location. A strong consensus (A) and (B) are the most favoured choices by the roles except for Other, where this scored low. Instead, its highest selection was (C) Non-Traditional Channels, where the C-Suite were not in favour of this option. NZ-Based and ROW groups agreed regarding the top selections; however, the strength of these selections differed.

(j) Brand elements

The brand elements sought out how each respondent viewed the representation of their offerings and business. There were four favoured choices over the rest, (A) Technology Pull, (B) Technology Push, (C) Transparency and (D) Values Alignment, which received selections from nearly half of the respondents each in Figure 38. Sustainability (E) was identified as being in a second group with one-third of respondents, possibly due to the shifting mindset of users of technology and companies towards the environment, followed by the remaining choices.

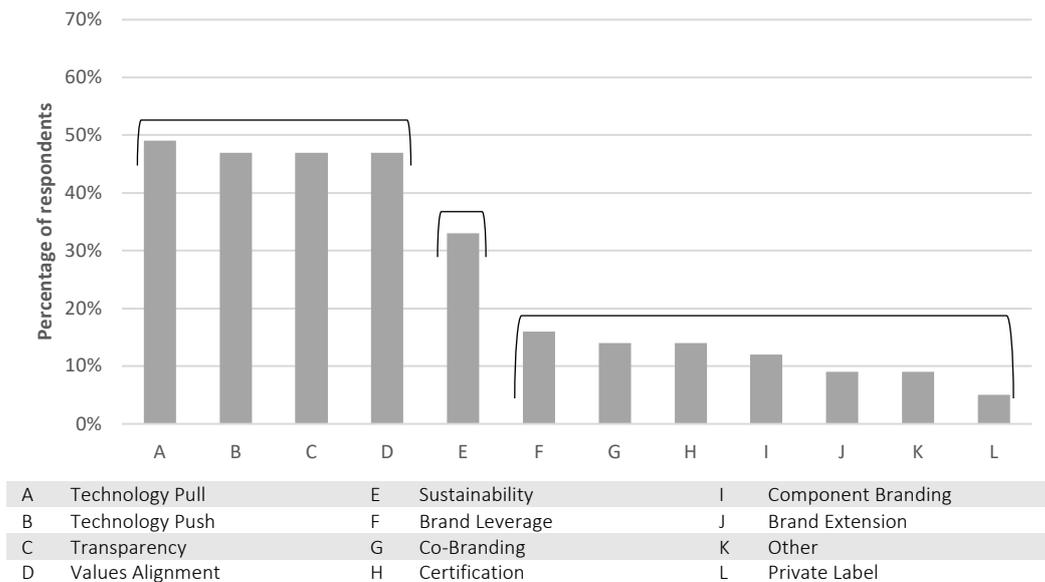


Figure 38. Brand elements perceived to lead to a disruptive innovation. Three groups were identified, with a group of four being strongly selected (A-D), followed by a single group (E) with somewhat favourable selections and finally, the least favourable selections (F-L). A strong divide between favourable and not favourable, with (L) Private Label being the least favourable choice towards the brand element.

Analysing by roles and location, most roles except for the Board and Advisors were strongly in favour of (A) Technology Pull. This was similar for (B) Technology Push, where all positions except Middle Management were strongly in favour. Looking closer, there is a slight difference between the two where BoD to Execs appear more in favour of (B) compared to (A), which is seen more favourably by Senior, Middle Management and Other. Identified as its group, (E) Sustainability was seen as somewhat favourable with the Board, CEOs, Execs, Senior Management and strongly the Other group. Brand Leverage (F) was seen as desirable by the Board and Advisors and (H) Certification and the Founders. Geographically, there were similarities between the two groups; however, the NZ-based group was heavily in support of (C) Transparency. The ROW group was spread across the top four selections with a greater proportion in support for sustainability than the NZ-based in Figure 39.

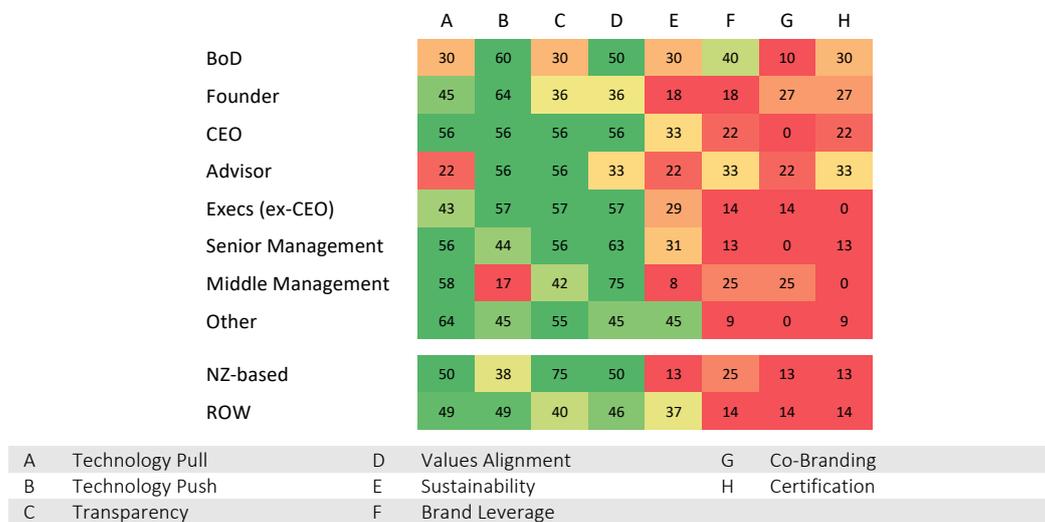


Figure 39. Heat map of brand elements’ roles and location (truncated). Overall, strong selections for the top 4 choices. However, groups can be seen within the choices with the roles when looking at the greater than 50% selections compared to the others. BoD and Advisor were not as strong in selections for (A) compared to the other roles as was Middle Management for (B). The BoD, CEO, Execs and Senior Management were somewhat favourable for (E) Sustainability compared to the other groups. This was also noted for the ROW-based group compared to the NZ-based group.

(k) Customer engagement elements

The customer engagement elements investigated the perceptions of how the respondents fostered compelling interactions in Figure 40. Experience Simplification (A) was the favoured choice within the overall group, with nearly 60% of respondents, indicating a strong inclination towards streamlining customer interactions. This was followed by a steady decline of the selections over the choices available, with (J) Curation being the least selected.

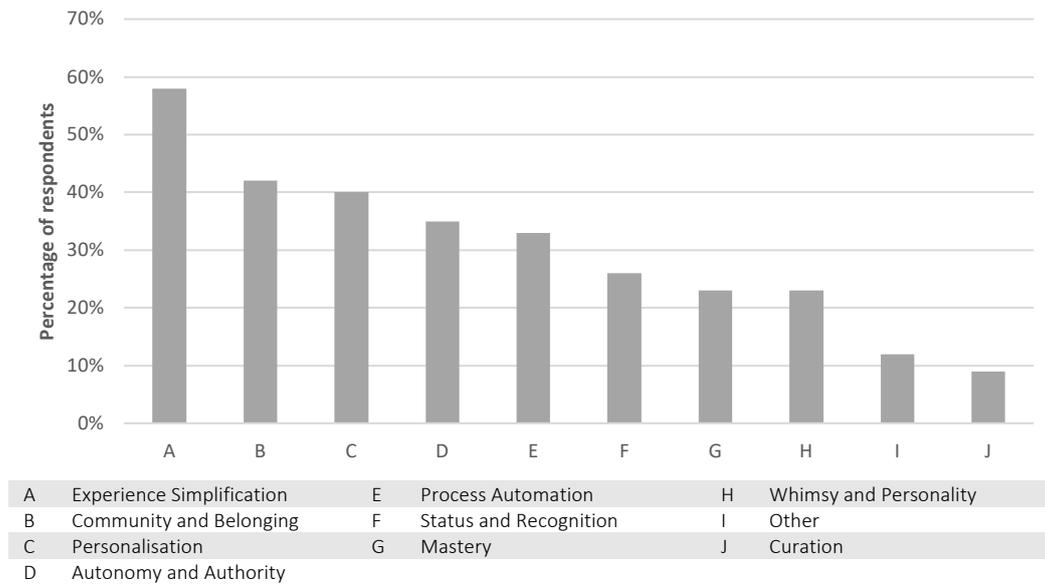


Figure 40. Customer engagement elements perceived to lead to a disruptive innovation. (A) Experience Simplification was the most favourable aspect regarding customer engagement compared with (J) Curation being the least favourable, which saw a steady decline in selection from A to J.

Analysing by role and location, the Execs did not reciprocate the overall view and did not select (A) Experience Simplification favourably. The Execs, however, selected first equal, (B) Community and Belonging and (E) Process Automation, which was also strongly selected for by CEOs and Founders. The Board, Execs and Founders favoured the concept of (F) Status and Recognition compared to the other positions. The Founders and the NZ-based groups were also favouring (H) Whimsy and Personality customer engagement elements compared to the other positions and geographical locations. Community and Belonging (B) was also strongly selected by the NZ-based group with nearly two-thirds, compared to somewhat favourable by the ROW with over one-third in Figure 41.

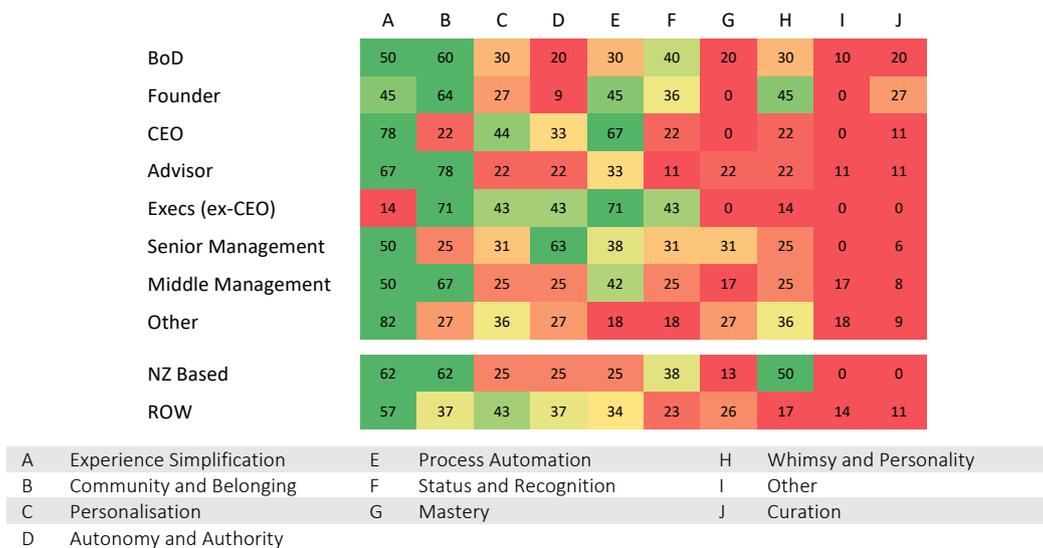


Figure 41. Heat map of customer engagement elements roles and location. Overall, strong selection for the top choice (A) Experience Simplification. However, the Execs group did not select this favourably. There is a mix of results from the roles, where the CEO, Senior Management and Other did not select highly (B) Community and Belonging compared to the other groups. While the C-Suite was highly in favour of (E) Process Automation. The NZ-based group selected (H) Whimsy and Personality strongly compared to the ROW group, which favoured (C) Personalisation.

(I) Summary of elements

Figure 42 on the following page displays the summary of all the elements together based on the respondent’s top three selections for each element with the heat map colouring described in the methodology and ranked from most to least favourable, with distinct leaders in the respective categories to least and blurred leaders for the respective categories.

This is followed by Table 16 which presents the findings as potential drivers or barriers towards implementing a disruptive innovation. The commercial elements all contain at least one driver, with selections greater than 35% and barrier, with selections of less than 10%, apart from product systems.

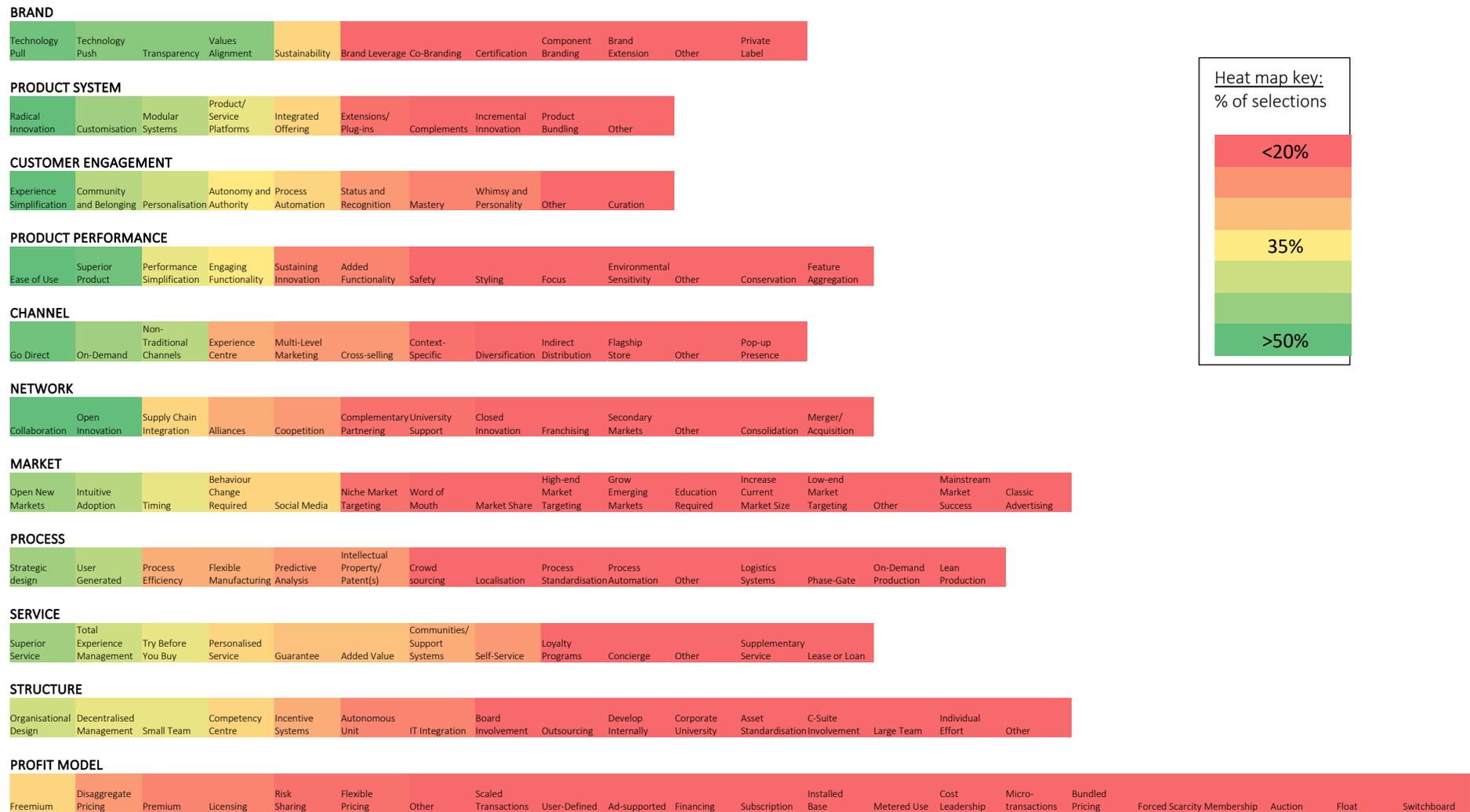


Figure 42. Summary of disruptive innovation (DI) elements. Heat map displaying the 11 elements ranked from strongly selected to weakly selected, based on the percentages of selections for each category. The elements were ranked from the strongest selections to the weakest selections of the participants. Branding was placed at the top as respondents appeared to understand the concept and relate to what they perceived strongly as being positive towards disruptive innovation. Although the largest category, the Profit model was placed at the bottom due to the varying responses being widespread with no clear consensus on at least one standout choice.

Table 16. Disruptive innovation strategies and tactics foundations

Element	Most favourable	Least favourable
Market	Open New Markets Intuitive Adoption Timing Behaviour Change Required Social Media	Grow Emerging Markets Education Required Increase Current Market Size Low-end Market Targeting Mainstream Market Success Classic Advertising
Network	Collaboration Open Innovation Supply Chain Integration	Consolidation Merger/Acquisition
Process	Strategic design User Generated	On-Demand Production Lean Production
Structure	Organisational Design Decentralised Management Small Team Competency Centre	Corporate University Asset Standardisation C-Suite Involvement Large Team Individual Effort
Profit Model	Freemium	Cost Leadership Microtransactions Bundled Pricing Forced Scarcity Membership Auction Float Switchboard
Product Performance	Ease of Use Superior Product Performance Simplification Engaging Functionality	Conservation Feature Aggregation
Product System	Radical Innovation Customisation Modular Systems Product/ Service Platforms Integrated offering	
Service	Superior Service Total Experience Management Try Before You Buy Personalised Service	Concierge Supplementary Service Lease or Loan
Channel	Go Direct On-Demand Non-Traditional Channels	Pop-up Presence
Brand	Technology Pull Technology Push Transparency Values Alignment Sustainability	Brand Extension Private Label
Customer Engagement	Experience Simplification Community and Belonging Personalisation Autonomy and Authority Process Automation	Curation

4.5 RATING THE COMMERCIAL ENVIRONMENT

The survey scope was broadened to understand the commercial environments that each participant perceived in their respective place of business, based on commonly discussed key business success factors. The summary of the 12 categories is presented below in Figure 43 from a Likert-scale scoring system from (1) Excellent to (5) Terrible, followed by summaries of each category individually.

	Excellent (1)	Good (2)	Average (3)	Poor (4)	Terrible (5)	5-point Likert Mean*
A) Availability of talent	24	45	24	5	2	2.2
B) Access to tech infrastructure	25	33	25	18	0	2.4
C) Education system	15	43	23	13	8	2.6
D) Networks	20	25	30	23	3	2.6
E) Access to alliances	15	27	37	20	0	2.7
F) Customer growth (international)	12	29	39	15	2	2.7
G) Availability of high-skill management	15	25	20	35	3	2.9
H) Mentoring	8	20	43	25	5	3.0
I) Development of disruptive technology breakthroughs	10	35	15	23	18	3.0
J) Customer growth (Domestic)	10	12	41	34	2	3.1
K) Government incentives	13	18	30	28	10	3.1
L) Access to capital	10	13	28	30	20	3.4

Figure 43. Ranking the commercial environment for business. A grey-scale heat mapping image of selection percentages to display respondents' perceptions from highly selected (darker grey) to lower selection (white) choices for the numerous aspects of the commercial business environment. The figure is ranked from strongest positive response, (A) the availability of talent with an average of 2.2 (a strong good to average) to the weakest, (L) access to capital with an average of 3.4 (Average to Poor). *Mean using a 5-point Likert scale (Option "Don't know" not displayed as all 0%).

From the results presented in the summary in Figure 43, it is evident that for all 12 categories, no category was perceived as Excellent by a majority of respondents, even the category with the most Excellent selections being ranked excellent by only one-quarter of the group. The closest to that was the (A) availability of talent followed by (B) access to tech infrastructure with means of 2.2 and 2.4, respectively. The weakest category identified by the respondents was (L) access to capital with a mean of 3.4, being Average to Poor, this category also has the highest number of Terrible selections out of any category.

Delving deeper into the responses for the commercial environment relating to common business aspects, it was identified that there were variations between groups of people, such as geographical and company job positions. Thus, five group comparisons were evaluated for each category listed in Figure 43 above. These were the entire respondent group (ALL), NZ-based, rest-of-world (ROW), Board, Advisors and Executives (BAE) and finally, Senior and Middle Management and Other (SMO). The details of each category of A to L broken down individually and comparing the five groupings listed above can be found in Appendix C.

- A) The availability of talent was the strongest positive aspect overall of all the categories, being scored just below Good with 69% of respondents selecting Excellent or Good, leading to a mean of 2.2. There were subtle differences between the groups. ROW perceived that the availability was quite good, with over 70% saying it was Good to Excellent compared to NZ-based where no Excellent selections were recorded but a 50:50 split with Good to Average, therefore no Poor or Terrible selections. There was some similarity when comparing the job positioning of the top level to other levels. However, BAE was more evenly spread across the scale, and the SMOs were more dominant in perceiving that it was good.
- B) Access to tech infrastructure was the second strongest positive aspect for all the categories, with a mean of 2.4 being closer to a perception that it is quite Good. The NZ-based group did not receive any Excellent choices compared to ROW, with nearly one-third and were more of the opinion that it was Poor compared to ROW respondents. There were slight differences between the BAEs and the SMOs, both with a similar trend.
- C) The education system perception of individuals within their own countries was overall seen as fairly Good with a mean of 2.6. Good was the most selected across all the groups, while most NZ-based respondents perceived the education system to be Good, with nearly two-thirds making this judgement.
- D) When networks were the topic of concern, there was an almost equal spread across four choices (Excellent to Poor), meaning the mean for networks by all respondents was above average at 2.6. This was evident in the B&Es group which had an equal divide for the first four options. There were no substantial differences between the groups in the perception of networks in their jobs or geographically.
- E) The access to alliances was overall perceived as slightly better than Average with a mean of 2.7. There were some differences geographically as the NZ-based group strongly selected for Average

and a few towards Good, Excellent and Don't Know compared to the ROW that was spread with some for Excellent, the majority for Good and Average and a quarter perceiving the access to alliances as Poor.

- F) The overall perception of customer growth in an international setting was just above Average, with the largest grouping in Average of 39%, leading to a mean of 2.7. Two-thirds of the NZ-based group selected that this customer growth was Average, with the remainder siding with Good. This was different from the ROW group, which were viewed more positively and negatively, with some Excellent and Poor choices.
- G) The availability of high-skill management was seen as just below Average for the entire group, with a mean of 2.9. This is reflected in the highest overall choice being Poor, with one-third of respondents. A similar trend of all the groupings was seen with the NZ-based, the only group with no Excellent selections.
- H) The perception of mentoring was seen as Average for the entire group, with a mean of 3.0. This is reflected in the highest overall choice being Average, with nearly half of respondents selecting Average for mentoring. A similar trend of all the groupings was seen with the NZ-based, the only group with no Excellent selections.
- I) The development of disruptive technology breakthroughs were perceived as below Average for the entire group of respondents, with a mean selection score of 3.0. The overall group was more inclined to agree and disagree with the category, with 45% selecting positively that it is done well to some extent versus 41% selecting negatively with Terrible to Poor, finally, a small group of 15% perceived it to be Average. Again, compared to the other groups, none of the NZ-based group ranked this category as Excellent, and were the only group where the perception of "Good" outweighed "Bad" substantially. On this criterion, the other groups were on average equal between the positive and negative perceptions.
- J) Respondents perceived customer growth in domestic settings as below average. The overall mean selection score is 3.1, with 75% of the selection being, Average and Poor, due to the lack of confidence internally for many nations and the uncertainty around the world. The NZ-based group were seen as the most positive of the groups with no Excellent and Terrible perceptions and equally matched between Good and Poor. Compared to the ROW group which had some Excellent perceptions and a greater number of Poor and Terrible. The same trend was seen between job groups.

- K) Government incentives were the second-worst category perceived by the respondents as being below Average with a mean selection score of 3.1. For the entire group, Average perception was the largest selection that was closely followed by Poor. The NZ-based group had no Excellent selections for government incentives, and while the largest group for the NZ-based was Good, the perception of Poor and Terrible combined were equal to it. A difference is seen in the other groups that selected Average or Poor as the largest selection, with a small amount of Excellent, Good and Terrible, similar to the overall group.
- L) Access to capital was the worst of the categories, with the mean being 3.4, with half the respondents perceiving it as either Poor or Terrible combined and less than a quarter perceiving it as Good or Excellent combined. Again, a similar trend with the overall group is seen with the ROW and the job positions groups. Compared to the NZ-based, which received no Good or Excellent selections for access to capital and two-thirds selecting Poor and Terrible access to capital.

5. BIOTECH SNAPSHOT

This chapter presents the findings from the snapshot mini-interviews that were conducted during the 2016 AusBiotech biotechnology conference in Melbourne to create a clearer picture of the situation that is present in the biotechnology industry at large in the Australasian region.

5.1 DESCRIPTIVE OVERVIEW

The data presented contains the findings from the mini-interviews conducted with 10 biotech business professionals who attended the AusBiotech 2016 conference. The participants were business professionals representing their work in various roles from business development to contract managers and answered five questions in five minutes.

5.2 DI PERCEPTION

The participants were asked to reveal their perception of the concept of disruptive innovation. Only one of the participants had not heard of the term disruptive innovation before the mini-interview. The perceptions communicated were different to the original definition of Christensen (1997). The consensus from all the respondents was that disruptive innovation was something that makes a big change, with some thinking of new technologies not seen before.

Participant response:

“It is about new technologies that will hit the current ones, so the innovations that are somehow unexpected, more effective than current technologies and they may become breakthroughs”

Other participants thought about the impact on the existing technologies and market players as they perceived disruptive innovation *“that makes other established technologies redundant and no longer relevant to the market”* and also *“an impact on the existing players in the market so you are disrupting that market. A new way of doing something, that is going to upset all existing players in the market”*

From the responses, there was a participant who was well-read in the academic aspects of innovation concepts and related their perception towards Pisano’s (2006) application and the way the business operates compared to the actual product, process, or service.

participant response:

“a change in business model rather than the product that’s actually coming through it but it is more how it engages with the customers and how it needs to be a different system in place for them to engage with the customers”

The mini-interviews unveiled diverse perspectives on disruptive innovation within the biotech community, pointing to potential disparities in understanding between academia and industry—an aspect pertinent to the first research question on aligning perspectives on disruptive innovation.

A majority of participants identified disruptive innovation as a significant shift, often linked to novel and more efficient technologies. Some highlighted its impact on existing technologies and market players, viewing it as a force that renders established technologies obsolete. One participant connected disruptive innovation to a shift in the business model, aligning with Pisano's (2006) framework. Notably, there was no unanimous definition, indicating variations in understanding within the biotech sector.

5.3 DISRUPTIVE BIOTECH

The perception of biotechnology as a disruptive industry divided the group of participants, with about half perceiving that biotech is a disruptive industry, but with different reasons as to why they think it is disruptive. The image of a disruptive industry was seen from different perspectives ranging from a focus on sporadic technology advancements as *“there are some biotechnologies that will be very disruptive, in the same way, for example, [monoclonal] antibodies in the 1980s were considered to be dreamland”* to being more focused on dominating other companies within your operating space, *“it’s a constant battle for new products, new drugs, new methods, whatever it might be, improving and by that it can destroy another company’s weakness”*.

While the other half were of the perception that the biotech industry was *“no, generally not”* a disruptive industry, and saw it being a fairly standard industry that just operates and is *“commercialised around very similar lines of existing value chains... [being] an adaptive technology rather than a disruptive technology”*.

There was a view that was caught between the two, being viewed from different aspects from within a company and how the introduction of technologies could be either disruptive or not, where it appears there is some confusion over the concept of innovation and about disruptive innovation.

Participant response:

Yes and no. It depends on what happens within a company...A whole-cell organism that has been engineered, then that would be not disruptive... because they are pulling that technology to replace something that’s within... what you really need for a disruptive innovation, is something that comes in and usually starts off with a small market share but they are meeting the unmet needs of a set of customers and its usual customers that don’t require as much, it’s not really technical capabilities, some of it is quality. Where you can have a little bit of lower quality and also the lower price because they don’t need the premium products that traditional companies went in that direction with routine innovation in the point of view of entrenched companies.

Although this participant does attempt to use the original definition by Christensen (1997) to describe their example for disruptive innovation with the small market share, they do appear to muddle innovation concepts regarding quality and uptake by users, which was typical among the participants.

The perspectives on whether the biotech industry is inherently disruptive were split, a matter relevant to the second research question about the commercial elements of disruptive innovation. This divergence underscores the importance of delving into and defining the commercial elements that could form the basis for disruptive innovation in biotech.

About half of the participants regarded biotech as disruptive, pointing to sporadic technological advancements such as monoclonal antibodies. Conversely, the other half viewed biotech as a standard, adaptive industry following existing value chains. Some participants expressed uncertainty or a lack of clarity regarding the concept of disruptive innovation in the biotech context. The varied reasons for perceiving biotech as disruptive, encompassing technological advancements and competition dynamics, offer nuanced insights into potential commercial drivers.

5.4 COMMERCIAL SUCCESS BARRIERS

Several barriers were brought to light during the interviews. The most common barrier that was noted by almost all the interviewees was that of money, costs, or lack of money for the various stages of the biotech companies, such as the start-up costs, and clinical trial stage where *“the universities and smaller research organisations cannot afford it,”* and it would then require *“a larger company [to] buy the IP”* to continue the process.

Money, therefore, appears to be the main barrier for biotech companies, in that they are underfunded to complete the journey from idea to market.

Participant response:

Number one, Capital. All biotech companies are undercapitalised for the journey they have to take because the road to commercialisation of becoming a product can be at least 10 years, and the company really has funding for 12 to 24 months

Another barrier that was mentioned by several interviewees was that of regulation, where the complexity of different regions added to time and costs for the already underfunded biotech companies as it *“adds an enormous cost to what we do.”*

Participant response:

One of the biggest barriers is that every jurisdiction in the world has their own clinical requirements and registration process. It could be simplified so that registration in one developed country is naturally then applied to others, why do we need to replicate all of that clinical process again

Another barrier that was mentioned by a couple of interviewees was that of public acceptance, as this still appears to be a barrier in the domain of the food/nutrition biotech sector seeking *“the public acceptance of GMOs, the Frankenfood kind of monster.”*

The market need was found by some participants to be one of the key items, in *“actually having something that is a sufficient benefit that people will be prepared to pay for it”*. Moreover, the price of many products and services increases because of the above barriers, the *“payers aren’t willing to pay as much for it.”* The market need is also related to the overall market size *“and [if] the market size is not big enough... you can’t do it in Australia and if you’re going global, you may as well be in Europe or the US, excuse the cliché, mostly the tyranny of distance, [being] too far away from the big markets.”*

Several barriers to commercial success in the biotech industry were pinpointed, aligning with our third research question that looks at the landscape profile of the New Zealand Biotech Industry. A prevalent hurdle was financial, as participants underscored the challenge of undercapitalisation throughout the extensive journey from concept to market. Additionally, regulatory complexities across diverse regions emerged as a substantial barrier, imposing both time and cost burdens. Public acceptance, notably in the food/nutrition biotech sector, was acknowledged as a distinct challenge. The market need, influenced by obstacles like regulatory complexities, played a pivotal role in determining success. This insight significantly contributes to comprehending the landscape of the New Zealand biotech sector, with a particular emphasis on the economic dimensions shaping its contours.

5.5 BIOTECH FUTURE

The future of biotech was investigated by asking respondents how they thought the future could be improved. Participants presented several potential approaches.

The involvement of the government, and better funding mechanisms with investors appear to be pertinent to most participants. They say that the *“government needs to either make the market have a reason to invest, by giving them benefits, benefits such as tax deductions tax modules, they have to give them advantages for making those investments.”* This was re-iterated in the sense of leveraging the governmental infrastructure that was already in place towards biotech, and enhancing funding opportunities after the research phase to be able to better fund the development and commercialisation phase. As well, investment capital needs to be better used, with a *“balance between capital going into real estate, mining and other sorts, into more speculative investments, in technology in Australia, but particularly biotech.”*

There was a need for better collaboration between government and universities in close association with companies, which was seen as different compared to Europe, where the universities and research organisations are detached from companies, where this can influence and accelerate the industry. This tied in with the clinical trial processes and the need for the *“connectivity of data”* and the hurdles required to go through as when you speak with *“consumers and consumer advocacy groups, they want to see what clinical trials are available”* as this will better utilise resources and increase chances for the appropriate recruitments. The collaboration aspect was again pressed with *“maybe a network where they can go to understand what is required and explain... how to take the project forward”*

An interesting aspect that was raised was the evaluation procedures used in university environments, *“it would be great if we could change those academic researchers were measured less on how many papers and more how applicable and useful that may be.”*

Finally, for the betterment of the biotech industry, *“would love to see big pharma...all the big ones bring R&D to Australia, we’ve got R&D, universities, small biotech’s, [but] the big pharma don’t do it here anymore... that’s the biggest gap we have in our industry.”*

Participants offered valuable insights into enhancing the future of biotech, aligning with our fourth research question on perceived innovativeness and success. Key recommendations included recognising the essential role of government involvement and improved funding mechanisms to incentivise biotech investments. Emphasis was placed on fostering collaboration among government, universities, and companies, highlighting the importance of better data connectivity and streamlined clinical trial processes. Furthermore, there was a call to re-evaluate evaluation procedures in academic settings, advocating for a shift towards measuring applicability and usefulness rather than solely focusing on publication counts. Participants also expressed a desire for significant pharmaceutical companies to invest in R&D locally, aiming to address existing industry gaps. These suggestions, directly correlate with the aim of boosting perceived innovativeness and potentially influencing the overall success of the biotech industry.

5.6 SUMMARY

The insights derived from the mini-interviews with biotech professionals offer significant implications for understanding disruptive innovation in the industry, aligning perspectives, and addressing barriers

to success. The diverse perceptions of disruptive innovation underscore the need for a comprehensive and shared understanding within the biotech community, especially considering potential misalignments between academia and industry. This is particularly crucial as disruptive innovation plays a pivotal role in shaping the industry's trajectory.

The exploration of whether the biotech industry is inherently disruptive provides a foundation for investigating the commercial elements that could drive innovation. The split opinions among participants reveal a nuanced landscape where some perceive disruptive forces, often tied to technological advancements, while others view the industry as more standard and adaptive. This duality prompts further examination of the specific dynamics and commercial drivers shaping disruptive innovation within biotech.

The identified barriers to commercial success, including financial constraints, regulatory complexities, and challenges related to public acceptance, illuminate the hurdles faced by biotech companies. This information is invaluable for Research Question 3, providing insights into the landscape of the New Zealand biotech sector. Financial constraints, in particular, shed light on the economic aspects influencing the industry, highlighting the need for strategic solutions to bolster financial sustainability.

In addressing Research Question 4 on perceived innovativeness and success, participants' suggestions for improvement align with the overarching goal of enhancing the biotech industry's future. The emphasis on government involvement, better funding mechanisms, collaborative efforts, and a shift in evaluation criteria in academic settings reflects a collective vision for fostering innovation and ensuring the industry's success. The desire for major pharmaceutical companies to invest in R&D in Australia adds a strategic dimension to addressing existing gaps in the industry, potentially catalysing transformative advancements. This can be seen visually within the following Figure 44 and the potential relationships between each of the themes.

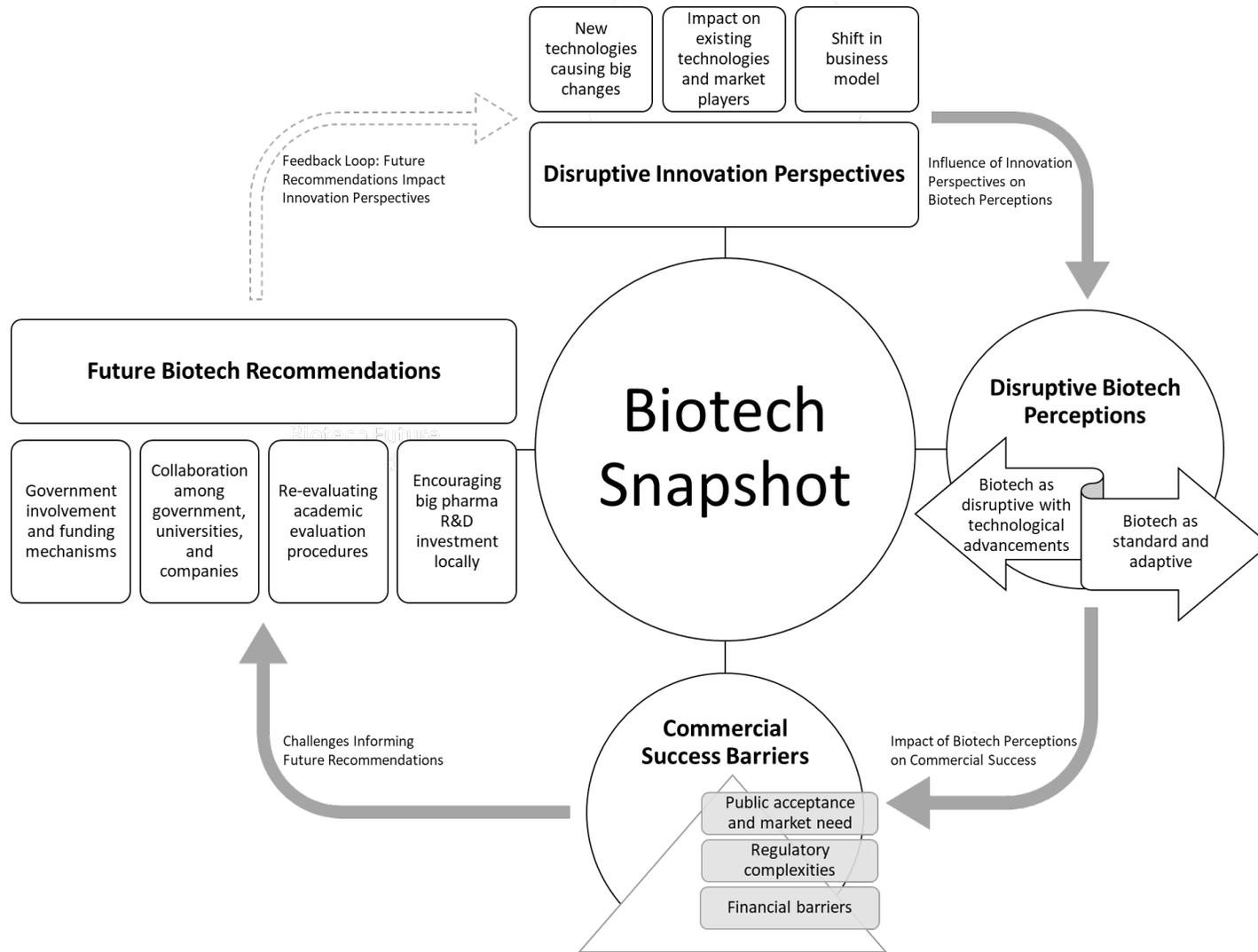


Figure 44. Biotech Snapshot Summary. The figure presents a diagram of the biotech snapshot and their potential relationships. It represents how diverse perspectives on disruptive innovation shape the way individuals perceive the biotech industry's disruptive nature. It also illustrates how the perception of the biotech industry, whether disruptive or not, influences the barriers to commercial success. It also provides how identified barriers contribute to the recommendations for improving the future of the biotech industry. Finally, it indicates that the recommendations for the future may impact how disruptive innovation is perceived in the biotech industry, creating a feedback loop.

6. NEW ZEALAND BIOTECH BATTLEFIELD

The following section is an analysis of the identified New Zealand biotechnology landscape, henceforth called, the biotech battlefield, through the profiling of individual biotech companies that were originally founded and operated in New Zealand, whether they are still alive and active, been successful or fallen (out-of-business), during the modern biotechnology era from the early 1970s. The analysis looked at each company as a whole entity, although, many of the companies are generally founded upon one initial project and as this develops, multiple other projects arise leading to each project being at different stages in the developmental process. These individual projects may or may not have their value chains and even their commercialisation strategy. Therefore, there can be substantial differences within the biotech industry depending on the sector within, relating to the technological and regulatory difficulty associated with the applications of the company, this allows an analysis of innovativeness influence on the success of these companies.'

6.1 NEW ZEALAND BIOTECH INDUSTRY

The New Zealand biotechnology industry was identified to consist of a total of 380 companies (alive and fallen) seen in Figure 45. This consisted of the companies being divided into being actively operating, as being “alive” or as out-of-business and being a “fallen” company. Of the 380 companies identified in the 50 years between 1970 and 2020, 292 companies were recognised as alive and 88 as fallen. Note: the identification is a time freeze of status as of 2020.

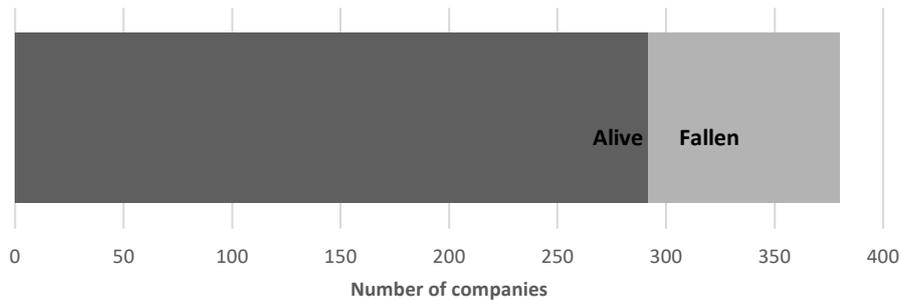


Figure 45. New Zealand biotech companies alive and fallen from 1970 - 2020. The total number of identified New Zealand biotech companies of 380 that are currently alive, n=292 or fallen, n=88.

The biotech industry was viewed from the point of view of the turn of the 20th century, pre-2000, and post-2000 (the pre-human genome project completion year over the 50-year biotech industry life), and the number of companies that were founded and fell before and after the year 2000 in Figure 46. Pre-2000, there were 142 companies formed (37%), compared to the post-2000 formation of 238 companies (63%). Since the founding of these companies, there was almost double the number of total fallen companies for those that were founded post-2000 but when this was adjusted for the proportion of companies in each respective ‘era’, the fallen rate was seen as nearly equal for the pre-2000 era companies with 21% falling compared to the 24% of the post-2000 era companies.

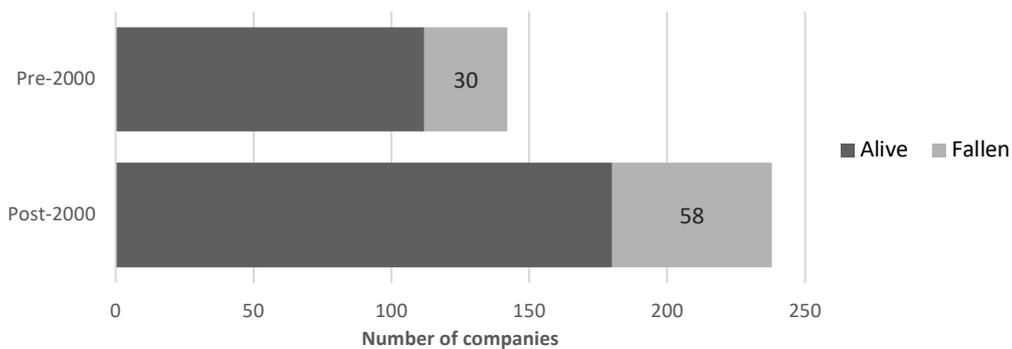


Figure 46. Companies alive and fallen in different eras. The New Zealand biotech industry companies that were formed pre-2000 consisted of 112 alive and 30 fallen companies. Compared to the post-2000 companies which were far greater in number with 180 alive and 58 fallen companies, indicating an increase in the number of companies but also proportionately fallen companies.

The data indicates a shift in the landscape over time, with a significant increase in the number of biotech companies formed post-2000. While this growth signifies a dynamic and evolving industry, the higher proportion of fallen companies in the post-2000 era raises questions about the sustainability and success rates of newer ventures. The higher fall rate for post-2000 companies could be attributed to a combination of increased competition, faster technological obsolescence, and perhaps more ambitious ventures. Rapid advancements in biotechnology may have increased the difficulty for newer companies to stay relevant and competitive. Understanding the reasons behind the decline in formations post-2008, possibly linked to the global financial crisis, is crucial for policymakers and investors.

6.2 NEW ZEALAND BIOTECH SECTORS

The 380 total identified biotech companies that make up the New Zealand biotech industry can be broken down into six sectors of primary application that form much of the biotech industry, which has been correlated to the different standardised colours of biotechnology, as seen in Figure 47. The largest biotechnology sector identified in New Zealand is the AgBio (green) sector with 119 companies or 31% of the industry relating to agricultural and animal applications.

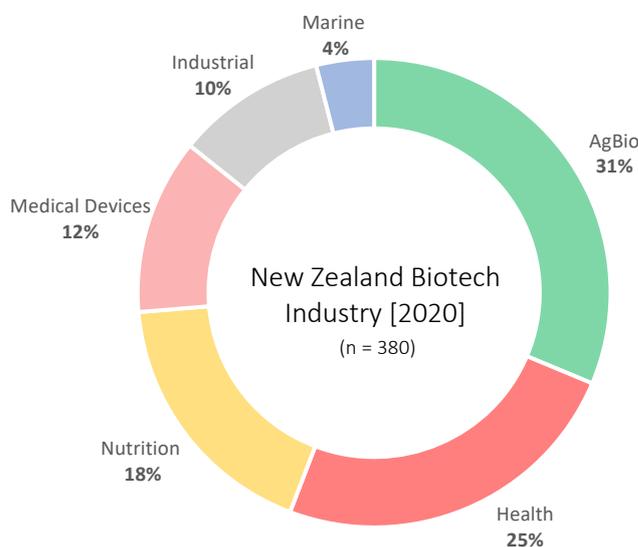


Figure 47. New Zealand biotech sector breakdown. The New Zealand biotech industry comprises of 380 identified companies sorted into six sectors of primary operations. AgBio was identified as the largest sector in New Zealand comprising 31% of identified companies. This was followed by Health (25%) and Nutrition (18%) to form the core basis of the New Zealand biotech industry. The remaining 26% was shared with Medical Devices (12%), Industrial (10%) and Marine (4%) being the smallest sector in New Zealand.

The breakdown of the industry, “pre-covid” into sectors demonstrates that AgBio (green) is the most prominent sector of biotech in New Zealand comprising 31% of the companies, of which further

breakdown within each sector can be seen in Table 17 regarding the companies that are identified as alive or fallen. A quarter of the companies were in the Health (red) sector, followed by Nutrition (yellow) at 18%, Medical Device (pink) at 12%, Industrial (grey) at 10%, and finally the Marine sector, which was identified as the smallest area of biotechnology in New Zealand with less than 4%. Of those that were currently active or alive, it was seen that the AgBio increased further to 33% while Health and Industrial lost percentage points. Upon further examination and the removal of the Medical Device sector from the data, the total number of biotech companies decreased to 334 incorporating 257 alive companies. The data shows that almost all the sectors increased with AgBio up to 36%, Health at 28%, Nutrition at 20%, Industrial at 12% and Marine remaining the same. A similar trend was seen when the same criteria were applied to the alive companies and the dominance of the AgBio sector increased to 38%, while the Health sector declined to 26% and small increases for the other sectors.

Table 17. Identified New Zealand biotech sector status breakdown

Sector	Alive (%)	Fallen (%)	Total (%)
AgBio	26	6	31
Health	18	7	25
Nutrition	14	4	18
Medical Device	9	3	12
Industrial	7	3	10
Marine	4	0	4
Total	78	22	100

The dominance of the AgBio sector shows a strong agricultural focus of the New Zealand's biotech industry. The focus on agriculture aligns with the country's economic strengths, but it also raises concerns about over-dependence on a single sector, as this could expose the industry to vulnerabilities tied to fluctuations in agricultural markets or regulatory changes and potentially limiting diversification opportunities. Additionally, the relatively small presence of the Marine sector prompts consideration of its strategic importance and potential for growth.

The breakdown of the New Zealand biotech sectors was further explored by the sub-sector by applying a broad secondary operation, which involved the specific application technology or business within its primary sector. This is seen in Figure 48, where each sector is broken down into the main applications. It is noticeable that within each sector except Medical Devices, the sub-sector of Services is significant, especially for Health and AgBio with 26% and 17% respectively. The six sectors were broken down to

portray the subsector variation within the sectors that shows the wide range of applications that the biotechnology industry is involved in.

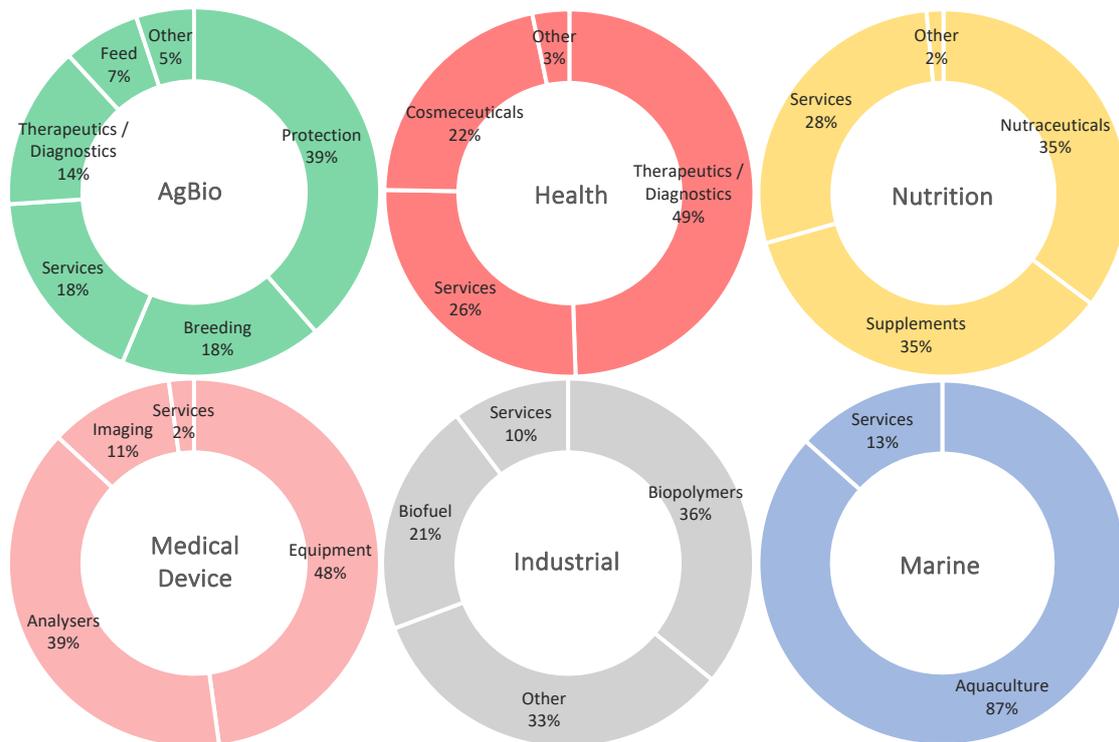


Figure 48. New Zealand biotech sub-sector breakdown. The New Zealand biotech six sectors breakdown within each respective sector displaying the composition of each sector. From each sector, there is a dominating component within it as well as services being prominent for each sector to varying degrees.

6.3 DATE OF INCEPTION

Each New Zealand biotech company was identified from records in the New Zealand Companies Office (as a limited liability company). The incorporation and founding year of all identified New Zealand biotech entities are shown in Figure 48 and colour coded according to the sector on which each is predominantly focused.

From the timeline of companies' formation in Figure 49, there has been a steady increasing trend in the number of biotechnology companies forming in New Zealand from the late 1970s until 2007, when there has been a steady decline in the number of biotech companies being formed. This could be attributable to many reasons such as the 2007/2008 Global Financial Crisis, and investors being much reluctant to invest in these types of companies, as they may look elsewhere for a lower-risk profile and companies that have a shorter market timeframe, given this industry requires resilience.

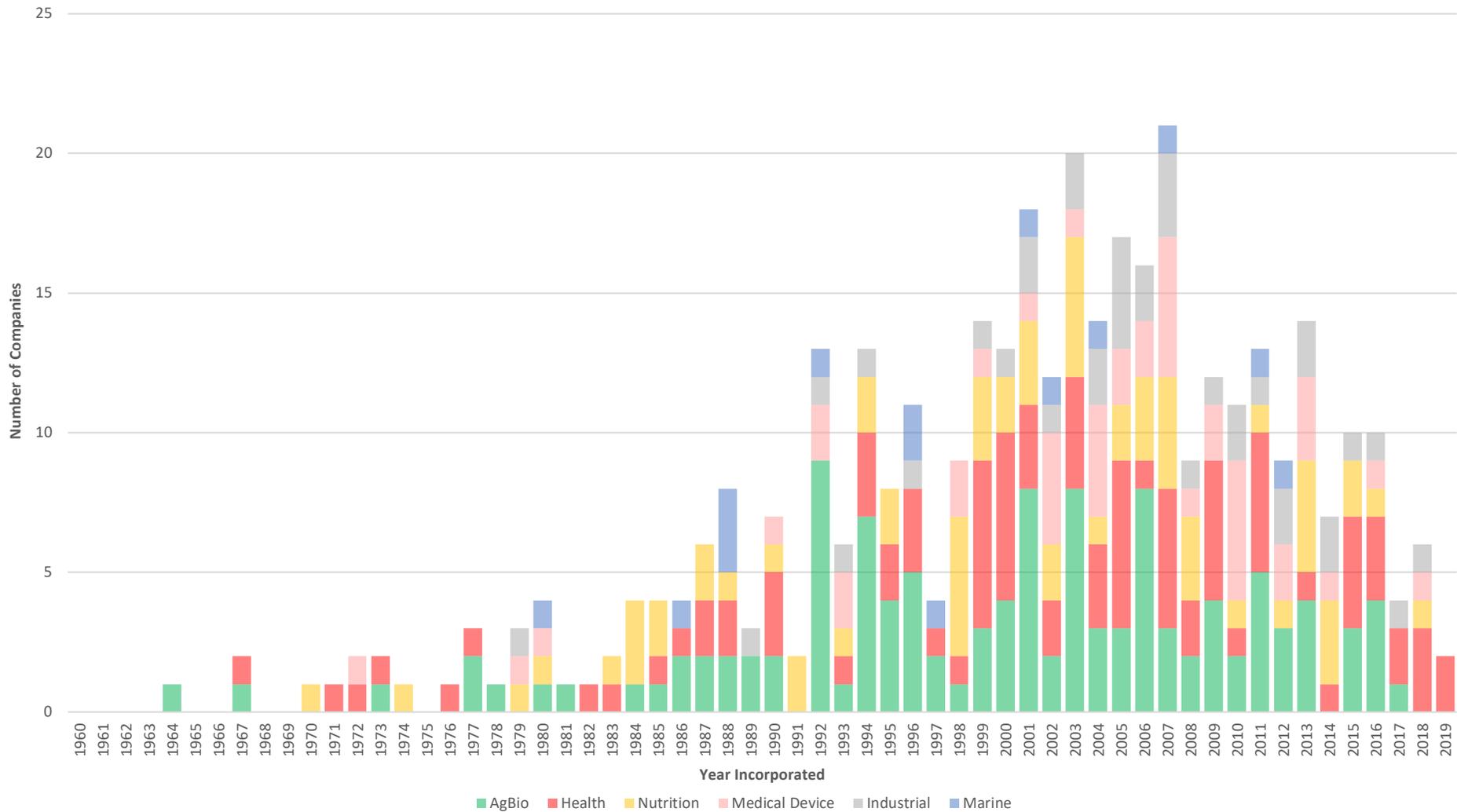


Figure 49. Year New Zealand biotech companies were incorporated. The timeline of incorporation of New Zealand biotech companies as a single block that is coded as its respective sector. The modern era of biotechnology in New Zealand appears to have started slowly but has shown overall steady growth from 1983 to 2007. There has been a decline in biotech company formation since 2008, which could be from numerous factors such as the global financial crisis, where investors have been less reluctant to invest in speculative ventures. Many of the sectors have seen constant formations except the Marine sector.

6.4 BIOTECH SUCCESS

Over the lifetime of the identified New Zealand biotechnology industry, the companies that were identified as alive or fallen were deemed as either a success or not. Of the companies that are currently alive, 72% are identified as being successful in terms of fair returns to the shareholders. This contrasts with the companies identified as having fallen to date where only 24% were deemed a success as seen in Figure 50. Note, that this does not consider if a product or service was released to the market.

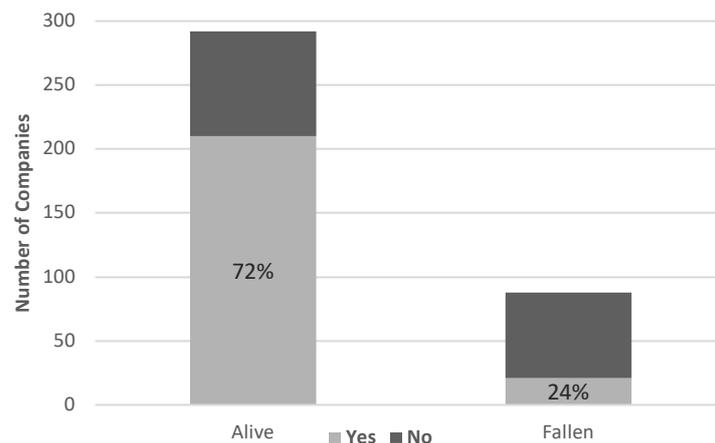


Figure 50. Success breakdown of alive and fallen New Zealand biotech companies. The proportion of companies that are alive and successful is much greater than the companies that have fallen and were successful with 72% compared to 24% respectively.

The data on the success rates of biotech companies, both alive and fallen, provides valuable insights into the challenges and opportunities within the industry. The definition of success solely based on shareholder returns might oversimplify the complex nature of biotech ventures. Success in biotechnology is multifaceted and should consider not just financial returns but also the societal impact of the innovations. Lack of market success doesn't necessarily equate to a failure in terms of contributing valuable insights or technologies to the scientific community. Biotech ventures often involve long development timelines, and success may manifest more slowly, especially if the companies are engaged in groundbreaking research.

6.5 AGE OF OPERATION

The data shows that the average age or years of operating of the identified biotech companies is just over 16 years old (16.1) from Figure 51. When the number of days from official founding to being

inactive or still operating after 2019 was looked at, the average age was 16.5 years. However, there are potentially several companies when cessation of operations dates could not be accurately found. The complete year data was close to the estimated exact day data (16.1 vs 16.5) to be used for the dataset.

The median age of New Zealand biotech companies was 14 years, indicating that half of the companies are between 0 and 14 years old, while the other half are between 14 and 52 years old, with the oldest company identified as operating for 52 years, although the original formation of the company may have been for different purposes and have adapted over the years into the company and sector it is today. When analysing the data by quartiles, half of the companies fall between the age of 8 years and 22 years old being the lower quartile and upper quartile respectively. Indicating there is 25% between 0 and 8 years old (8-year spread) and the remaining 25% between 22 and 52 years old (30-year spread). The mode or age that contained the highest number of companies in the New Zealand biotech industry is 11 years currently with 20 companies at this age point.

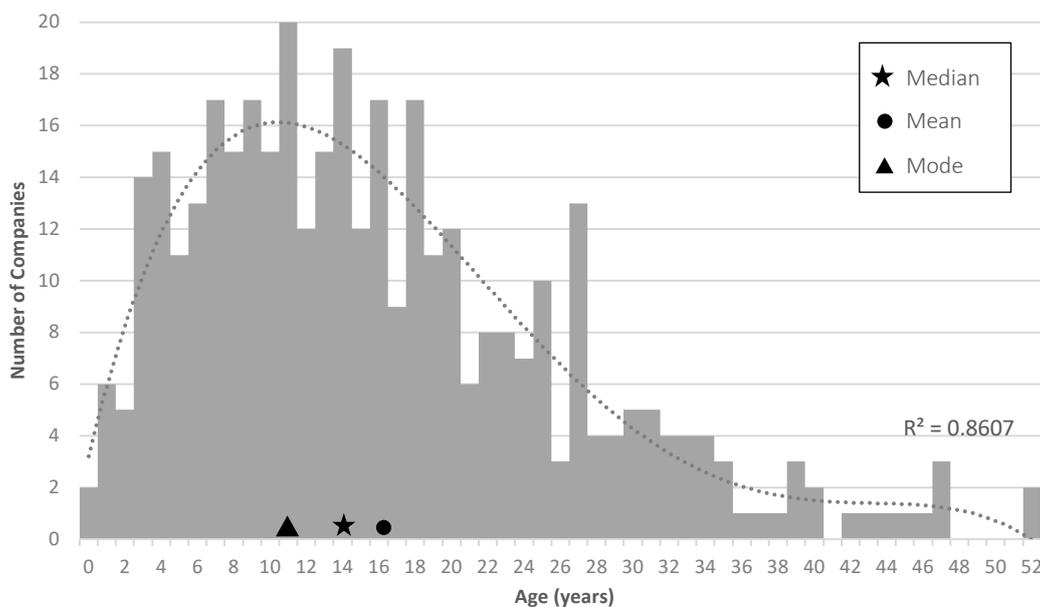


Figure 51. New Zealand biotech age. The count of all New Zealand biotech companies' years in operation displays a right-skewed non-normal distribution with most companies aged between 0-25 years old. The average (o) ● years' operating were 16 years (16.1), while the median () ★ as 14 years old. The age with the most companies was seen as 11 years old () ▲ with 20 companies.

The distribution of the age of biotech companies highlights the relatively young nature of the industry in New Zealand with most companies operating for less than 25 years. The presence of companies operating for over 50 years might suggest resilience, adaptability, or a niche focus that has stood the test of time. The right-skewed distribution of company ages may indicate a recent surge in biotech activities, potentially driven by increased awareness, funding availability, or technological advancements.

The data is further examined between the years' operating for companies deemed alive (active) versus fallen (inactive) companies in Figure 52.

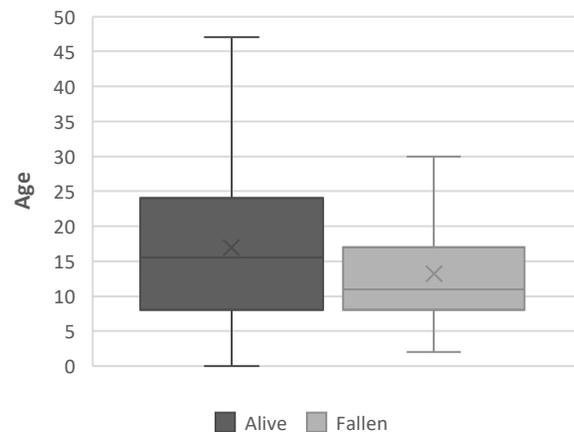


Figure 52. New Zealand biotech industry years' operating comparison. The figure displays the collective grouping of companies recognised as being alive or fallen. The average years' operating was 17.0 and 13.2 for the alive and fallen groups respectively, while the median was lower at 16 and 11 years respectively. The alive companies' upper quartile was 24 years, and the lower quartile was 8 years compared to the inactive companies which had a UQ of 17 years and an LQ of 8 years. The active companies have a greater spread of years of 47 years with two companies at 52 years compared to the inactive companies spread of 28 years.

It can be seen from Figure 52 that the majority (>75%) of the alive companies are similar to the overall data seen in Figure 51 compared to the inactive companies which have a much lower number of years operating with 75% nearly under the average of active companies at 17 years. The spread of active companies is far greater than those of inactive with 0-47 years compared to 2-30 years respectively with a few outlier data points for both groups.

6.6 THE LIFE OF NEW ZEALAND BIOTECH SECTORS

From the overall data that was collected, details of each sector could be extracted as seen below with the age of companies within each sector (active and inactive) in comparison to one another in Figure 53.

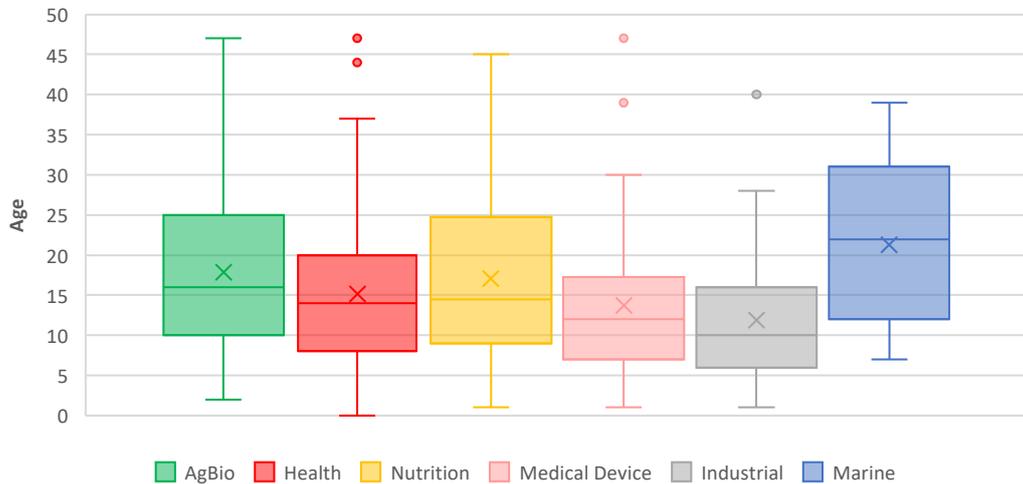


Figure 53. New Zealand biotech sector years' operating comparison. The figure displays the sector breakdown and the years' operating with the Marine sector appearing to be the oldest on average at 21.3 years and with its entire sector between 7-39 years. This is followed by AgBio and Nutrition with their interquartile range being nearby of each other of 9-25 years. The industrial sector appears to have the smallest overall spread of its companies in age ranging between 1-28 years and the lowest mean and median age with 11.9 and 10 years respectively. The AgBio sector has the largest age range of the sectors with 2-47 years, excluding outlier points, while Health has three outliers at 44, 47 and 52 years, being the largest value of the dataset.

The data shows that there are some differences between the ages of companies within the sectors. The smallest identified sector, Marine, appears to be the sector in which companies operate the longest once they start operating with the entire sector being between 7–39 years of operations, with the average operations being 21 years. This was followed by the AgBio and Nutrition sectors with the next largest interquartile spread around 9–25 years of operating. The smallest spread was seen with the Medical Device and Industrial sectors with almost all their respective companies operating between 1–30 years. The longevity of the Marine sector could be attributed to stable conditions or slow innovation cycles. The Industrial sector's shorter lifespan might be due to rapid technological changes or market dynamics.

6.7 COMMERCIAL STATUS

The industry was examined as to the commercial status by market stage. Much of the industry is currently in the market with ~53% of companies and 19% identified as service companies. Therefore, it was estimated that there are ~28% of companies that are not in the market as pre-market or post-market, split 21% and 7% respectively. The data is further analysed by the market stage of the individual sectors as seen below in Figure 54.

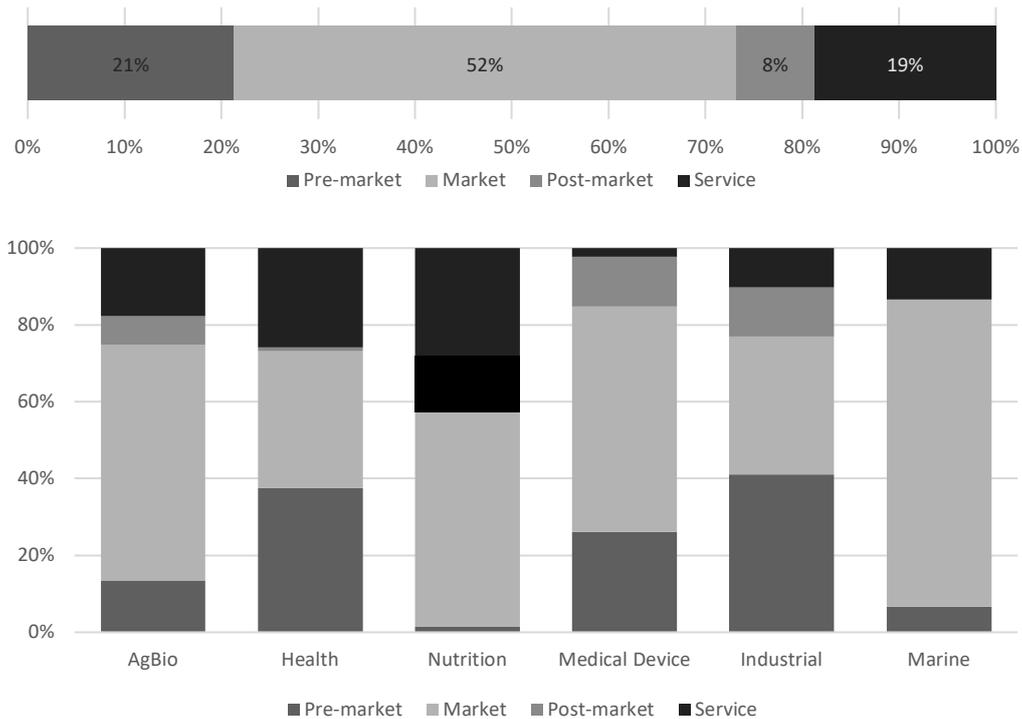


Figure 54. New Zealand biotech market stage of sectors. There are differences in the market stages of the sectors, where Industrial has the greatest proportion of pre-market companies (~40%) followed by Health (~38%). The Marine sector was seen as having the greatest proportion of in-market companies (~80%) followed by AgBio (~63%), Medical Device (~61%) and Nutrition (~60%) with Health and Industrial having the smallest proportion of market companies (~35%) but the largest pre-market companies (~40%). While Nutrition and Health consisted of the most service companies (~26%).

Filtering the industry to consist of the alive companies, the data found that 67% of the companies are in the market, 13% are pre-market with the remainder being service companies at 19%.

The sectors each display different market stages within their sector. Within the sectors, the pre-market and post-market may contain companies that are either active or inactive, while the in-market group contains only active companies. The Nutrition sector contains the greatest proportion of post-market companies with ~18% and the least pre-market companies, while the Industrial sector contains the greatest proportion of pre-market companies with ~45% as well as laying claim to the title for the sector with the lowest proportion of companies in the market with ~40%. Three sectors have a significant proportion of the identified companies in the market with the Marine sector having the greatest

proportion of market companies with ~93% followed by the Nutrition and AgBio sectors, with about 80% each. The Marine sector had the lowest number of post-market companies followed by the Health sector. Viewing the data as the entire industry, the average age of companies identified as pre-market was ~8 years old, with the in-market companies being ~19 years old and finally, the post-market companies were ~14 years old. Filtering for only the alive companies, the average age of the pre-market companies was 6 years old, the in-market companies were 18 years old, and the service companies were ~20 years old.

6.8 NEW ZEALAND UNIVERSITY INVOLVEMENT

The New Zealand biotech industry is involved with New Zealand universities, in the form of research being translated as spin-out companies or through research collaborations and the commercial entity listed against the university commercialisation arm. There was a total of 57 companies that were identified as biotech spin-outs of New Zealand universities commercialisation offices (previously listed in Section 2.2.6 Table 5), representing 15% of the total identified companies. The human healthcare area involving Health and Medical Devices appeared to be the dominant area of focus with biotech companies being formed from universities with 72% of the spin-out companies as seen in Figure 55 breakdown of the different universities and the sectors they have formed companies in.

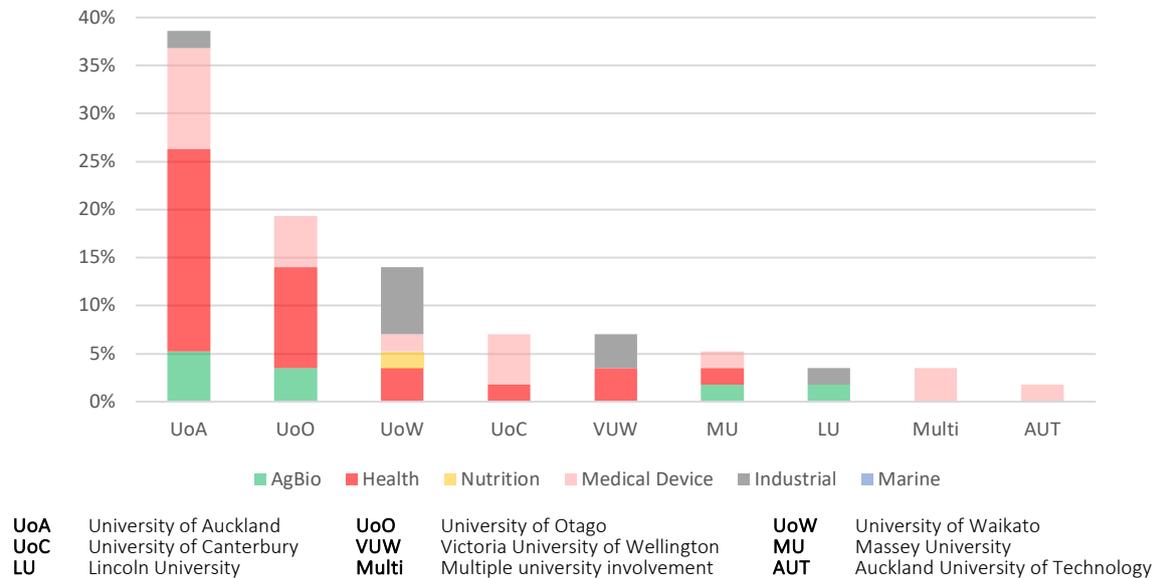


Figure 55. Biotech sectors of New Zealand university spin-outs. The figure displays the percentage distribution of all the university biotech spin-out companies from New Zealand universities with the removal of the companies that were not. Of these university spin-out companies, 72% have come from the general human healthcare area of biotech with Medical Device and Health. A few companies for each of AgBio, Industrial and Nutrition were identified. There have been no companies currently identified as being spin-outs for the Marine sector.

Medical Device and Health sectors dominate the focus of spin-out companies with 30% and 42% respectively. There was a smaller amount of AgBio and Industrial spin-outs with 12% and 14% each followed by Nutrition with 2%. There were no spin-out companies identified from the Marine sector.

As seen in Figure 55, the University of Auckland (UoA) via UniServices, has formed the most biotech companies out of the eight New Zealand universities and accounts for ~40% of all the spin-out companies. This is followed by the University of Otago (UoO), and the University of Waikato (UoW) with ~20% and ~15% respectively, with the other five universities contributing less than 10% each and the Auckland University of Technology (AUT), New Zealand's youngest university commercialisation office being the lowest contributor.

The founding of the New Zealand university biotechnology spin-outs has occurred consistently since 1999, until 2019 from Figure 56. Consisting of at least one to two companies a year, with some years producing exceptional years such as 2007, which had a far greater number formed primarily from the University of Waikato.

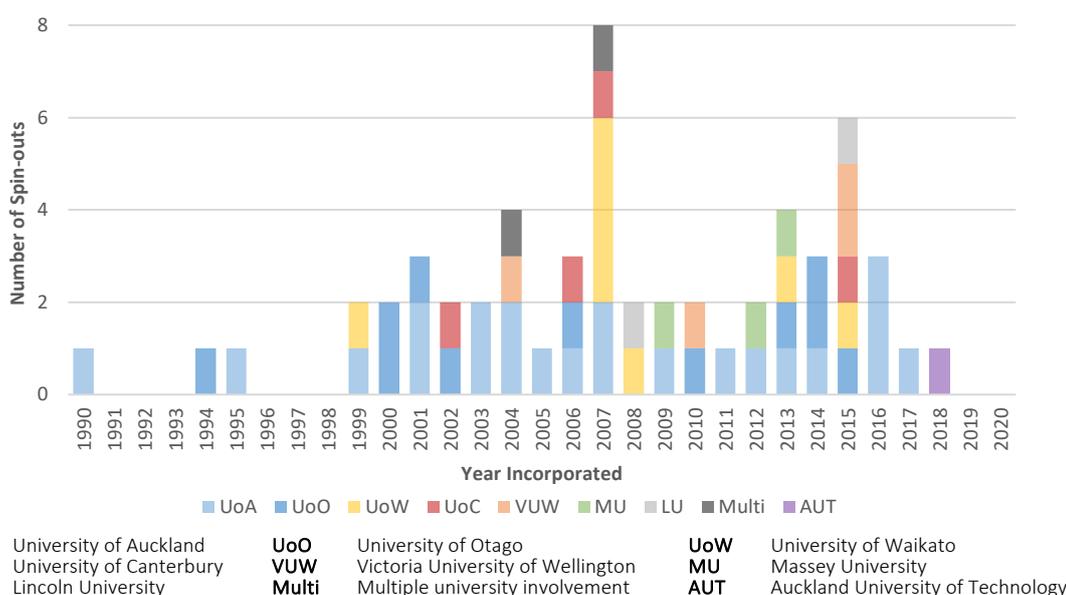


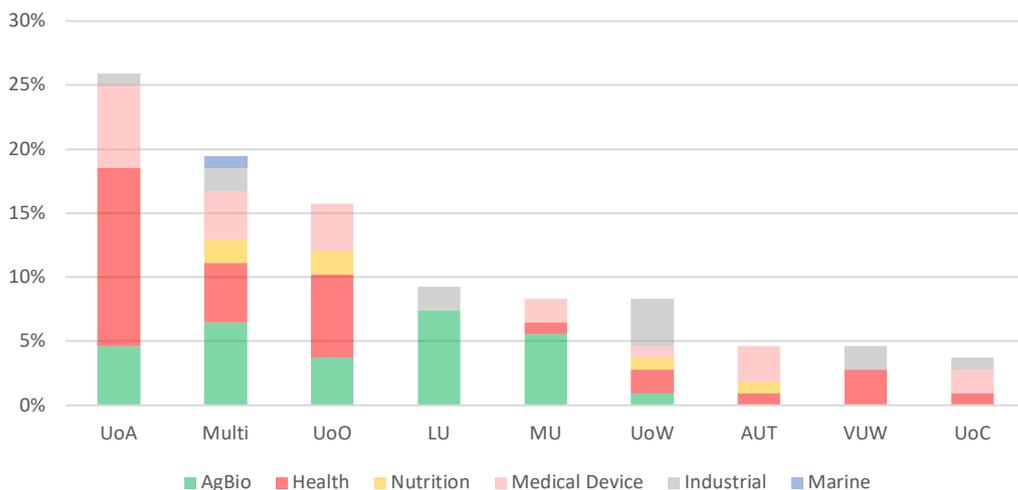
Figure 56. The founding of New Zealand university biotech spin-outs. The years of incorporation of biotech companies by the New Zealand universities, where Auckland has been constant with nearly one new entity a year compared to the other universities. The largest year of new companies was 2007 with Waikato forming four new companies in this year. Each of the other universities has been sparse and sporadic in the new biotech entities formed.

The University of Auckland has remained quite consistent at forming one spin-out in the biotech industry almost every year for the past 20 years, while AUT has only managed one biotech spin-out during that same time, although AUT is the youngest of the universities, just passing 20 years of age.

The collaboration between biotech companies and universities, particularly the creation of spin-outs, showcases the role of academic research in industry development. The University of Auckland leads in forming biotech spin-outs, with a focus on human healthcare. The University of Auckland's consistent contribution might be attributed to proactive technology transfer offices, strong industry partnerships, or a conducive entrepreneurial ecosystem. Spin-out companies are most prevalent in Health and Medical Device sectors. The concentration in healthcare-related spin-outs may reflect academic strengths or market demand. The low involvement of newer institutions raises questions about their research-commercialisation synergy. Strengthening collaboration between universities and emerging commercialisation offices could foster a more diversified biotech landscape.

Only ~63% of the spin-outs are currently alive, while ~37% have already fallen from various causes. When looking at the commercial status of the university spin-outs, the picture is not much better for the overall university landscape with ~60% not in-the-market, with the majority closing before making it to the market. This is split with 54% pre-market and 6% post-market and the remaining ~33% in-the-market. The samples may be too small as many of the universities have fewer than five spin-outs over this biotech timeframe. While universities play a crucial role in generating innovative ideas, challenges in translating academic research into commercially viable products may arise due to differences in academic and commercial priorities, limited industry mentorship, or gaps in entrepreneurial skills among researchers.

Analysing the biotech industry data further, the number of New Zealand biotech companies that have some involvement or association with a New Zealand university is ~28% or 108 companies of the entire New Zealand biotech industry, including the spin-out companies, considering any research collaborations between a company and a university. This is an 89% increase in the number of companies on top of the spin-out companies. The increase was mainly due to a substantial increase in the number of AgBio relationships of nearly 350% involvement, with all other sectors also increasing between 35% and 50%. The distribution of the sector company's involvement with New Zealand universities is seen in Figure 57.



UoA University of Auckland **Multi** Multiple university involvement **UoO** University of Otago
LU Lincoln University **MU** Massey University **UoW** University of Waikato
AUT Auckland University of Technology **VUW** Victoria University of Wellington **UoC** University of Canterbury

Figure 57. Biotech sector count on New Zealand university research collaborations. Displaying the New Zealand biotech companies that have an association with a New Zealand university. Health, AgBio and Medical Device companies are involved predominantly with universities with greater than 80% combined. UoA has the highest number of companies involved with it making up greater than 25%. There were also several more combined research collaborations with multiple universities being the second largest group, just under 20%.

Every sector is seen to have some involvement from a university. Three sectors form the majority of utilising universities for their company, which are Medical Device, AgBio and Health divided around 25% each. The greatest increase that was noticeable from the companies with a university association is that of a collaborative approach involving multiple universities increasing from just over 3% to 19% of all university association companies, while UoA decreased from 39% to 26%. The other universities had small changes of less than 5%. The involvement of universities by companies that are alive was 72%, and by 28% that have fallen.

6.9 NEW ZEALAND BIOTECH GEOGRAPHICAL DISTRIBUTION

The geographical location of the biotech companies in New Zealand is identifiable as being near the major cities through the company’s office address or website address. Many companies are based in the greater Auckland (AKL) region with ~40% of the industry located in this region. This is followed by the Canterbury (CAN) (15%) and Waikato (WKO) (12%) regions, with three regions consisting of ~7% each, Otago (OTA), Wellington (WGN) and Tasman (TNM) and the remaining regions with less than 5% of companies in their localities as seen in Figure 58.

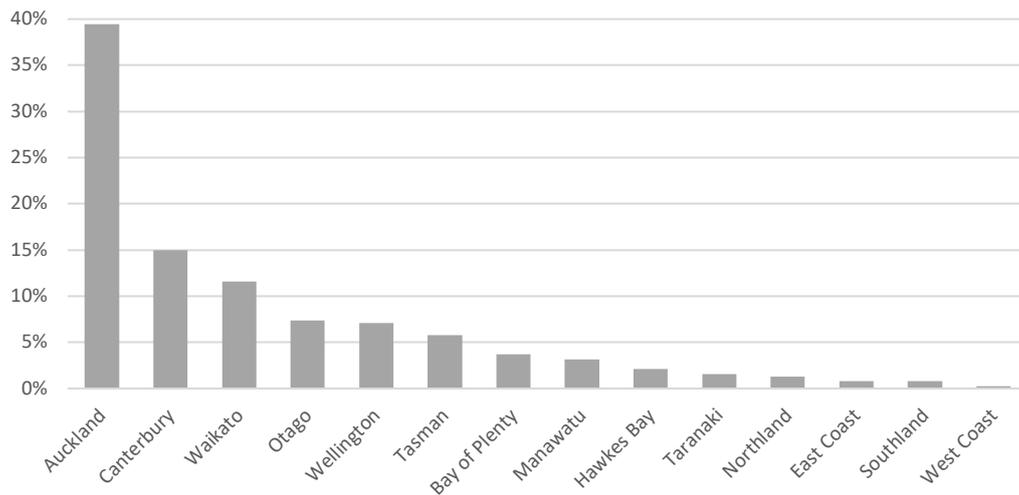


Figure 58. Regional spread of the New Zealand biotech industry. The Auckland region is the dominant region for New Zealand biotech companies to be located with ~40%. The other regions with major cities make up the remaining top five regions with Canterbury (15%), Waikato (12%), Otago (7%) and Wellington (7%). Tasman is the only other region with greater than 5% with the remaining regions containing less than 5%.

The regional dominance of the Auckland region along with the next top five regions are identified as having the larger populations as well as having a university presence in these regions. Auckland has three universities (The University of Auckland, Auckland University of Technology, and Massey University), Canterbury (University of Canterbury and Lincoln University) and Wellington (Victoria University of Wellington and Massey University) with two, and Waikato (University of Waikato) and Otago (University of Otago), with one each. The Manawatu-Whanganui region is the only region with a university (Massey University) that had less than 5% of companies identified.

The regions are further broken down into their sector distribution in the map Figure 59, mapping out the New Zealand biotech industry. The sector distributions could be due to lifestyle factors, such as business focus, geography, and metropolitan area. The Auckland region appears to have a larger presence of healthcare companies with nearly half of the region consisting of Health or Medical device companies. The next largest region is the Canterbury region, which appears to have a large presence of AgBio companies accounting for 38% of its region with the next five regions of a similar ranking. The Waikato region has a similar regional structure to that of the Canterbury region with AgBio being favoured and a similar distribution for the other five sectors.

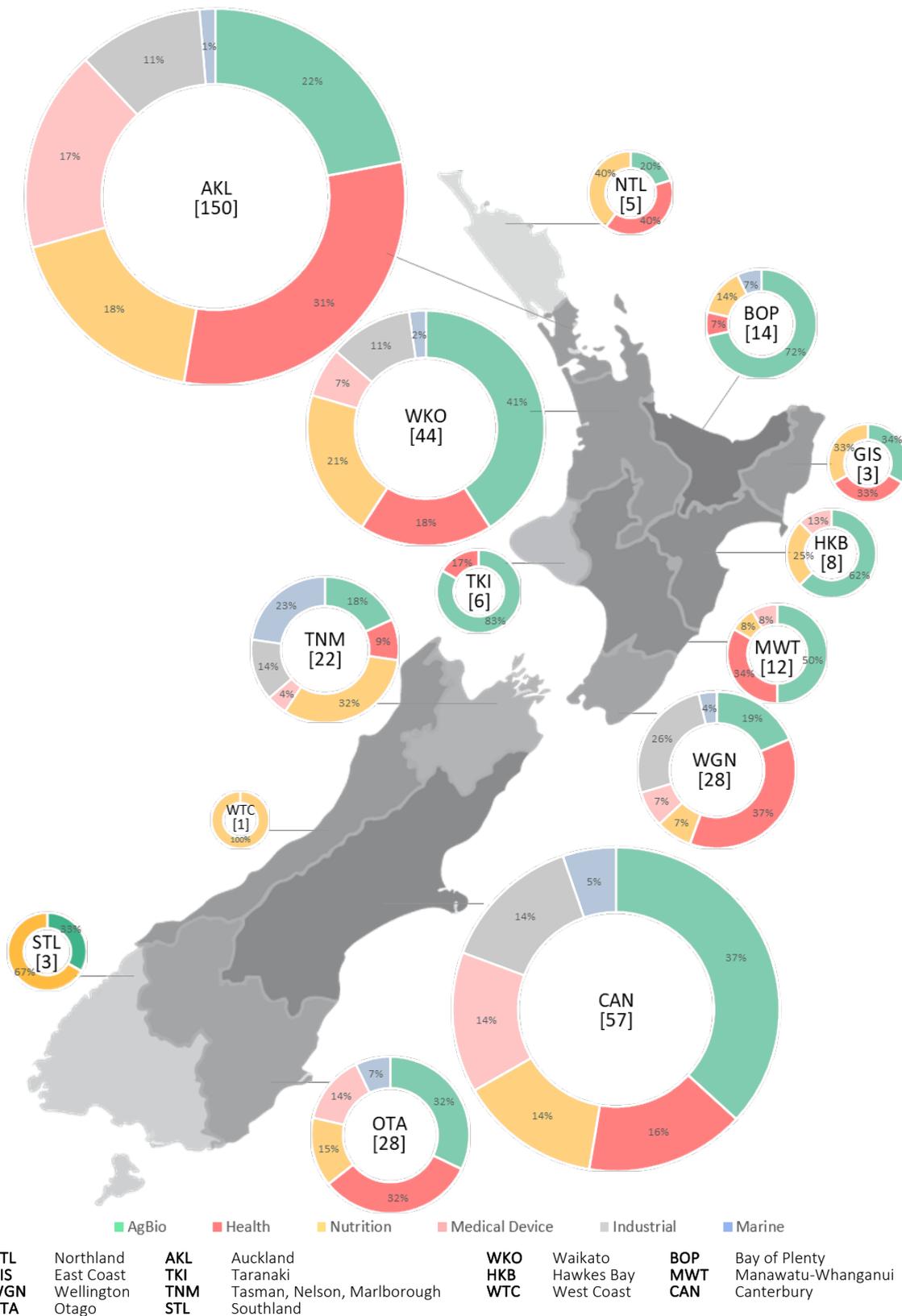


Figure 59. New Zealand biotech regional distribution map. Map of the New Zealand biotech geographical distribution. The number of identified companies for each region is portrayed within the sector breakdown circle. The sector breakdown circle gives a breakdown of the distribution of sectors for that specific region. For example, the Canterbury [CAN] region has a total of 57 identified companies, of which 37% AgBio, 16% Health, 14% Nutrition, 14% Medical device, 14% Industrial, and 5% identified in the Marine sector. The Auckland [AKL] region is the largest region for biotech companies with 150 companies while the West Coast [WTS] region is the smallest with only one company identified within the Nutrition sector.

There are varying distributions of the biotech sector amongst the regions, such as the Otago (OTA) and Wellington (WGN) regions being of similar size, while the Otago region has a higher proportion of AgBio and Health companies compared to Wellington, which has a far greater Industrial sector presence. This can be seen between all the regions, where there appears to be a greater focus on one sector over the others. The Tasman (TNM) region was identified as the region with the greatest number of Marine sector companies, however, proportionally, the dominant sector for the Tasman region was Nutrition with 32% followed by Marine with 27%, while the healthcare area of Medical Devices and Health was the lowest. Only five regions were identified to contain companies from all six sectors of the biotech industry. These were Auckland, Canterbury, Waikato, Wellington, and Tasman, with Otago missing only the Industrial sector. These regions made up approximately 86% of the New Zealand biotech industry, while the remaining regions did not manage to acquire more than four of the sectors with two of the regions only having one sector present, West Coast (WTC) and Taranaki (TKI).

The data analysed the biotech sector distribution when the size of the region was considered urban or rural. There were 248 companies based in urban surroundings that appear to have a widespread focus on almost all the sectors except the Marine sector compared to the 132 rural companies who appear more focused on AgBio, Nutrition and higher in the Marine sector as seen in Figure 60 below and less focused on the healthcare area involving Health and Medical Device.

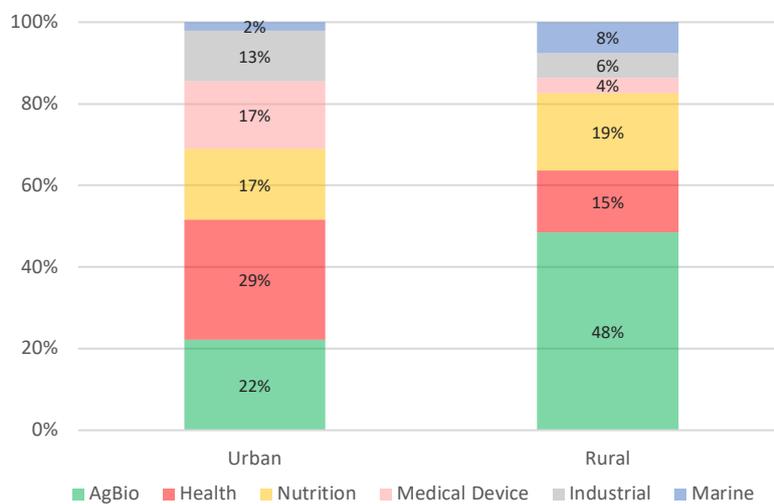


Figure 60. New Zealand urban or rural biotech sector focus. The figure displays the difference in the sector breakdown by the type of area the companies are in as an urban or rural company. Of the 248 urban companies, there was an even distribution between AgBio, Health, Nutrition, Medical Device followed by Industrial and a smaller amount of Marine. This contrasts with the 132 rural companies that were dominated by AgBio with close to 50% followed by Nutrition with nearly 20%. Marine was greater for the rural companies compared to the urban companies while the remaining sectors were much lower in focus compared to the urban companies.

The concentration of biotech companies in urban areas versus rural areas raises questions about the factors influencing geographical distribution. Urban areas have a more balanced sector distribution,

while rural areas focus heavily on AgBio. This may suggest urban-rural disparities in industry focus. The sectoral concentrations in different regions may be influenced by local strengths and resources. A further detailed breakdown of each sector, containing a list of all companies identified within each respective sector that were included in the data analysis is in Appendix D.

6.10 LOST TO NEW ZEALAND

Over the years, there have been several companies that have been lost to the New Zealand biotech landscape for numerous reasons. It was found from the analysis that there have been an estimated 132 (35%) companies that have undergone this process. The main reason for being lost to New Zealand appears to be by being sold or acquired into a different company that is not a New Zealand company but a foreign entity with ~59% of the lost companies identified as having been lost in this way. In some cases, the information as to why the company is no longer operating has not been forthcoming or easily located and the category has been applied through journalistic articles and subjective measures as to why they have been lost in Figure 61.

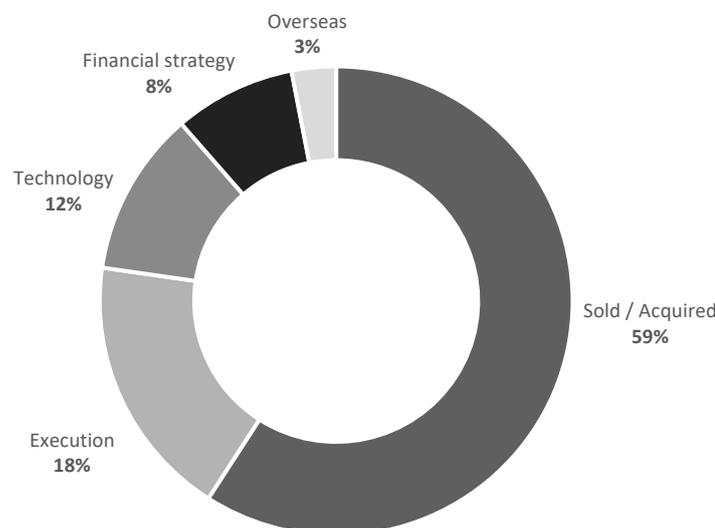


Figure 61. Causes of companies lost as a New Zealand biotech. The causes show that most companies identified have been sold/acquired (~59%) from New Zealand. There were several reasons in the operation of the companies that causes them to be lost with issues in the execution & implementation (18%), the underlying technology (11%), and leaving New Zealand shores by moving overseas (3%).

Several reasons were able to be identified as to why companies were no longer operating in New Zealand through numerous news and industry reports. These were potential issues in the execution and implementation of the company offering for ~18% of companies. There were ~11% that appeared to have issues with the underlying technology, ~8% with a financial strategy concern and ~3% that left New

Zealand shores to an overseas location and operation. There may be many companies that were not able to be identified in this process.

The loss of 35% of companies, predominantly through acquisitions by foreign entities, underscores the global nature of the biotech industry and the attractiveness of New Zealand biotech companies to foreign entities may stem from technological prowess or niche expertise. This loss to NZ suggests a vulnerability in retaining intellectual property and economic benefits within New Zealand. Companies lost due to issues in execution, underlying technology, and financial strategies raise concerns about the robustness of business models and technological foundations.

The year of being lost for each company is detailed in Figure 62, displaying the two largest years of identified losses were 2014 and 2019 with 17 companies lost. This was trailed by the year 2015 with 14 companies, therefore 35 companies were lost in two years. The earliest identified company lost to New Zealand was in 1998. Since the mid-2000s there has been consistent attrition of companies to the New Zealand economy. The number of companies lost to New Zealand compared to companies formed since 2002 was 131 versus 207 founded giving a ratio of 0.63 companies lost for everyone 1.00 companies formed since 2002.

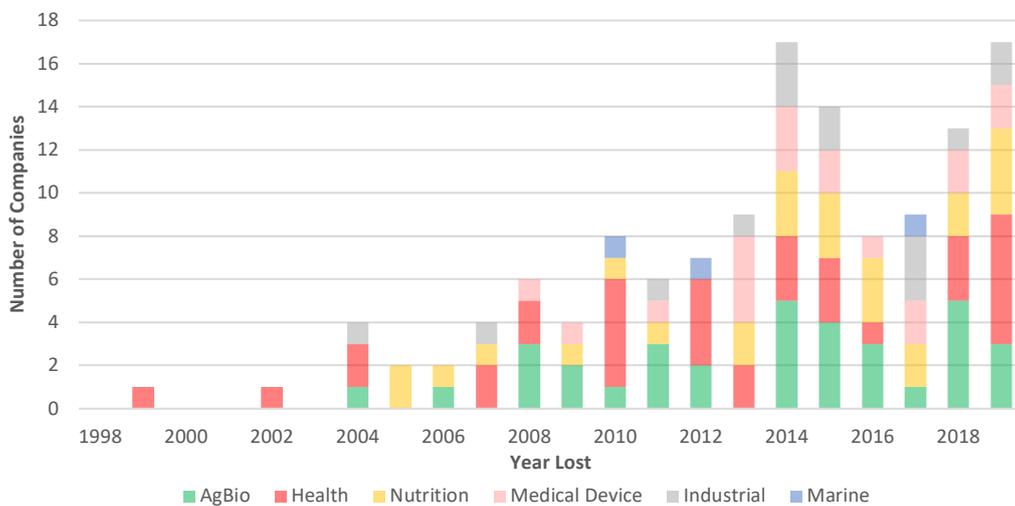


Figure 62. Year New Zealand biotech company was lost. The figure displays the year in which the respective sector company has ceased operations and/or been acquired and lost to New Zealand. There has been a steady increase in the number of companies lost to New Zealand with the largest years being 2014 and 2019 with 17 companies followed by 2015 with 14 companies from all sectors.

The figure displays that there has been a consistent variation in the companies that have been lost to New Zealand proportional to the size of the overall respective sector with the New Zealand biotech industry. With 29% of lost companies being AgBio compared to the 26% overall composition.

6.11 PERCEIVED INNOVATIVENESS OF NEW ZEALAND BIOTECH

The perceived innovativeness scorecard developed by the author was applied to companies that were identified as alive. The data utilises 292 active companies and calculated that the average perceived innovativeness (PI) score from the criteria detailed in section 3.7.5 for the New Zealand biotech industry was 44 displayed in Figure 63 suggests a moderate level of innovation. This might suggest a balanced landscape with room for improvement but also some commendable innovation.

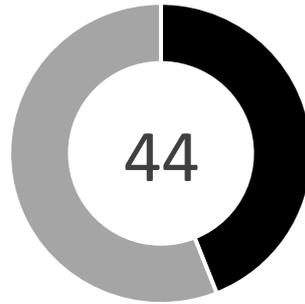


Figure 63. New Zealand biotech industry perceived innovativeness. The entire identified active biotech industry of New Zealand scored an average PI score of 44.

6.11.1 Innovativeness of the New Zealand biotech industry

The distribution of the PI scores for the active New Zealand biotech industry individually is displayed in Figure 64. The figure displays an overall normal distribution, with a slight left skewness. From Figure 63, there is a large grouping of companies at PI scores of 16, 29, 39, and 42, could indicate certain barriers or facilitators influencing innovation at these levels with the highest count of 15 companies scoring 42. There is a wide spread of companies between scores 21 and 80. There were only a handful of companies that scored greater than 80, that could be perceived as being highly innovative for the New Zealand biotech industry, if the nominal score was divided into five sections of not innovative (0-20), a little innovative (21-40), somewhat innovative (41-60), innovative (61-80) and highly innovative (81-100).

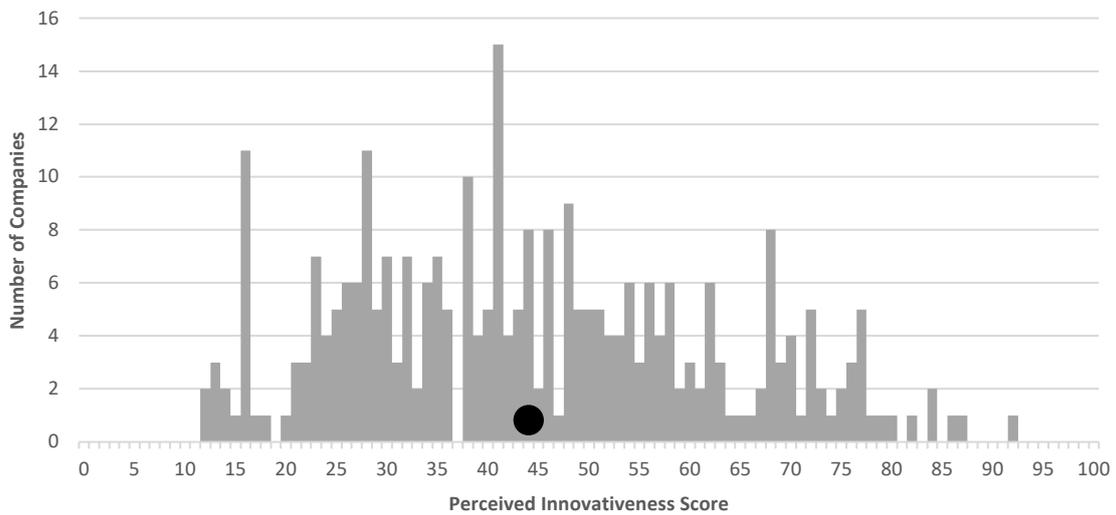


Figure 64. New Zealand biotech perceived innovativeness distribution. A near normal distribution of scores within the active New Zealand biotech industry. The average of 44 is denoted with the black circle and the most common score was 42. There were only a handful of companies that scored greater than 80 in terms of perceived innovativeness.

6.11.2 Innovativeness of New Zealand biotech sectors

Analysing the New Zealand biotech industry within the individual sectors in Figure 65, it was perceived that the highest average scoring biotech sector for innovativeness was Medical Device and Industrial with 56 each. This was followed by the Health scoring 52 and the Marine scoring 47. The lowest perceived scoring industry was Nutrition with 33.

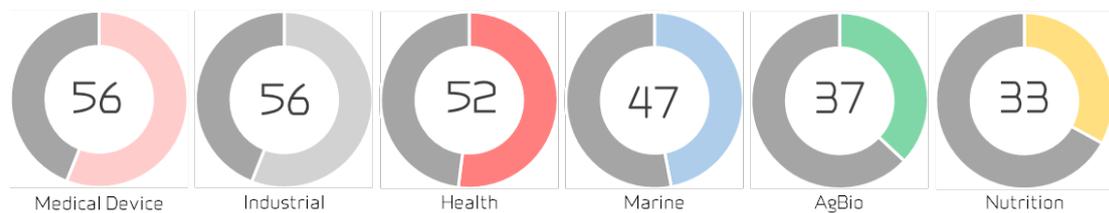


Figure 65. New Zealand biotech sectors' perceived innovativeness. The Medical Device and Industrial sectors were evaluated by the scoring system to be the most innovative with an average of 56, followed by the Health and Marine sectors, scoring 52 and 47 respectively. The AgBio and Nutrition sectors appeared to score the lowest scores with 37 and 33 respectively. Ordered by the ranking of the average PI score.

The PI scores within the sectors are represented by Figure 66, this shows that the Nutrition sector scored generally lower than the other sectors, followed closely by the AgBio sector, with most of these companies scoring below 50 in their respective PI score. The Health sector is seen to have the greatest scoring spread ranging from about 13 to the highest PI score of 92. The remaining three sectors were of a similar trend in scoring with varying degrees of range.

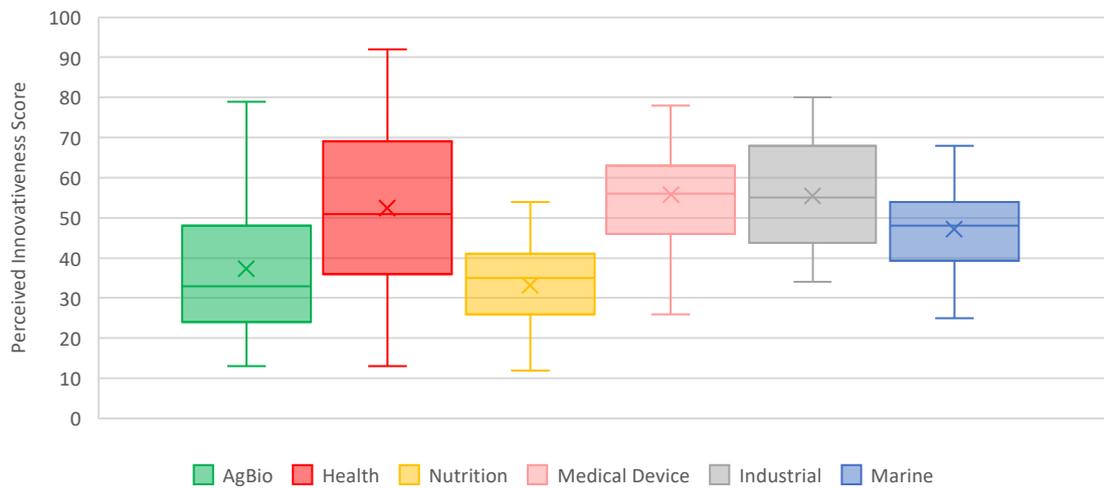


Figure 66. Perceived innovativeness spread within the New Zealand biotech sectors. The individual sectors' PI scoring shows the Nutrition sector as the lowest and most compact in its scoring range compared to the other sectors. The Health sector has the greatest range from ~13 to 92. Ordered in size of the sector from largest to smallest.

6.11.3 Commercial and environment innovativeness

The industry was divided into the company being a privately-held or publicly listed company and revealed a difference in the perceived innovativeness (PI) score. Publicly listed companies were seen as more innovative with a PI score of 63 compared to the privately-held companies that scored just below the industry average of 43 in Figure 67 which might be attributed to better access to capital markets or increased scrutiny, pushing for continuous innovation.



Figure 67. New Zealand biotech private or public company perceived innovativeness. The public companies scored a higher perceived innovativeness score of 63 compared to the private companies that scored below the industry average with 43.

When the industry was analysed in terms of the respective company's location in terms of city-based or country-based in Figure 68. The companies that were based within an urban environment scored higher in the perceived innovativeness with an average of 48 compared to the companies that were based in the rural environment, which scored an average of 39, below the overall industry average of 44 which may be linked to factors like access to talent, research institutions, or a more developed infrastructure that fosters innovation.

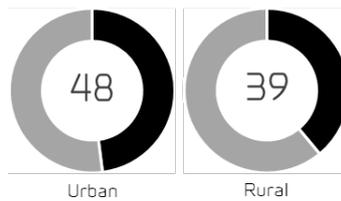


Figure 68. New Zealand biotech urban or rural company perceived innovativeness. The companies that were in the urban environment scored a higher score compared to the rural companies with 48 and 39 respectively.

The PI scores for the different market stages were assessed. The analysis found that the companies that were yet to enter the market, in the pre-market stage scored the highest with 64. This was followed by the companies that were in-the-market with 43, although below the overall industry average of 44. The final group considered was that of the service group, which scored 37 in Figure 69.

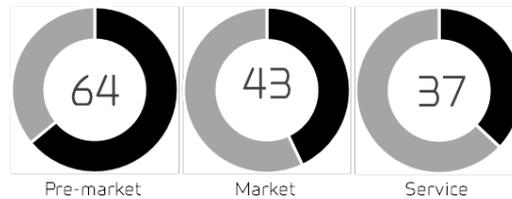


Figure 69. New Zealand biotech market stage perceived innovativeness. The pre-market companies scored the highest with 64 compared to the market with 43, followed by the service group with 37.

6.11.4 New Zealand university innovativeness

The perceived innovativeness was assessed for the companies that were identified as alive and a New Zealand university spin-out. It was found from the analysis that the average score was 61, compared to the companies that were not a university spin-out that scored 42 in Figure 70.

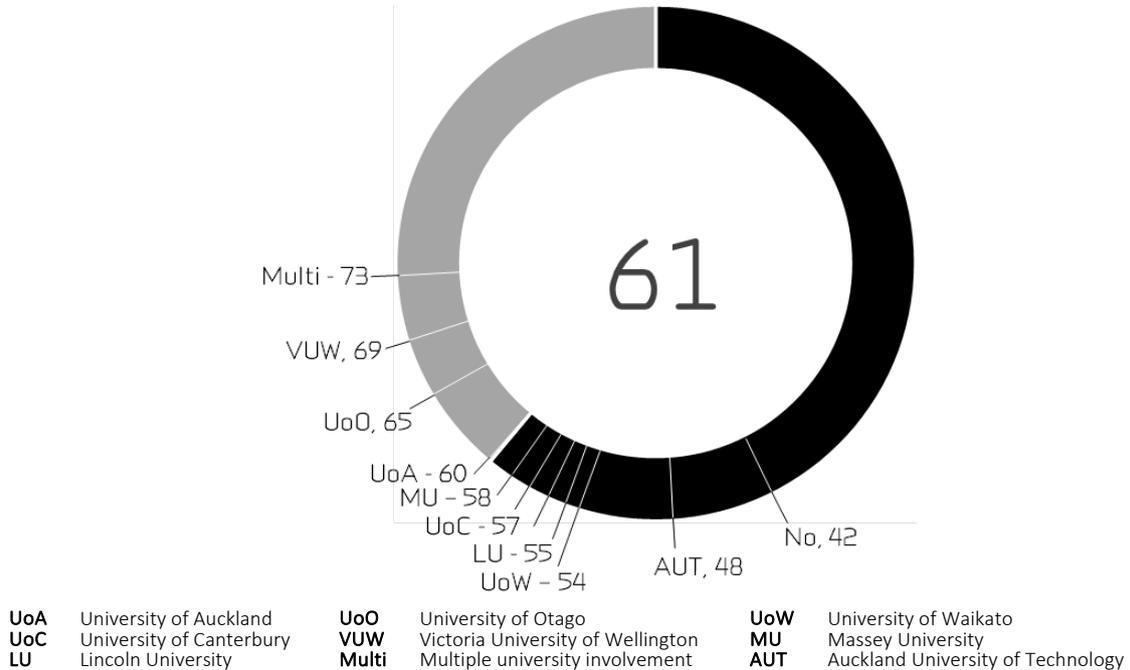


Figure 70. New Zealand university spin-out perceived innovativeness. The average score for the university spin-outs was 61, much higher than the non-spin-out (No) companies with 42. The companies from the collaboration of universities scored the highest PI scores of 73, followed by Victoria University of Wellington (VUW) with 69 down to The Auckland University of Technology (AUT) with the lowest university score of 48.

From Figure 70, all the university spin-outs in New Zealand scored higher than the average of the entire biotech industry. AUT scored the lowest with a score of 48, this was followed by the University of Waikato (UoW) with 54. The highest scores appeared to be when multiple universities combined to form a company and the perceived innovativeness score was 73 from the dataset.

The data could draw upon whether a company was located within the proximity of a university that would allow simple interactions between the two. The scoring of perceived innovativeness found that those companies that were located closer in proximity to a university scored higher than those companies that were not with a score of 48 to 39 in Figure 71.

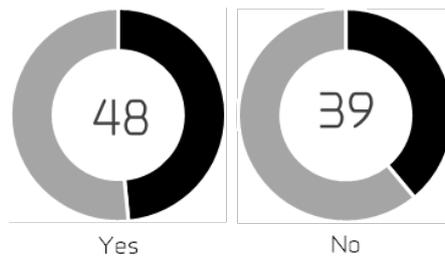


Figure 71. New Zealand university proximity perceived innovativeness. The companies that were located close to a university scored a higher innovativeness score of 48 compared to the companies that were not with a score of 39.

The higher PI scores for university spin-outs (61) and companies in proximity to universities (48) suggest the positive impact of academic collaboration and knowledge transfer on innovation. Proximity to a university may facilitate easier collaboration and knowledge exchange, contributing to higher perceived innovativeness.

The PI score was assessed for the biotech companies that had an association, such as research collaborations as well as being a spin-out with the New Zealand universities and found the average score was 59, compared to the non-associated companies which scored 39, broken down in Figure 72.

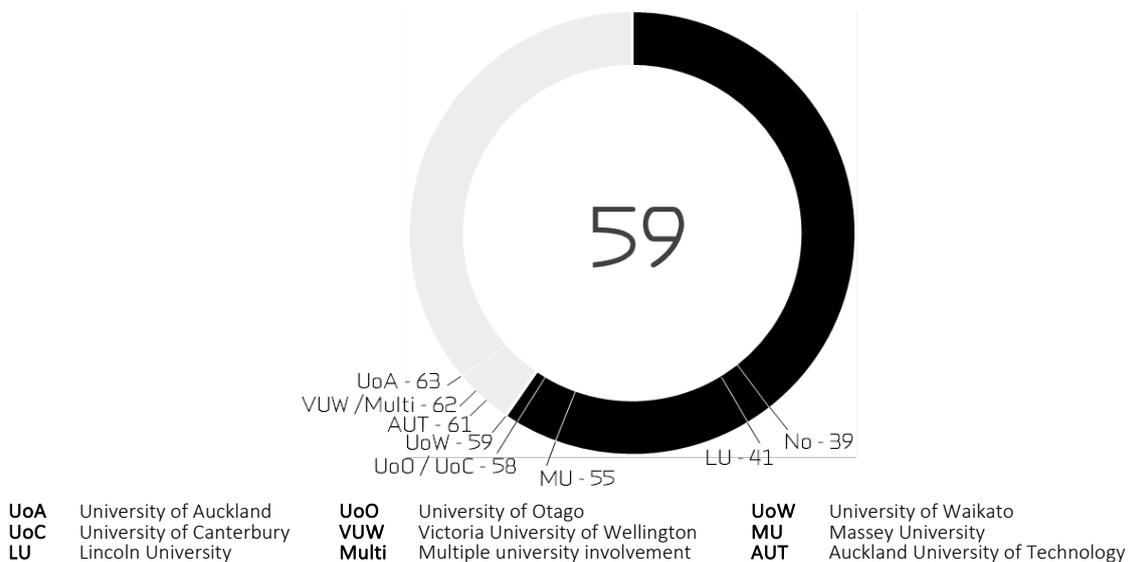


Figure 72. New Zealand university association perceived innovativeness. An association with a university appears to score higher for innovativeness with a score of 59 compared to a score of 39 for those that were not associated (No). Lincoln University (LU) scored the lowest for the university association with 41, increasing through the other universities where clustering is seen between the score of 55 and 63, with The University of Auckland (UoA) scoring the highest.

From within Figure 72, the PI score of companies that had associations with universities differed. All companies that had university associations scored higher than the companies that did not have associations with a university as this group scored a perceived innovativeness score average of 39. Of the companies that were associated with universities, Lincoln University (LU) associated companies

appeared to score the lowest with 41. There appeared to be a gap between LU and the other university associations as seen in Figure 71 and the grouping that appears between 55 with Massey University (MU) and 64 with the University of Auckland (UoA) scoring the highest PI score as a university association.

6.11.5 Regional location innovativeness

The perceived innovativeness of the different regions was compared with the average scores of all the alive companies from within each respective region, and it is seen in Figure 73. The Wellington (WGN) region scored the highest with 53, while the lowest scoring region was the East Coast (GIS) with 27.

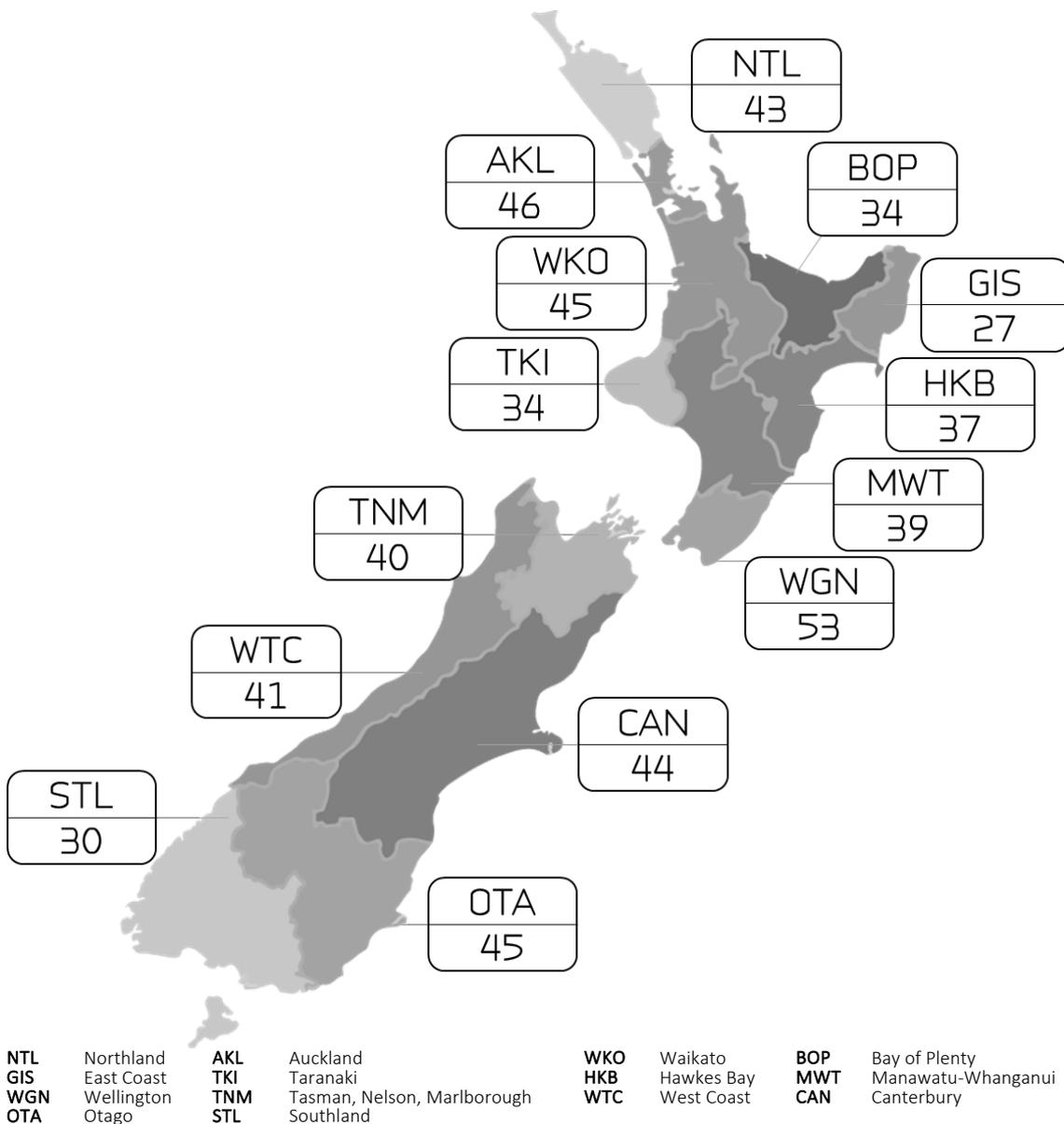


Figure 73. Perceived innovativeness by region. The Wellington (WGN) region scored the highest PI score with 53, while the East Coast (GIS) region scored the lowest with 27. All the regions can be seen scoring predominantly in the 40s and only four regions scoring the same or over the overall industry average of 47.

From Figure 73, the PI score is fairly low with only one region (WGN) scoring greater than 50. All regions have scored between 29 and 53 with many of them, which includes the larger regions scoring around the 40s. The areas with the greatest population appear to have scored the highest scores compared to the smaller regions. Varied innovativeness across regions (Wellington at 53, East Coast at 27) could be attributed to differences in infrastructure, government support, or industry clusters. Regions with higher populations, like Wellington and Auckland, may benefit from a more robust ecosystem and greater resources, contributing to their higher scores.

6.11.6 New Zealand biotech success and innovativeness perception

The perceived innovativeness (PI) scorecard was also applied to the subjective analysis of whether each biotech company was deemed-a-success according to the current analysis of providing a fair return to owners (shareholders) in Figure 74. The analysis found that the group of companies that were deemed not-a-success generated higher PI scores than the companies that were deemed-a-success with 58 versus 39 respectively. The counterintuitive finding that unsuccessful companies have higher PI scores (58 vs. 39) challenges the conventional belief that higher innovation leads to success. This could indicate potential issues in translating innovation into commercial success.

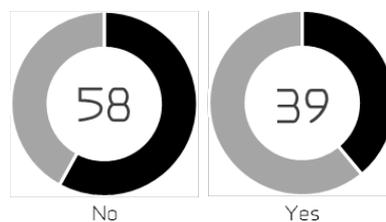


Figure 74. Success status perceived innovativeness of New Zealand biotech companies. The companies that were deemed not-a-success had a higher PI score of 58 compared to the companies that were deemed-a-success with 39.

The data was further analysed in Figure 75 to display the PI score and the number of companies with each score as two datasets as being deemed-a-success or not.

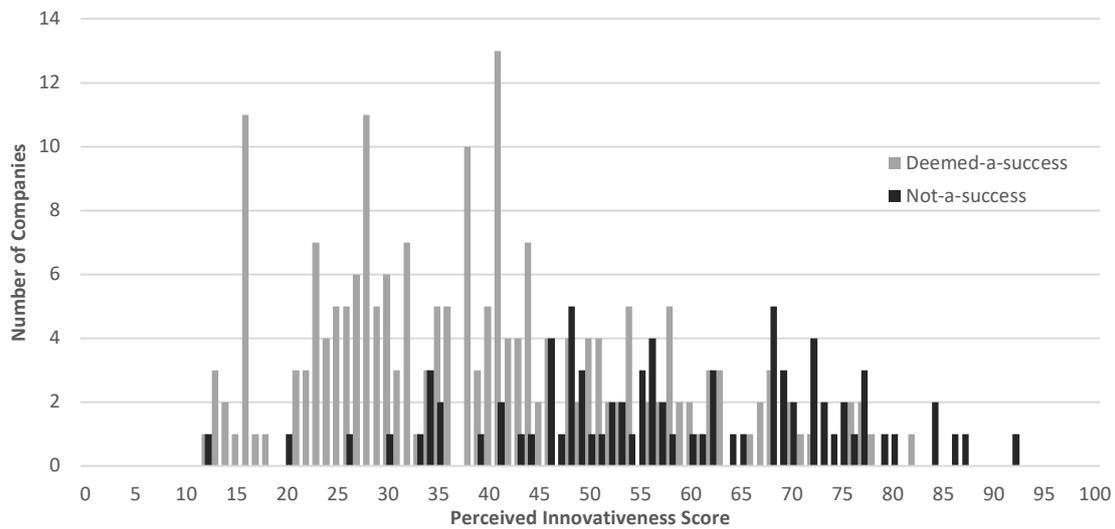


Figure 75. Perceived innovativeness success comparison. The spread of companies and their innovativeness scores as being a success (light) or not being a success (dark) displays that there are more unsuccessful companies towards the higher end of the innovativeness score compared to the successful companies.

The graph shows that the companies that were deemed-a-success are primarily located towards the left side of the scoring in relation to the perceived innovativeness, scoring lower scores. In contrast to the companies that were deemed to be not-a-success, the majority of the companies are located towards the right side of the graph, scoring higher scores, indicating that the companies that were perceived as being more innovative were not as successful. This is seen from the box and whisker plot in Figure 76 where the grouping of the not-successful companies has a higher PI score compared to the companies that were deemed successful.

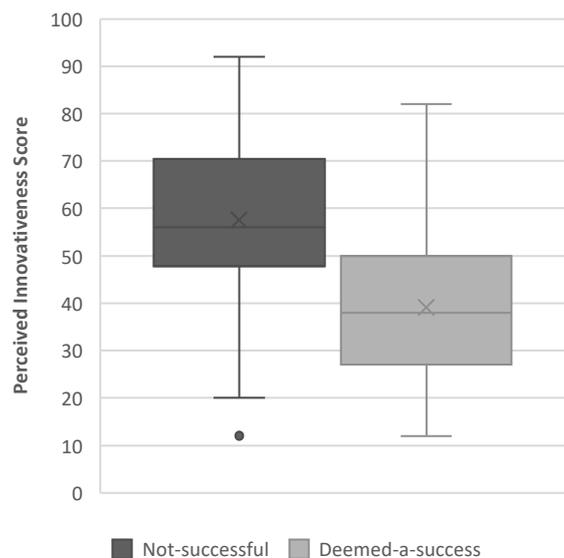


Figure 76. Deemed-a-success and perceived innovativeness box and whisker. The success category had an overall lower scoring spread with the majority (~75%) of PI scores being below ~50 compared to the not successful companies that had the majority (~75%) of companies scoring greater than ~50.

The two groupings within Figure 76 display the scoring spread of the deemed success status of the analysed companies. The data shows that the companies that were not deemed-a-success had a greater scoring spread, but also scored many companies greater than 50 with the lower quartile being ~50 and the upper quartile being ~70. This is in comparison to the companies that were deemed-a-success that had a lower quartile of ~30 and an upper quartile of ~50, scoring below that of the not-successful companies.

The sector-specific analysis further highlights discrepancies, suggesting that success in the biotech industry might be influenced by factors beyond innovativeness, such as market dynamics or business strategies. It was identified that this was the case across all but one sector. In Figure 77, for each individual sector, it can be seen that the companies that were deemed-a-success scored lower in terms of perceived innovativeness compared to the companies that were not deemed-a-success. The only sector for which this was not the case was the Marine sector, but this could also be due to the small size of the industry. The Health and AgBio sectors appeared to have the largest gap between being deemed-a-success or not with more than 20 points between the two categories.

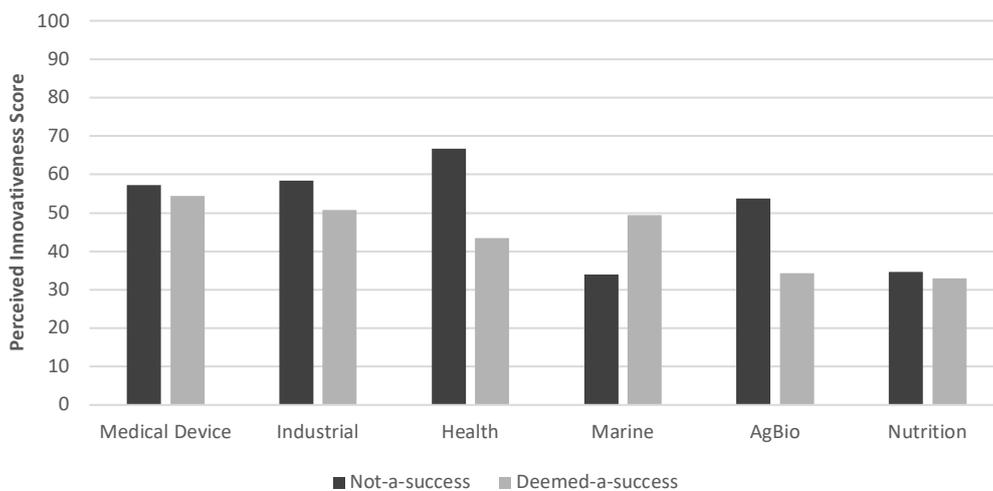


Figure 77. Perceived innovativeness of the biotechnology sectors deemed-a-success or not. The sectors scored higher PI scores for companies that were not deemed-a-success compared to the companies that were deemed-a-success, except for the Marine sector which score much higher for its success albeit, it contained the smallest sample of the industry. The Health and AgBio sectors had the largest differences between the successful or not scoring.

A complete one-page summary of all the PI scoring comparisons can be seen in Table 18, providing a breakdown of the New Zealand biotech industry.

Table 18. New Zealand biotech perceived innovativeness summary

<u>New Zealand Biotech Industry</u>															
44															
<u>Sector</u>															
<i>Medical Device</i>			<i>Industrial</i>			<i>Health</i>			<i>Marine</i>			<i>AgBio</i>		<i>Nutrition</i>	
56			56			52			47			37		33	
<u>Sub-sector¹</u>															
<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>	<i>G</i>	<i>H</i>	<i>I</i>	<i>J</i>	<i>K</i>	<i>L</i>	<i>M</i>	<i>N</i>	<i>O</i>	
68	66	63	63	60	51	44	44	42	39	37	37	34	33	31	
<u>Ownership</u>															
<i>Public</i>							<i>Private</i>								
63							43								
<u>Environment Locality</u>															
<i>Urban</i>							<i>Rural</i>								
48							39								
<u>Successful?</u>															
<i>No</i>							<i>Yes</i>								
58							39								
<u>Market Stage</u>															
<i>Pre-market</i>					<i>Market</i>					<i>Service</i>					
64					43					37					
<u>University Spin-out²</u>															
<i>Multi</i>	<i>VUW</i>	<i>UoO</i>	<i>UoA</i>	<i>MU</i>	<i>UoC</i>	<i>LU</i>	<i>UoW</i>	<i>AUT</i>	<i>No</i>						
73	69	65	60	58	57	55	54	48	42						
<u>University Proximity</u>															
<i>Yes</i>							<i>No</i>								
48							39								
<u>University Association²</u>															
<i>UoA</i>	<i>VUW</i>	<i>Multi</i>	<i>AUT</i>	<i>UoW</i>	<i>UoO</i>	<i>UoC</i>	<i>MU</i>	<i>LU</i>	<i>No</i>						
63	62	62	61	59	58	57	55	41	39						
<u>Regional Location³</u>															
<i>WGN</i>	<i>AKL</i>	<i>OTA</i>	<i>WKO</i>	<i>CAN</i>	<i>NTL</i>	<i>WTC</i>	<i>TNM</i>	<i>MWT</i>	<i>HKB</i>	<i>TKI</i>	<i>BOP</i>	<i>STL</i>	<i>GIS</i>		
53	46	45	45	44	43	41	40	39	37	34	34	30	27		

- 1 **A** Therapeutics / Diagnostics **B** Imaging **C** Biopolymers **D** Biofuel
E Analysers **F** Equipment **G** Aquaculture **H** Other
I Cosmeceutical **J** Nutraceutical **K** Breeding **L** Services
M Feed **N** Supplements **O** Protection
- 2 **Multi** Multiple universities involved
VUW Victoria University of Wellington
UoA University of Auckland
LU Lincoln University **OTA** University of Otago
CAN University of Canterbury
AUT Auckland University of Technology **MAS** Massey University
WAI University of Waikato
No No spin-out or association
- 3 **WGN** Wellington
WKO Waikato
MWT Manawatu-Whanganui
STL Southland **AKL** Auckland
TNM Tasman, Nelson, Marlborough
HKB Hawkes Bay
GIS East Coast **OTA** Otago
NTL Northland
TKI Taranaki **CAN** Canterbury
WTC West Coast
BOP Bay of Plenty

Scorecard development reliability

The perceived innovativeness scorecard was assessed for reliability with the IBM SPSS Statistics program where the input data collated was processed with a Cronbach Alpha score (UCLA: Statistical Consulting Group., n.d.). This was identified as 0.733, which is seen as an acceptable coefficient for most social science research and is a good sign of reliability.

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.733	.740	9

The data was also tested for the inter-item correlation for the identification of multicollinearity as seen below. The data suggests that the scorecard items have a positive relationship with each other as they are predominantly positive, but none of the items have a high correlation that could lead to multicollinearity with the highest scoring pair being 0.620.

Inter-Item Correlation Matrix									
	Intellectual Property	Industry Newness	Consumer Behaviour	Infrastructure	Competitiveness	Meaningfulness	Strategy	Translation	Sub-sector rating
Intellectual Property	1								
Industry Newness	.561	1							
Consumer Behaviour	.599	.620	1						
Infrastructure	.150	.144	.092	1					
Competitiveness	.322	.552	.462	.116	1				
Meaningfulness	.432	.595	.555	.064	.486	1			
Strategy	.414	.263	.350	.135	.249	.229	1		
Translation	-.117	-.232	-.185	-.102	-.260	-.249	.275	1	
Sub-sector rating	.264	.356	.308	-.121	.305	.423	.381	.197	1

The original basis of the PI scorecard consisted of 16 criteria, which on first analysis, found that many items overlapped each other. These were reduced to the nine criteria that were used in the final PI scorecard. These nine criteria were also tested through various scenarios of the removal of each criterion and also the removal of multiple criteria to judge if they had a material impact on the PI score outcomes.

7. DISCUSSION

The preceding chapters presented the findings from the survey, interviews, data mining and scorecard development involving innovation, disruptive innovation theory, the biotechnology industry of New Zealand and its perceived innovativeness. In this chapter, the major findings are discussed in relation to research questions that were developed from the study of relevant previous literature. The first part of the discussion relates to research questions one and two of disruptive innovation theory and the commercial elements as a foundation:

- 1. How aligned is the understanding of disruptive innovation between academia and industry?**
- 2. What commercial elements could set the foundations of disruptive innovation?**

These questions are answered predominantly from the online survey and interview phase of the research with quantitative and qualitative data and assisted in the development of the later stages such as data mining and scorecard development. The second part of the discussion relates to research question three, which relates to the profiling of the New Zealand biotechnology industry.

3. What is the landscape profile of the New Zealand biotechnology industry?

This question is answered through the mix of the data mining phase and the first phase of the survey and interviews due to the nature of profiling individual companies and various findings of the respective companies. Finally, the third part of the discussion explores the application of the developed perceived innovativeness scorecard to the New Zealand biotechnology industry and in doing so addresses the last research question:

4. How does the perceived innovativeness of New Zealand biotech relate to success?

This question is addressed through the analysis of the PI scorecard application to the New Zealand biotechnology industry. Finally, the chapter is closed off with the research implications, the limitations and concluding remarks.

7.1 DISRUPTIVE INNOVATION

The research attempted to identify the alignment of innovation concepts such as disruptive innovation understanding from the literature to the practical application, and if there are commercial elements that could be the foundation towards disruptive innovation. To achieve this, a total of 43 completed surveys were analysed for the first phase, followed by 10 structured interviews from active biotechnology personnel for the second phase. The combined data of the survey and interviews created a picture of themes to allow a formal understanding of the relationship and alignment around the innovation concepts and theory between industry practitioners and academia as well the potential commercial foundations a business or a project could be built upon from an industry perspective of disruptive innovation theory to increase the chances of success.

The results from the survey and the interviews presented a distinct theme from practitioners, who were highly educated but not involved with academia. The research found that the definitions of disruptive innovation are not used in the prescribed modern academic way by Christensen (1997) but were identified as a generalised used term. The survey results showed that there was no overwhelming sense of understanding, with none of the potential disruptive innovation definitions receiving greater than 50% of the participants' selections. The top three ranked definitions of disruptive innovation selections were:

- Disorder to the current environment by introducing something new
- Rapid growth, creating own market, displacing other product(s)
- Breaks traditional markets by providing functionality thereby broadening and developing markets

The observation that three choices carry a similar theme indicates a shared conceptualisation of disruptive innovation as a transformative force. The pattern of themes in these top selections was the notion of pushing older companies or products to the side with the introduction of newness and functionality. This does appear to align somewhat with some academia where disruptive products or services will help create a new market or network and weaken or destroy an existing product or market category (Seba, 2014). The top selections also appear to combine other academic framings such as discontinuous innovation that involves dramatic leaps in familiarity and use as well as breaking from past practices, and allowing industries and markets to emerge, transform or disappear. They can help companies rewrite industry rules or create entirely new industries (DeTienne & Koberg, 2002; Kaplan, 1999; Veryzer, 1998).

The observed diversity in responses might be attributed to the evolving nature of disruptive innovation and its contextual interpretation. While the diverse responses are insightful, investigating how certain industries or roles may influence specific definitions could provide deeper insights into the nuanced interpretations of disruptive innovation. This exploration would contribute to a more comprehensive understanding of the factors shaping individuals' perceptions.

The analysis of the data finds that the disruptive innovation definition by Christensen (1997, 2003), which was split into two parts for the survey due to its length was not highly ranked by participants. The two parts were ranked seventh (Markets appear as if from nowhere, creating massive new sources of wealth, tends to have roots in technological breakthroughs) and twelfth (Smaller, cheaper, reliable, and convenient products that moves up a market, eventually displacing established competitors) out of the 14 available options. The top selections do appear to have some alignment with the seventh-ranked part of Christensen's disruptive innovation with the introduction of newness and technological breakthroughs, and a rapid growth item that creates its own market and then pushes into other markets. Although, it appears that the core features of Christensen's disruptive innovation of a smaller, cheaper, reliable, and convenient item moving up a market ranked poorly and is not where the current thinking of practitioners currently lies. The low recognition of Christensen's original definition could signal a gap between academic discourse and practical business understanding. This discrepancy may indicate a lack of dissemination of foundational disruptive innovation theories in the business community. Exploring whether respondents draw from alternative sources and understanding the

disconnect between academic definitions and practical applications would enrich the interpretation, shedding light on the awareness gap.

There is also a difference in the current thinking around where in a market a disruptive innovation enters by creating its own market space and breaching the traditional markets compared to the slow displacement of moving up through a market over time. The overall perception from the data appears to be more aligned with the Oxford English Dictionary and Merriam-Webster definition of interrupting the normal continuity, or even more recently, the media's extensive use of the term as a buzzword as opposed to the academic representation of disruptive innovation. This also demonstrates why Christensen attempted to speak out about the misapplication of the term in 2015, where he described the too broad usage of how the use of disruptive innovation being used for any situation in which an industry has been shaken up and previously successful incumbents have stumbled, but this is almost where the term has come to be understood and applied today.

There is also no distinction from the results about the different types of disruption that could be implemented such as at the lower-end, higher-end or big-bang disruption (Carr, 2005; Christensen, 1997; Christensen & Raynor, 2003; Downes & Nunes, 2013; Schmidt & Druehl, 2008). As it appears in most responses for reference to disruptive innovation, it could be seen as being a product, service, process, etc., introduced to a market that creates new market segments and/or replaces previous offerings at any entry point. This appears to be quite aligned with Schumpeter's theory of shifting profit pools, rearranging industries and replacing established businesses in a dynamic approach of creation and destruction, otherwise known as creative destruction (Anderson & Tushman, 1990; Croitoru, 2012; Drucker, 1955; Hendy & Callaghan, 2013; McCraw, 2009; Schumpeter, 1934, 1939). It could be proposed that if the term holds weight and has application in today's business practices, the modern sense of disruption is still working out its meaning.

The academic and industry application of DI was again different when practitioners identified whether they had been the instigator of disruption or were on the receiving end of being disrupted. In the academic framing, this would be limited to a small number worldwide being truly a disruptor or disrupted. However, due to the differences in DI definitions, practitioners perceived that they were a disruptor and experienced being disrupted quite substantially. This could potentially indicate that there is a spectrum to the level of disruption that individuals or companies would feel as is depicted in the literature of Figure 2.

The research investigated whether there were commercial elements, by utilising the Ten Types of Innovation (Keeley et al., 2012) as a framework. Within this framework, could foundations be

established, from an industry perspective, for the best chances of developing and implementing a disruptive innovation. The research found that there were elements that were more highly favoured by practitioners compared to other elements when thinking of disruptive innovation. This output involving a suite of commercial elements towards DI does not appear to be clearly identified in other literature to date, with most literature making broad approaches to a specific product or offering aspects such as targeting pricing, the size of products and convenience with rapid improvement (Christensen, 1997; Christensen & Raynor, 2003; Utterback & Akee, 2005). Other approaches have been to introduce a different product or service or be a small, low-margin business that large companies will ignore (Charitou & Markides, 2003). While Ali (2004) provides some aspects such as introducing entirely new performance features, improving performance by 5x or more, or significantly reducing cost (30% or more). The literature does not appear to provide any guidance beyond what could be described as a business-as-usual approach and typical business or innovation cycles. The research attempted to outline the best and the least favourable strategic thinking as well as implementable tactics for disruption innovation.

The strategies and tactics that were selected by greater than 33% of participants were viewed as favourable while those that were selected by less than 10% of the participants were viewed as not being favourable for disruptive innovation. A summary of the most and least favourable disruptive innovation strategies and tactics can be seen in Table 19 and the definition for each item is in Appendix B.

Due to business operations being multifaceted, the data encapsulates multiple elements of business segments where appropriate combinations should be applied to potentially increase the chances of success and a disruptive innovation. The analysis identified that there was at least one strategy or tactic that was favoured for all the commercial elements with many having multiple options (from Table 16 and upcoming Table 19). The same could be seen for the unfavoured options within the elements apart from product systems. Surprisingly, the analysis also identified that six elements were more heavily favoured in terms of selection certainty with greater than 50% of selections, creating a greater divide between the favoured and unfavoured towards the thinking of DI. The top favoured elements were brand, product systems, customer engagement, product performance, channel and network which will be detailed further.

The brand element looked at how the business and offerings are represented. This contained the most strongly selected grouping from the data concerning DI with four favoured selections over the others with one selection acting as the divider of the favoured versus unfavoured. The highly favoured brand selections were technology push, whereby the need or demand for the offering comes from the marketplace, followed closely by its antagonist, technology push, where R&D is needed for new

technology to drive new products. This was then grouped with transparency and values alignment where businesses allow customers to see into the operations and participate along with the values that are expressed consistently in all aspects of the business. These four aspects help a business formulate the best branding approach today and should not come as a surprise due to the current value placed on brands by businesses around the world.

The product system element involved how the business creates complementary offerings, where radical innovation was the most favoured DI approach that a business introduces dramatically new technical and commercial skills into existing markets. This top selection approach aligns with the thinking of the practitioners' general understanding of DI, reinforcing the need for new technical and commercial skills for disruptive innovation and signals a shared understanding of its disruptive potential. However, role-specific and geographical differences underscore the importance of customisation. Organisations should leverage radical innovation while recognising role-specific and regional nuances, ensuring a balanced and context-specific product system strategy.

The customer engagement element involved how a business fosters compelling interactions and found that experience simplification was the most favoured DI approach whereby, reducing complexity and focusing on delivering specific experiences exceptionally well. Interestingly, this approach is well aligned with the original Christensen definition of convenient items in DI.

The product performance element that examined the development of distinguishing features and functionality found that the data suggests that ease of use and a superior product were the favoured DI approaches. This response is highly correlated to the blended understanding of DI from the practitioners and the alignment with academia whereby a business would operate by making the offering simple, intuitive, convenient, and comfortable to use as well as developing an exceptional design of high-quality and cutting-edge technology. The description of these attributes appears to be able to be placed in multiple market segments, not just the low or high-end and would be a user's expectation of product performance with new offerings today. with the customer engagement of experience simplification of reducing the complexity and this was seen again with the product performance element focusing on ease of use with a simple, intuitive, convenient, and comfortable offering. These element selections align closely with the original work of Christensen (1997) and Christensen & Raynor (2003). While there were also differences or expansions upon the concept with the product performance of a superior product.

The data analysis of the channel element for the delivery to customers and users identified three highly favoured DI approaches that appear related. These were to go direct and skip the traditional retail

channels, thereby connecting directly with customers. Not surprisingly today, this was followed by using non-traditional channels to reach customers and an on-demand approach to delivering goods in real-time wherever and whenever. These three channel elements' top selections would not come as a shock to many in a world where a fast and instant environment is sought daily and suggests an alignment with contemporary business strategies. The lower selection of traditional approaches highlights the need for businesses to adapt to evolving consumer behaviours. Organisations should capitalize on the growing preference for direct and flexible channels.

Finally, the network element involving the connection with others to create value was a closely aligned combination of collaboration and open innovation was the favoured DI approaches, where partnering with others for mutual benefit to leverage, extend and build on expertise. This again was not a surprising finding from the data due to the interconnectedness and global nature of business today to any other time in history and working with other individuals or businesses in other regions have never been easier.

There were also several points to note from the results such as in the market element, the observed hierarchy aligns with current industry trends favouring unconventional market approaches. The concept that the DI approach should open new markets and that a behaviour change is required for the market was seen as a favoured selection. This could indicate key differences in the thinking from the practitioner to the academic and that there is a spectrum of disruption relating to innovation. As well as social media being identified as a favoured DI approach in this digital era replacing the means of classic advertising, which was an unfavoured approach. This is also identifiable with the market aspect of low-end targeting falling to the unfavoured side which is the original premise of DI. Also on the other side, the aspect of education being required was not a favoured response to a disruptive innovation and would somewhat contradict the earlier responses from the participant group. Another element category that presented some interesting findings was that of the structure element for businesses. Although they did not feature as a highly favourable element overall, there was a clear distinction that a small team, decentralised management, a competency centre, and organisational design being the favoured DI approaches. In stark contrast to the unfavoured approaches involving C-suite involvement, a large team, or individual effort, and having a corporate university along with asset standardisation. These approaches do align with the literature on using skunkworks or specialised teams to achieve a disruptive innovation.

The absence of a dominant profit model suggests a challenging environment, and the diverse preferences across roles and locations emphasize the need for a flexible strategy. The prominence of Freemium may indicate a trend, but the lack of a strong majority calls for caution in assuming a one-

size-fits-all approach. Organisations should consider a hybrid strategy that incorporates elements appealing to various roles and regions for a more resilient profit model.

It should be noted that any approach should not be selected or dismissed but should be analysed to see if it is the best fit to complete the job. The following table 19 presents a summary of the business elements that were identified in the findings as the most favoured and least favoured strategies and tactics when thinking of disruptive innovation.

The study reveals a moderate gap between academic and industry perspectives on disruptive innovation, with practitioners seeing it as transformative and diverging from traditional academic definitions. This discrepancy highlights the dynamic nature of disruptive innovation, impacting academia, industry, and future research. The need for better dissemination of foundational theories in the business community is emphasised, suggesting enhanced collaboration for a comprehensive understanding. The study underscores the importance of bridging this gap for effective strategies, particularly in the biotechnology sector.

Additionally, the study identifies specific commercial elements favoured by practitioners for successful disruptive innovation. Practical strategies extend beyond typical business cycles, offering unique insights. Elements such as brand, product systems, customer engagement, and network provide a strategic framework for businesses aiming at disruptive innovation. Integrating these findings with the broader study emphasises the practical aspects and strategic considerations necessary for bridging the gap between academia and industry in harnessing disruptive innovations.

Table 19. Disruptive innovation strategies and tactics foundations

Element	Most favourable	Least favourable
Market	Open New Markets Intuitive Adoption Timing Behaviour Change Required Social Media	Grow Emerging Markets Education Required Increase Current Market Size Low-end Market Targeting Mainstream Market Success Classic Advertising
Network	Collaboration Open Innovation Supply Chain Integration	Consolidation Merger/Acquisition
Process	Strategic design User Generated	On-Demand Production Lean Production
Structure	Organisational Design Decentralised Management Small Team Competency Centre	Corporate University Asset Standardisation C-Suite Involvement Large Team Individual Effort
Profit Model	Freemium	Cost Leadership Microtransactions Bundled Pricing Forced Scarcity Membership Auction Float Switchboard
Product Performance	Ease of Use Superior Product Performance Simplification Engaging Functionality	Conservation Feature Aggregation
Product System	Radical Innovation Customisation Modular Systems Product/ Service Platforms Integrated offering	
Service	Superior Service Total Experience Management Try Before You Buy Personalised Service	Concierge Supplementary Service Lease or Loan
Channel	Go Direct On-Demand Non-Traditional Channels	Pop-up Presence
Brand	Technology Pull Technology Push Transparency Values Alignment Sustainability	Brand Extension Private Label
Customer Engagement	Experience Simplification Community and Belonging Personalisation Autonomy and Authority Process Automation	Curation

7.2 NEW ZEALAND BIOTECHNOLOGY INDUSTRY

The research attempted to profile the New Zealand biotechnology industry with various points. To achieve this, an in-depth analysis was taken to profile individual companies and present a picture of the New Zealand-founded and operated biotechnology industry. It should be noted that from the final presentation of the New Zealand biotechnology industry analysis, there could be many additional New Zealand-founded and operated companies that were not identified due to limitations of available resources in which they were founded and ceased operating before information being readily available and accessible. The exact profiling of the biotechnology industry was particularly difficult due to the multiple broad definitions applied and due to almost all the companies being private companies and thus information not being easily accessed. The information that could be attained from an extensive survey directly to the active companies could have both positives and negatives due to self-reporting factors.

The biotechnology industry definition that has been applied for the research was broad to capture as many companies as possible as previously applied in surveys were found to be narrow involving only companies that conducted R&D. This was seen to create non-comparable findings to other countries such as the US, who included companies from healthcare, food and nutrition, agriculture, industrial and environmental sectors. The same could be seen when comparing to the European countries and thus makes it difficult to compare across different regions of the world and countries.

The findings from the research identified that there were 380 identified companies of which, currently 292 biotechnology companies were still alive and New Zealand-founded and operated over the modern biotechnology timeframe. This number appears to be a significant change to the New Zealand biotech industry in 2005 when there were six public companies and 47 private companies (Ross & Ward, 2005) to the highest record of 474 companies in the Bioscience Survey of 2011 by Statistics New Zealand (2012). This research presents a much higher number of companies with 380 than the BioTechNZ (2020) survey of 211 companies. New Zealand would appear to be overachieving in this industry in comparison to Australia with around 540 companies, by having half the number of companies but with one-fifth the population of Australia. However, the growth rates of the respective countries differ, and the number of public companies differs greatly with Australia having over 100 public companies to New Zealand's 13 active public companies. There appears to be a distinct difference in business attitudes and investment in the biotechnology industry between the two countries. This trend is seen when compared to countries further abroad such as the United States, although at a much larger scale, the numbers do not correlate to country sizing or value as well as the numbers of biotech companies being founded yearly. For example, the US has approximately 66 times the population of New Zealand, but the number of biotech companies is only about 33 times greater which would indicate that the number of biotech

companies in New Zealand exceeds expectations per capita. This is also seen when compared to European and Asian countries, although the data from China is less known.

The findings oppose the general trend of the biotech sector division being dominated by human health but may not come as a surprise to New Zealanders that the AgBio sector was the largest identified sector from the research with 31% of all identified companies and increasing to 33% of the alive companies. This finding of the AgBio sector being the largest is comparable to previous data from Statistics New Zealand through the bioscience surveys and importing and exporting data and the dominance of the primary agricultural roots embedded in the country, which Hendy & Callaghan suggest should be reduced in terms of the country's reliance. However, the research findings of the sector breakdown differ from the BioTechNZ (2020) survey which reported that Health was the largest sector with 52% followed by Agriculture, Industrial and Marine with higher proportions compared to the research. This point of difference could be more closely related and align with the worldwide biotech sector view if the research combined the Health and Medical Device sectors under the same umbrella and would consist of 37% of the New Zealand biotechnology industry thus making it the largest sector. In other countries such as Australia and the US, this is the trend, with Health comprising over 50% of their respective industry (Commonwealth of Australia, 2022; Vuleta, 2021). It was surprising to see the low number of the Marine sector for a country that is rich in water resources in the Pacific Ocean.

A key finding of the research identified that the average age of a New Zealand biotech company from the entire landscape was 16 years old. This was further examined with respect to the companies that are alive, and the average age increased to 17 years old compared to the fallen companies that were of an average age of 13 years. The small Marine sector was identified as having the oldest average age sector at 21 years old, although the sector size may be too small to compare equally to the other sectors. The AgBio and Nutrition sectors were the next oldest and trailed by the Industrial sector being the youngest average age at 11 years old from the New Zealand biotechnology industry. This supports worldwide data regarding the ages of biotechnology companies, with the New Zealand companies potentially outliving their counterparts in other regions of the world and being a walking dead (Godfrey et al., 2020; Patzelt et al., 2008; Pfeffer, 2012; Pisano, 2006; Vuleta, 2021). This could be possibly quite different to the approach seen in the US where the timeframe is shorter due to the capital and investing structures in place. This could also reflect that the New Zealand companies have limited resources in terms of financial support as well as personnel and therefore proceed at a slower rate in general. This is seen from the total R&D expenditure for the country of all industries in 2020 totalling \$7.2bn (Statistics New Zealand, 2021, 2022). While in comparison, just the US public biotech companies spent \$27.1bn on R&D in 2006 and more recently, in 2016, spent \$38.8bn (Ernst & Young, 2006, 2017).

Regarding the commercial status, over half the New Zealand landscape was deemed to be in the market and the service companies nearly a 20% addition, leaving approximately 30% of companies not currently in the market as pre- or post-market. The research is comparable to the recent survey that reported that about 30% of companies are early-stage commercially and pre-revenue (not in the market) (BioTechNZ, 2020). The Health and Industrial sectors appear to have the smallest proportion of in-market companies (~35%) but the largest pre-market companies (~40%) compared to the Marine sector with the highest in-market and lowest pre-market companies. The data shows that when filtered for only alive companies, the companies that are in the market being 67% are of an average age of 18 years old, while the companies that are pre-market comprising of 13% are of an average age of 6 years old. This would align with literature and market reports surrounding the biotechnology industry where companies that are in the market appear to be of lower value, shorter product development timelines, and regulatory requirements such as in the Marine, Nutrition and AgBio sectors compared to the more modern technical biotech companies which generally face the typical cycle of 10-15 years of research and development for a product to get market-ready before entering the market such as for the Health and Industrial sectors (Vuleta, 2021). This could also be a reason for the low post-market companies identified in the New Zealand landscape as they are still in development or early in the market lifecycle.

The research analysis identifies that several companies were founded from university origins. It was determined that a total of 57 companies were labelled as biotech spin-outs of New Zealand universities representing 15% of the total identified companies or 12% (36) of alive companies. The total number identified in the research is an increase from the previously reported total of 44 of all New Zealand university commercialisations of any industry by Te Pōkai Tara (2012) in 2006. This is a significant increase, particularly from the biotechnology perspective, however, there have been no further reports in recent times to indicate a trend in university spin-outs. When comparing to the other countries, on average from the GrantGov (2021) report, UK universities were spinning out 23 companies a year over 20 years compared to New Zealand's approximate three per year over a similar period. Although, again relatively speaking, this does align with population proportions. The human healthcare area involving Health and Medical Devices was the dominant area of focus for university biotech spin-out companies with ~72%. The majority of spinouts were from the University of Auckland with nearly 40% and the University of Otago with ~20%, this was to be expected from UoA with the oldest and most established commercialisation office in New Zealand. The youngest university commercial office, AUT, consisted of the least spinouts. A similar picture is seen regarding the industry and university involvement. The total number of companies involved with a university in some capacity increases to ~28% or 108 companies of which 72% are still alive. This is an 89% increase in university involvement and particularly around the number of AgBio relationships of a 350% increase in involvement. It would then seem that universities

would attempt to research and then commercialise healthcare offerings as a spin-out while companies would seek university expertise with AgBio applications.

The research findings identify the geographical location of the New Zealand biotech landscape to have some similarities to the bioscience and BioTechNZ surveys with most of the companies being near the major cities. The research suggests that the Auckland region is the dominant region for biotech comprising ~40% of the total landscape. This was like the BiotechNZ (2020) survey that reported 37% for the Auckland/Northland region. The research, however, differed in that the Canterbury region was the second largest with 15% and then the Waikato region with 12% compared to the survey which had the Wellington region as the second largest at 18% and then Christchurch (Canterbury) and Dunedin (Otago) at 6% each (BioTechNZ, 2020). While the Wellington region came in at 7% in the findings alongside the Otago and Tasman regions. The geographical locations of the New Zealand companies appear to be based on major cities, university locations or even specific sector dominance. Besides Auckland being the largest city, it also contains three of the eight universities, while the Canterbury region consists of two universities, and the Waikato region is known for its farming environment with AgBio, as is the surprising find of the Tasman region that was seen to have a hub of Marine sector companies focused on aquaculture, which could be partly due to the environmental advantage to host these types of companies within the Marlborough Sounds. This group of like-for-like companies is often seen for biotech companies such as the well know biotech clusters in Cambridge, UK and San Francisco and Boston, US where the companies can leverage off each other from success to equipment, personnel and collaborations (Bania et al., 1993; Casper & Karamanos, 2003; Garnsey & Heffernan, 2005; Munroe & Anguiano, 2003).

Although the findings from the New Zealand biotech landscape present 380 companies, approximately 35% of the identified companies have fallen and/or are no longer New Zealand-owned and operated companies. Most of these lost companies were through a process of mergers and acquisitions. This appears to be aligned with the trend of large bio or pharma companies buying up smaller biotech companies to keep them at the forefront of the market with new innovative technologies (Evens & Kaitin, 2014; Salle & Thomas, 2020). A finding that may not be surprising from this research was the companies deemed-a-success that are alive being 72% in comparison to the fallen companies with only 24% being deemed a success. This does somewhat seem in conflict with most of the companies being acquired and then being not-a-success for the founders or early investors. The companies that are still alive and deemed-a-success could also still be contributing to a fair return to the owners, due to the commercial stage and maturity that a respective company may be at the time of the analysis. It does appear that this industry does have long lifecycles to be able to be deemed-a-success for owners.

The biotechnology landscape in New Zealand is marked by significant growth and diversity, featuring 380 identified companies—a substantial increase from historical data. A noteworthy shift challenges conventional trends, as the AgBio sector emerges as the largest, constituting 31% of all identified companies. This deviation from the dominance of human health-focused biotech sectors showcases the industry's adaptability and resilience.

The sustained presence of companies, especially within the AgBio sector, underscores the industry's stability and longevity. The unique distribution of sectors and the notable average company age contribute to the characterisation of New Zealand's biotech landscape as distinctive. Overall, the findings highlight the industry's robustness and its ability to carve a unique niche within the global biotechnology arena.

7.3 NEW ZEALAND BIOTECH AND INNOVATIVENESS

The research attempted to identify how the perceived innovativeness of a company in the New Zealand biotechnology industry relates to its success. In doing so, the research explored the relationship and the notion that the higher the innovativeness of a company, the greater the chances of being successful. To examine this, the research developed the perceived innovativeness (PI) scorecard to take a snapshot of an actively operating company and assess its position in respect to the company being innovative or not, which in return could be useful for early-stage companies and investor relations, to demonstrate a potential impact and provide a competitive advantage to compete on the global stage. The PI score could also be used as a tool that allows practitioners to evaluate their own company to assess where there are aspects of improvement across the entire operation of the company. The simple tool encapsulates many aspects of the business from IP, infrastructure, technology offering, consumer behaviour requirements, the strategy employed, the level of competition and the meaningfulness it will have on society, the stage of development as well as a biotechnology sub-sector rating. The developed PI scorecard which is seen in Figure 78 requires each criterion completed and the sum of the score to provide a PI score.

Perceived Innovativeness Scorecard				
	None ×	Little ★	Some ★★	Substantial ★★★
Intellectual Property	0.0	5.1	10.2	15.3
Industry Newness	0.0	7.4	14.8	22.2
Consumer Behaviour	0.0	6.5	13.0	19.4
Infrastructure	0.0	1.4	2.8	4.2
Competitiveness	0.0	2.8	5.6	8.3
Meaningfulness	0.0	3.2	6.5	9.7
Strategy	0.0	3.2	6.5	9.7
Translation	0.0	1.9	3.7	5.6
Sub-sector Rating	0.0	1.9	3.7	5.6

Figure 78. Perceived innovativeness scorecard. The scorecard is used when assessing the perceived innovativeness of a company at a particular point in time. The company is scored on the nine criteria labelled down the left side column and each criterion is assessed as none (no star), little (★), some (★★), or substantial (★★★). This will provide a weighted scoring value for each criterion, of which, the sum of the criteria will provide the perceived innovativeness score for each company.

The scoring of a company's perceived innovativeness is a subjective external evaluation of a company's ability to innovate and wield substantial influence. Companies often strive to cultivate an image of innovation, influencing consumer perceptions, investor confidence, and market positioning. This perceived innovativeness can potentially serve as a precursor to the adoption of disruptive innovation strategies as detailed through the development of the perceived innovativeness diagnostic scorecard in the methodology section.

The impact of a company's perceived innovativeness can extend beyond a mere image boost; it can play a pivotal role in influencing the mindset of various stakeholders, including directors, management, investors, and analysts. In the context of disruptive innovation, which should transcend technological advancements to encompass shifts in processes, offerings, and the overall customer experience, innovativeness can be a visual indicator and critical driver for success. This goes beyond introducing novel ideas; it involves strategically translating these ideas into tangible products or services that reshape industries. Companies fostering a culture of innovation and being perceived as pioneers often gain a competitive edge, acting as a catalyst for disruptive innovation that challenges traditional norms.

The companies that are on the pathway to success in other industries understand the transformative power within the disruptive innovation space and harness it to create unique value propositions, differentiating themselves in the market. Commercial success, however, is not solely dependent on the innovation itself but requires the strategic integration of disruptive ideas into the market. Key tactics

from the Ten Types of Innovation, such as business model innovation and brand innovations, become integral in this process.

Furthermore, the commercial aspects of disruptive innovation extend beyond product development. Companies must navigate intricate ecosystems, adapt business models, and forge strategic partnerships to maximize the impact of their innovations. The synergy between perceived innovativeness and disruptive innovation is evident as companies leverage their brand reputation to attract top talent, secure investments, and form collaborations. Essentially, a company's perceived innovativeness acts as a magnetic force, attracting resources and opportunities that fuel its journey toward disruptive innovation and sustained success in the ever-evolving business landscape.

The nexus of perceived innovativeness, disruptive innovation, and commercial success is intricate and multifaceted. Companies that master this interplay, incorporating drivers of innovation, are better positioned to not only introduce groundbreaking ideas but also to navigate the complexities of the market. Recognising the interconnected nature of these elements is imperative for businesses aiming not just to innovate but to thrive in an ever-evolving business landscape.

The profiled New Zealand biotech landscape was analysed with the developed PI scorecard and the analysis identifies that the overall New Zealand biotechnology industry of the 292 alive companies had an average PI score of 44. This could be suggested to present a fair representation of an industry as not every company will be scoring the high scores as is indicated with the lowest identified PI score for an active company being 16 while the highest PI score identified was 92 and the data appears almost as a normal distribution.

An interesting finding was that it was the Medical Device and Industrial sectors scored the highest PI score average with 56, potentially due to numerous aspects of the sector involving well developed IP, industry newness, consumer behaviour, the low level of competition, and the meaningfulness provided. However, this was closely followed by the Health sector with 52. It was surprising that the Health sector did not score the highest PI score, while also surprising was the Marine sector scoring not too far behind the top three and above the overall industry average. This could be due to the Marine sector being the oldest sector but also the relative size of the sector and the limited competition potentially. Only two sectors scored below the industry average with AgBio and Nutrition scoring 37 and 33, which did not come as too much of a surprise due to the older traditional biotechnology techniques typically used for these two sectors.

The findings suggest that looking at commercial standing, the publicly listed companies were perceived as being quite a bit more innovative than private companies with an average PI score of 63 versus 43. This could also be due to the transparent nature the public companies must have to shareholders whereas private companies are relative unknowns to many people. Additionally, it was suggested that companies located in urban settings are slightly more innovative than their rural counterparts. This does not seem surprising due to most of the rural companies being within the AgBio, Nutrition and Marine sectors, compared to the urban companies being involved in Health and Medical Device sectors. When the commercial position was analysed, it was identified that the companies that were in the development phase of pre-market had the highest PI score of 64. This was substantially higher than the companies that were in-market with a PI score of 43, and was similar to the public or privately-held companies. The companies that were classed as post-market could not be assessed with the PI scorecard as they are either fallen companies or no longer New Zealand companies and the scoring is only applicable to alive companies. The analysis did output the service companies and found that they scored lowest with 37.

A notable finding was that of the university spin-outs (formed by the university) and associations (external to the university but collaborative working) which had similar averages regarding the cohort analysed. The university spin-out average PI score were 61 while the university associations were 59. This was again similar for the companies that were not a spin-out and not associated with a university in any capacity, with average PI scores of 42 and 39 respectively. The university PI scores were quite a bit higher than the non-university PI scores, but this was expected due to expectations around the knowledge base and novel research at universities. The highest PI score of 73 was when multiple universities were utilised which would allow them the skills, expertise, equipment, and collaborative approach to being more highly innovative and shows that the use of higher education institutions could be beneficial to positioning a company to be innovative.

When the regional location concerning the perceived innovativeness was analysed, the regions with the largest populations and cities scored the highest PI scores. Wellington scored the highest at 53, Auckland with 46, Waikato and Otago both with 45 and Canterbury with 44. The numbers below these regions are limited due to the number of companies in the smaller regions down to the lowest PI score of 27 from the East Coast. This is not surprising that the five largest cities scored the highest, which is likely due to several factors including number of people in smaller closer proximity and having universities within a short distance.

Through the analysis of the New Zealand biotechnology industry and various aspects within it (detailed in section 3.7.2 Table 12), the theory of, the higher the perceived innovativeness of a company, the

greater the chances of being successful was analysed. The data surprisingly suggests that a higher PI score indicates negative success outcomes for a company, with lower PI scoring companies achieving better deemed-success outcomes. The data analysis shows that the average PI score for companies deemed-a-success was 39 compared to the companies deemed not-a-success much higher at 58. The biotechnology companies in New Zealand that presented simple, lower specification, and less technical offerings appear to have a greater chance of being successful companies. This low scoring trend is seen particularly for the Health and AgBio sectors due to the large divide between the deemed-a-success or not PI scores, where the PI scores were significantly different to each other (over 20 points). The majority of the companies that could be termed as innovative or highly innovative (scoring greater than 60) were of a higher chance of not being a success. The only sector where this differed was the Marine sector, however, this is the smallest sector and could be influenced by the small number. This could be due to risk averseness from both the government and the investing community and the unknown scientific and commercial pathway for highly innovative companies. The findings presented relating to the PI scores and success-outcomes should have an unlikely or low risk of methodological error due to the robustness testing of the scorecard. Each variable of the PI criteria was tested, and no logical or sensible selections were able to show a positive association and indicates that a negative association probably holds true.

This study investigates the relationship between perceived innovativeness and success outcomes in the biotech industry, revealing unexpected findings. Contrary to common beliefs, a negative correlation is observed, indicating that companies with lower PI scores often demonstrate better deemed-success outcomes. Sectors like Health and AgBio exhibit significant differences in PI scores between successful and unsuccessful outcomes, challenging the conventional notion that higher perceived innovativeness directly correlates with success. This suggests potential risk averseness in highly innovative ventures.

The study highlights the role of perceived innovativeness, measured by the diagnostic PI scorecard, in shaping the strategic direction of biotech companies. Perceived innovativeness attracts crucial resources, collaborations, and opportunities, contributing to the journey toward disruptive innovation. Sector-specific nuances are unveiled, emphasising variations in success and perceived innovativeness across different segments of the biotech industry. Factors such as industry age, competition levels, and regional dynamics influence the perceived innovativeness of companies.

The unexpected negative correlation prompts a re-evaluation of traditional assumptions, suggesting potential risk averseness and uncertainty in the commercial pathways for highly innovative companies, particularly in certain sectors. The developed diagnostic PI scorecard proves practical for evaluating and comparing companies, providing valuable insights for decision-makers, investors, and industry

practitioners. Understanding the interplay between perceived innovativeness, disruptive innovation, and commercial success is deemed imperative for navigating the complex business landscape in the New Zealand biotech industry. This study not only contributes insights into disruptive innovation understanding but also offers a valuable tool for assessing and leveraging perceived innovativeness in this dynamic industry.

7.4 SUMMARY

In delving into the realm of disruptive innovation, this research undertook a multifaceted exploration, contributing significantly to both theoretical frameworks and practical insights. Notably, the examination of DI understanding exposed a moderate gap between academic conceptualisations and industry interpretations. This underscored the dynamic and contextually nuanced nature of disruptive innovation, revealing a need for more effective dissemination of foundational theories within business communities.

The research further extended its theoretical contributions by applying the Ten Types of Innovation framework to identify commercial foundations crucial for disruptive innovation. By elucidating practitioners' preferences for specific elements and unveiling strategies favoured in the industry, the research provided actionable insights for strategic considerations. Additionally, the exploration of alignment with various business elements emphasised the importance of tailored, hybrid strategies rather than universal approaches.

The application of the developed Perceived Innovativeness (PI) Scorecard to the New Zealand biotech industry marked a pivotal advancement. This comprehensive tool, assessing companies based on nine criteria, not only provided a practical innovation assessment but also demonstrated the strategic significance of perceived innovativeness. The unexpected revelation of a negative correlation between PI scores and success outcomes challenged conventional beliefs, highlighting potential risk averseness and uncertainty in the commercial pathways for highly innovative ventures.

Turning attention to the New Zealand biotech environment, the study enriched understanding by profiling the industry landscape, company age, longevity, collaboration dynamics, geographical distribution, and mergers and acquisitions. It revealed the adaptability and resilience of the New Zealand biotech industry, challenging conventional trends and showcasing a unique niche in the global biotechnology arena.

This research has contributed to the understanding of disruptive innovation, its drivers, and the New Zealand biotech environment. By bridging gaps between academia and industry, offering practical tools for assessment, and challenging traditional assumptions, it provides a foundation for navigating the intricate landscape of disruptive innovation in the biotech sector.

7.5 CONCLUSION

This section includes concluding remarks concerning the research questions and implications of the research, as well as the limitations of the research and discussion about potential future directions.

Innovation is a conceptually difficult notion to capture, and even more so when probing deeper down to a particular phenomenological concept such as disruptive innovation, but the concept has stirred enormous interest around the world. Given the research previously conducted that thrust it into the limelight and the extensive use of the term, the awareness of DI has increased massively since its popularisation by Christensen (1997). Yet, overall, it is surprising how differently the term is used by almost everyone, particularly between academia and industry. There is also little to no information of the foundations for applying DI beyond some product characteristics. This poor understanding of DI alongside lack of information and less-than-expected commercial outcomes of the New Zealand biotechnology industry, an important industry, is crucial to growing the high-value knowledge economy. This has led to the development of a diagnostic scoring method in this thesis to analyse the biotechnology companies and evaluate the strategies required to lead to successful outcomes.

This research aimed to improve the understanding of disruptive innovation theory, by utilising a mixed-methods pragmatic approach through the qualitative and quantitative analysis of the online survey and structured interviews. The research has identified a modern approach to DI and that there is some alignment of the understanding of disruptive innovation between academia and industry. This was initially demonstrated by the generally similar lack of agreement of both practitioners and academics on a set definition. Instead, a conglomerate of definitions was found which teased out themes providing new insight towards a focused understanding. This involved the notion of pushing older companies or products to the side with the introduction of newness and functionality creating its own market spaces.

Within the online survey and interviews, the research also investigated the potential of commercial foundations of DI for application in various industries such as biotechnology. The research has shown that there is the potential for a commercial foundation of DI that can inform the uninformed of different strategies and tactics that could be beneficial. From the findings, there is a selection of potential

commercial enhancers, particularly in the brand, product systems, customer engagement, product performance, channel and network elements, or impairments with items from profit model, service, brand, market, structure, and product performance.

Profiling the New Zealand biotechnology industry showed a picture that was different from the global technology view. Archival and data mining methods were used to locate each company within the landscape. There were 292 companies identified as currently alive, with a total of 380 identified in the landscape, a significant increase from previous data. AgBio was the largest sector identified comprising of 33% of the live companies compared to the typical picture of Health being the dominant sector with over 50%. The average age of the fallen companies was 13 years and meets industry norms of a long lifecycle. This is seen from the active companies' pre-market company average age being 6 years and the in-market average age being 18 years. Although the industry is small, the data suggests that the New Zealand biotechnology industry outweighs other regions by population proportion such as the US and Australia in terms of the number of companies and personnel within the industry.

This research established the perceived innovativeness diagnostic scorecard developed by multiple criteria decision analysis, through an adjusted and combined analytical hierarchy process using a pairwise comparison and simple additive weighting between the criteria to evaluate the relationship between innovativeness and success in the New Zealand biotechnology industry, where it was found through an iterative development process that being an innovative company may be related to negative successful outcomes with the companies that were deemed as being not-a-success having higher PI scores compared to their deemed successful counterparts.

7.5.1 Implications

This research makes key theoretical and practical contributions to the topic of innovation. The research has implications for several aspects. It has expanded the existing knowledge of disruptive innovation beyond the focus on large incumbent firms through an exploratory approach and brings together the alignment of the industry and academic understanding of DI and the commercial elements surrounding it. The research has also developed new insights into the foundations of disruptive innovation activities and the applications which could be applied to the New Zealand biotechnology industry. These foundations can be a catalyst for building theory to better understand how the theory can be translated into practical settings. Understanding the New Zealand biotechnology landscape and the focus on innovative ideas was essential and important to develop the knowledge of an industry that is heavily based upon the knowledge economy. Thereby profiling and mapping the entire industry will contribute

to the New Zealand economy for further use and collaboration of companies. This research also developed and demonstrated the application of the perceived innovativeness scorecard in a mixed-method research design utilising qualitative and quantitative inquiry methods within the biotechnology context.

This research has also made two practical contributions by understanding the theory better, by enhancing the innovation capabilities of the New Zealand biotechnology industry, through the tools of the DI foundations identified to increase the ability to develop and implement potentially disruptive innovations. Additionally, as the research developed the perceived innovativeness scorecard from a whole company perspective, it will allow companies to be able to assess and identify potential strengths and weaknesses that could hinder their innovation process. The research directs biotechnology leaders to essential sources of information. Finally, the research will enhance New Zealand's competitiveness for a knowledge-based economy, as a small, isolated country will not flourish from commodities alone, while the creation of high-value or high-end products and services should be developed through technical and skilled occupations such as within the biotechnology industry.

7.5.2 Limitations

The research does have some study design limitations, which also present opportunities for future research. Firstly, ethical committee limitations prevented the targeted recruitment of participants. Therefore, the survey participant capture could have been increased through more direct contact methods with well-connected individuals. The method of issuing the survey randomly presents an issue of selection bias by capturing individuals that like to complete surveys, when other individuals would be better to create a representative sample. Therefore, more purposive sampling could be completed and the total number of completed surveys could have been increased to generate more generalisable findings.

It should also be noted that within biotechnology studies, there are peculiarities, in which readers should be careful to draw direct comparisons between the companies and processes that may have been used with those in other industries due to the high levels of tacit knowledge and uncertainty (Pisano, 2006).

The interpretative approach used in qualitative research is too subjective. Findings can rely too much on the researcher's worldview about what is significant, and upon the close personal relationships that the researcher frequently strikes up with the people studied. While adequate for this research, this

could be improved upon with other innovation or biotechnology experts' analysis and criticism through a Delphi-like study, which could have generated even more findings. It should also be noted that readers should be careful to draw generalisations at this stage and should instead think about the transferability of the findings with similar country economies.

The large amount of data collected from observations, data mining and archival sources will contain a number of imperfections. Much of the data is not publicly available, especially for the smaller and privately owned companies, although the researcher attempted to reduce the bias by seeking extensive sources of data. This makes the task of triangulating the data difficult and could skew some aspects of the data. Hence also the Delphi-like study could assist in some of these limitations. Additionally, all the data sets were collected in bulk typically related to one another at a single time point, and innovation trends and companies are dynamic and rapidly changing, so implementing a longitudinal study might be a worthwhile effort in future research.

7.5.3 Key Points

In summation, from the definitions utilised throughout this thesis, three key findings have been presented. The thesis has identified a purposeful disruptive innovation definition aligned between the practitioner and the academic. Also, allowing a set of potential foundations of strategies and tactics to be implemented towards disruptive innovation. The thesis also mapped for the first time the entire New Zealand biotech industry of New Zealand-founded companies in completion. Finally, the thesis generated a perceived innovativeness measurement to analyse the biotechnology companies, which in-turn found that the companies that were perceived as being innovative were likely to be aligned with unfavourable success outcomes, subject to the caveats involved in the thesis. Of course, there are variances and discordances around all the definitions, therefore, when making comparisons, it is important to check the definitions and if they are the same and tested against similar research.

7.5.4 Future directions

Theory research is continually evolving, and interest is growing both in industry and academia. Two initial potential directions of future research could be:

An expansion of the New Zealand biotechnology landscape, with in-depth interviews and frequent surveying, would allow for more enriched data that could better develop and portray the landscape. There could also be further development of the PI scorecard, starting with a Delphi-like study from this research, and then testing the application in other biotechnology networks and countries.

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APPENDICES

The following section displays the study appendices that include the online survey participant information sheet, the online survey involving the questions that were presented to participants directly on Qualtrics.

APPENDIX A: ONLINE SURVEY PARTICIPANT INFORMATION SHEET

.

Participant Information Sheet

AUT

TE WĀNANGA ARONUI
O TĀMAKI MAKĀU RAU

Online Survey Participant

Date Information Sheet Produced:

18 March 2016

Project Title

Identifying and Enhancing Disruptive Innovation: engaged with NZ Biotech.

I am Chris Trent, a student of the Auckland University of Technology invite you to be a participant in an anonymous online survey. The survey will contribute to the research involved for the completion of a Doctor of Philosophy. Participation in the survey is voluntary and you may withdraw at any time during the survey. There are no conflict of interest issues, as your confidentiality will be maintained and whether you choose to participate or not will neither advantage nor disadvantage you.

What is the purpose of this research?

The purpose of this research is to gain an overview about innovation processes. The survey requires you to draw upon your innovation experience and relay the thinking towards the perspectives of disruptive innovation. The ultimate outcome of the research will be to generate a deeper understanding towards disruptive innovation and has the potential to generate models that may be able to assist success in commercialisation. This survey will contribute towards the completion of a Doctor of Philosophy and additional presentations and/or publications may arise from the complete research outcomes.

How was I identified and why am I being invited to participate in this research?

You were identified as a potential participant based on the network of the researchers involved in the research and your work experience.

What will happen in this research?

If you agree to participate, all you need to do is complete the online survey drawing upon your innovation experience. Your responses will help to better understand innovation processes and contribute to a deeper understanding for disruptive innovation.

What are the benefits?

The potential benefits of this research is that part of the findings from the survey may help develop a model that can help to enhance the disruptive features of products and reduce the features that impair such progression. This can assist in more success stories for companies in commercialisation. The research may also be applied and be effective towards a wide range of industries, assisting them in the commercialisation process. The research will contribute to the completion of a Doctor of Philosophy.

How will my privacy be protected?

The information you provide will be confidential and anonymous. Any identifying information will not be used in any reporting or presentation of the results. Only the researcher (including project supervisors) will have access to your responses.

What are the costs of participating in this research?

The only cost to participating in this research is that of your time. The survey will take approximately 15-20 minutes to complete depending on responses.

What opportunity do I have to consider this invitation?

The survey has been extended to November 30, 2016 after which it will be closed. Originally, this was August 30

How do I agree to participate in this research?

You will not be required to complete a physical consent form but will have to give online consent to participate in the survey to be able to proceed with the questions.

Will I receive feedback on the results of this research?

Yes, you will receive a summary of the results several weeks after the closure of the survey if you request to receive in the section asking if you would like a summary. This summary will be provided to the email address that you provide during the survey.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Professor Stephen Henry, shenry@aut.ac.nz, +64 (9) 921 9708.

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEK, Kate O'Connor, ethics@aut.ac.nz, 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Chris Trent, chris.trent@aut.ac.nz, +64 (9) 921 9710, Scott Laboratory Building, AUT University

Project Supervisor Contact Details:

Professor Stephen Henry, shenry@aut.ac.nz, +64 (9) 921 9708

Professor John Raine, john.raine@aut.ac.nz, +64 (9) 921 9634

Approved by the Auckland University of Technology Ethics Committee on 24/03/2016, AUTEK Reference number 16/74.

APPENDIX B: QUALTRICS ONLINE SURVEY

The online survey participants completed with each page being the same as if the participants were viewing and completing it themselves online.

INNOVATION SURVEY

If you would like a summary of results, please enter an email address below

Please note that the summary may not be available for 6 months

Your email address will NOT be used for anything other than supplying a summary of the survey results should you request.

Email address

What industry are you working in?

Drop down box _____

What positions do / have you held in the last 15 years?

- Board Member
- Chairman
- Advisor
- Founder
- Chief executive officer (CEO)
- Chief scientific officer (CSO)
- Chief financial officer (CFO)
- Other executive team
- Senior management
- Middle management
- Other

INNOVATION SURVEY

What do you understand the term "disruptive innovation" to mean?

Can have more than one answer

- Changes the bases of competition by changing the performance metrics along which firms compete
- New product that causes chaos to existing markets
- Utilisation requires a mindshift in customer thinking
- There is no definition, it is indefinable
- Disorder to the current environment by introducing something new
- Breaks traditional markets by providing functionality thereby broadening and developing markets
- Placed at the edge of markets, that eventually rapidly grows, broadening and developing its own market
- Rapid growth, creating own market, displacing other product(s)
- A product that makes a big impact
- Something new and exciting
- The transformation of existing markets and development of new markets
- Markets appear as if from nowhere, creating massive new sources of wealth, tends to have roots in technological breakthroughs
- Smaller, cheaper, reliable and convenient products that moves up a market, eventually displacing established competitors
- Other

INNOVATION SURVEY

DISRUPTIVE INNOVATION

The study applies the following definition

Disruptive innovation is an innovation that rapidly grows to develop its own market by displacing another product and usually requires a change in mindset of the customer.

INNOVATION SURVEY

Have your own products been directly affected by a disruptive innovation?

Was your company responsible for a disruptive innovation?

Does the marketplace need to be educated about a disruptive innovation before the market will adopt it?

How would or should this education occur?

- Conferences
- Universities
- Online tutorials
- Advertising
- Workplace training days
- I don't believe education is required
- Don't know
- Other

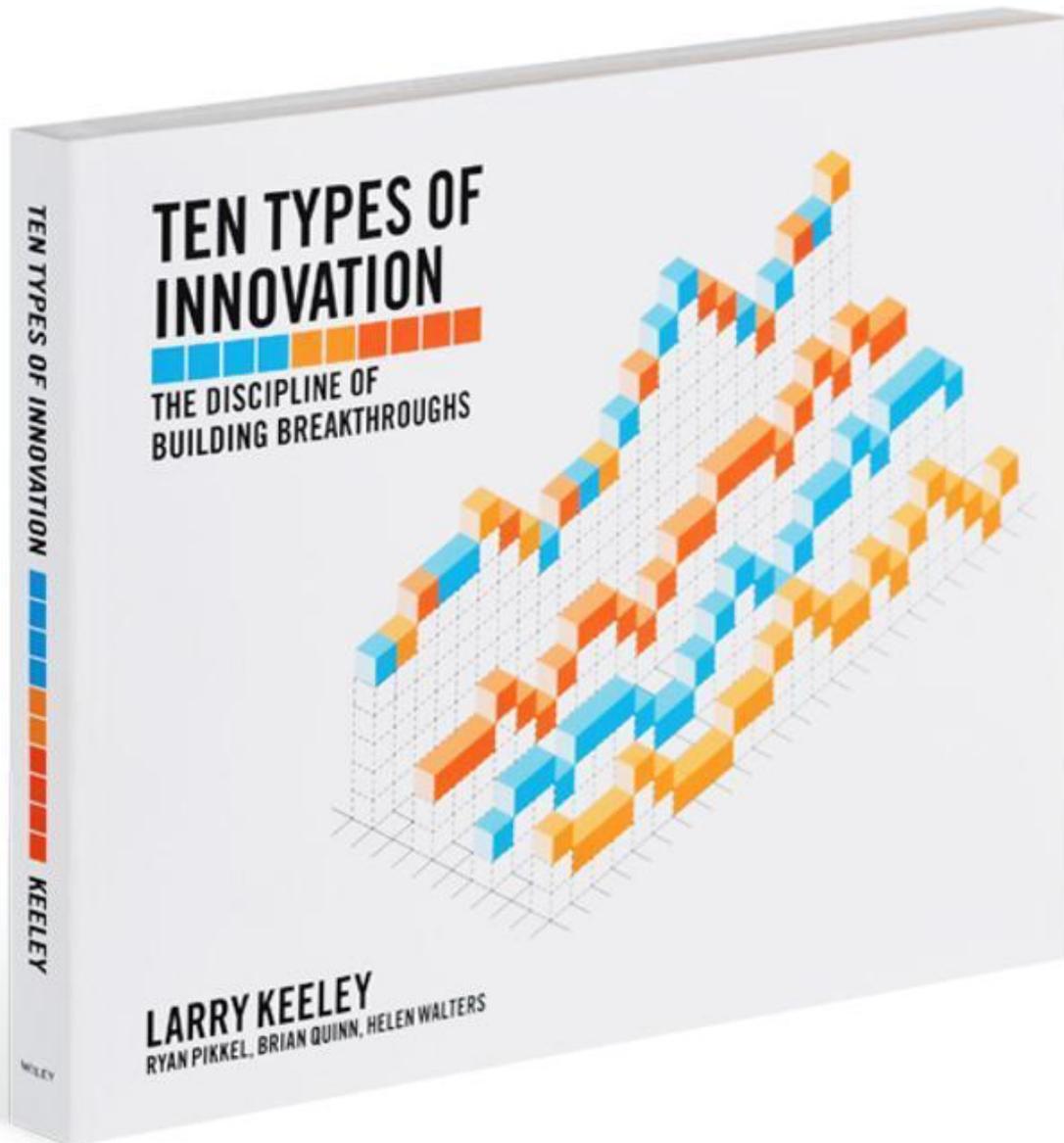
In the early stages of research and development for a product, does an autonomous unit need to be created to manage disruptive innovation?

INNOVATION SURVEY

The following questions requests that you draw upon your overall experience of product innovation with a focus on disruptive innovation.

You will see an **aspect in bold** followed by a definition of that aspect in brackets

The categories for the questions and the majority of aspects utilised have come from the work of Larry Keeley, Helen Walters, Ryan Pikkell & Brian Quinn (2013) "Ten Types of Innovation: The Discipline of Building Breakthroughs" John Wiley & Sons (Book and the Innovation Tactic cards that are associated with the book)



INNOVATION SURVEY

What are three critical MARKET aspects that can lead to achieving a disruptive innovation?

Market = How you aim to deliver your offering

- Mainstream Market Success** (proven, established standards and well supported)
- Social Media** (computer-mediated tools that allow people to create, share, or exchange information, career interests, ideas, and pictures/videos in virtual communities and networks)
- Intuitive Adoption** (ability to understand or know something without any direct evidence or reasoning and adopt)
- Low-end Market Targeting** (lower-priced products suitable for customers who are not willing or able to spend large amounts of money)
- Behaviour Change Required** (transformation or modification of human behaviour)
- Increase Current Market Size** (entering a well established market and increasing the reach of the market)
- Education Required** (the teaching of a products features, uses and applications before being adopted)
- Market Share** (large percentage of market share required)
- High-end Market Targeting** (most sophisticated and expensive products in that market or range)
- Open New Markets** (the creation of markets not previously identifiable or present)
- Niche Market Targeting** (a small subset of a market with specific features)
- Grow Emerging Markets** (the increase in market wealth for emerging markets)
- Word of Mouth** (passing of information from person to person by oral communication)
- Timing** (the choice, judgement, or control of when something should be done)
- Classic Advertising** (attracting public attention to a product or business, as by paid announcements in the print or broadcast)
- Other**

INNOVATION SURVEY

What are three critical NETWORK aspects that can lead to achieving a disruptive innovation?

Network = How you connect with others to create value

- Merger/Acquisition** (combine two or more entities to gain access to capabilities and assets)
- Coopetition** (join forces with someone who would normally be your competitor to achieve a common goal)
- Supply Chain Integration** (coordinate and integrate information and/or processes across a company or functions of the supply chain)
- Open Innovation** (Obtain access to processes or patents from other companies to leverage, extend, and build on expertise)
- Franchising** (license business principles, processes, and brand to paying partners)
- Closed Innovation** (have control over the entire process i.e. hiring the best employees, keeping data internally, etc.)
- Alliances** (share risks and revenues to jointly improve individual competitive advantage)
- Consolidation** (acquire multiple companies in the same market or complementary assets)
- Secondary Markets** (connect waste streams, by-products, or other alternative offerings to those who want them)
- Complementary Partnering** (leverage assets by sharing them with companies that serve similar markets but offer different products)
- Collaboration** (partner with others for mutual benefit)
- University Support** (project involvement with a university such as initial research)
- Other**

INNOVATION SURVEY

What are three critical PROCESS aspects that can lead to achieving a disruptive innovation?

Process = How you use methods to do your work

- Flexible Manufacturing** (use a production system that can rapidly react to changes and still operate efficiently)
- Crowd sourcing** (outsource repetitive or challenging work to a large group of semi-organised individuals)
- Localisation** (adapt an offering, process, or experience to target a culture or region)
- User Generated** (put your users to work in creating and curating content that powers your offerings)
- On-Demand Production** (produce items after an order has been received to avoid carrying costs of inventory)
- Lean Production** (reduce waste and cost in your manufacturing process and other operations)
- Logistics Systems** (manage the flow of goods, information and other resources between the point of origin and the point of use)
- Process Standardisation** (use common products, processes, procedures, and policies to reduce complexity, costs, and errors)
- Process Automation** (apply tools and infrastructure to manage routine activities in order to free up employees)
- Predictive Analysis** (model past performance data and predict future outcomes to design and price offerings accordingly)
- Intellectual Property/Patent(s)** (protect an idea that has commercial value - such as a recipe or industrial process - with legal tools like patents)
- Phase-Gate** (project is divided into phases separated by gates that are required to be cleared)
- Process Efficiency** (create or produce more while using fewer resources - measured in materials, energy consumption or time)
- Strategic design** (employ a purposeful approach that manifests itself consistently across offerings, brands, and experiences)
- Other**

INNOVATION SURVEY

What are three critical STRUCTURE aspects that can lead to achieving a disruptive innovation?

Structure = How you organise and align your talent and assets

- Autonomous Unit** (a unit that is operates separately from the main business for a project)
- Decentralised Management** (distribute decision-making governance closer to the customer or other key business interfaces)
- Individual Effort** (a single member drives the project)
- Incentive Systems** (offer rewards (financial or non-financial) to provide motivation for a particular course of action)
- Competency Centre** (cluster resources, practices, and expertise into support centres that increase efficiency and effectiveness across the broader organisation)
- Large Team** (10+ members involved in a project)
- Outsourcing** (assign responsibility for developing or maintaining a system to a vendor)
- Small Team** (2-9 members involved in a project)
- C-Suite Involvement** (major role in the decision making of projects)
- Asset Standardisation** (reduce operating costs and increase connectivity and modularity by standardising your assets)
- Corporate University** (Provide job-specific or company training for managers)
- Develop Internally** (full process developed from start to finish internally)
- Organisational Design** (make form follow function and align infrastructure with core qualities and business processes)
- Board Involvement** (heavily influence the strategic decision making process for projects)
- IT Integration** (integrate technology resources and applications)
- Other**

INNOVATION SURVEY

What are three critical PROFIT MODEL aspects that can lead to achieving a disruptive innovation?

Profit model = How you make money

- Subscription** (create a predictable cash flows by charging customers upfront to have access to the product/service over time)
- Float** (receive payment prior to building the offering - and use the cash to earn interest prior to making margins)
- Flexible Pricing** (vary prices for an offering based on demand)
- Licensing** (grant permission to some other group or individual to use your offering in a defined way for a specified payment)
- Cost Leadership** (keep variable costs low and sell at high volumes at low prices)
- Scaled Transactions** (maximise margins by pursuing high volume, large scale transactions when unit costs are relatively fixed)
- Freemium** (offer basic service for free, while charging a premium for advanced or special features)
- Risk Sharing** (waive standard fees/costs if certain metrics aren't achieved, but receive outsize gains when they are)
- Forced Scarcity** (limit the supply of offerings available, by quantity, time frame or access, to drive up demand and/or prices)
- Metered Use** (allow customers to pay for only what they use)
- Installed Base** (offer a "core" product for slim margins to drive demand and loyalty; then realise profit on additional products and services)
- User-Defined** (invite customers to set a price they wish to pay)
- Microtransactions** (sell many items for low prices to drive impulse purchases at volume)
- Disaggregate Pricing** (allow customers to buy exactly and only what they want)
- Bundled Pricing** (sell in a single transaction two or more items that could be sold as standalone offerings)
- Membership** (charge a time-based payment to permit access to locations, offerings, or services that non-members don't have)
- Ad-supported** (provide content/services for free to one party while selling listeners, viewers or "eyeballs" to another party)
- Switchboard** (connect multiple sellers with multiple buyers; the more of each, the more valuable the switchboard)
- Financing** (capture revenue not directly from the sale of a product, but from structured payment plans and after-sale interest)
- Premium** (price at a higher margin than competitors, usually for a superior product, offering, experience, service or brand)
- Auction** (allow a market and its users to set the price for goods and services)
- Other**

INNOVATION SURVEY

What are three critical **PRODUCT PERFORMANCE** aspects that can lead to achieving a disruptive innovation?

Product performance = How you develop distinguishing features and functionality

- Environmental Sensitivity** (provide offerings that do no harm to the environment)
- Safety** (increase the customer's level of confidence and security)
- Sustaining Innovation** (minor improvements to a previously known product)
- Added Functionality** (add new functionality to an existing offering)
- Styling** (impart a style, fashion or image)
- Conservation** (design your product so that customers can reduce their use of energy or materials)
- Focus** (design an offering specifically for a particular audience at the expense of others)
- Performance Simplification** (omit superfluous details, features, and interactions to reduce complexity)
- Feature Aggregation** (combine existing features found across offerings into a single offering)
- Ease of Use** (make your product simple, intuitive, convenient and comfortable to use)
- Engaging Functionality** (provide an unexpected or newsworthy experiential component that elevates the customer interaction)
- Superior Product** (develop an offering of exceptional design, quality and/or experience, cutting edge technology)
- Other**

INNOVATION SURVEY

What are three critical PRODUCT SYSTEM aspects that can lead to achieving a disruptive innovation?

Product system = How you create complementary products and services

- Incremental Innovation** (minor, simple modifications or adaptations of current products)
- Customisation** (modify or build according to individual or personal specifications)
- Complements** (sell additional related or ancillary products or services to a customer)
- Modular Systems** (provide a set of individual components that can be used independently, but gain utility when combined)
- Product/Service Platforms** (develop systems that connect with other, partner products and services to create a holistic offering)
- Integrated Offering** (combine otherwise discrete components into a complete experience)
- Product Bundling** (offer several products for sale as one combined product)
- Radical Innovation** (dramatically new technical and commercial skills in existing markets)
- Extensions/Plug-ins** (allow first- or third-party additions that add functionality)
- Other**

INNOVATION SURVEY

What are three critical SERVICE aspects that can lead to achieving a disruptive innovation?

Service = How you support and amplify the value of your offerings

- Try Before You Buy** (let customers test and experience an offering before investing in it)
- Loyalty Programs** (provide benefits and/or discounts to frequent and high-value customers)
- Supplementary Service** (offer ancillary services that fit with your offering)
- Concierge** (provide premium service by taking on tasks for which customers don't have time)
- User Communities/ Support Systems** (provide a communal resource for product/service support, use and extension)
- Lease or Loan** (let customers pay over time to lower upfront costs)
- Self-Service** (provide users with control over activities that would otherwise require an intermediary to complete)
- Total Experience Management** (provide thoughtful, holistic management of the consumer experience across an offering's life-cycle)
- Superior Service** (provide service(s) of higher quality, efficacy, or with a better experience than any competitor)
- Guarantee** (remove customer risk of lost money or time stemming from product failure or purchase error)
- Personalised Service** (use the customer's own information to provide perfectly calibrated service)
- Added Value** (include an additional service/function as part of the base price)
- Other**

INNOVATION SURVEY

What are three critical CHANNEL aspects that can lead to achieving a disruptive innovation?

Channel = How you deliver your offerings to customers and users

- Diversification** (add and expand into new or different channels)
- Experience Centre** (create a space that encourages your customers to interact with your offerings but purchase them through a different channel)
- Indirect Distribution** (use others as resellers who take ownership over delivering the offering to the final user)
- Context Specific** (offer timely access to goods that are appropriate for a specific location, occasion or situation)
- Multi-Level Marketing** (sell bulk or packaged goods to an affiliated but independent sales force that turns around and sells it for you)
- Cross-selling** (place products, services or information that will enhance an experience in situations where customers are likely to want to access them)
- Pop-up Presence** (create a noteworthy by temporary environment to showcase and/or sell offerings)
- Flagship Store** (create a store to showcase quintessential brand and product attributes)
- Non-Traditional Channels** (employ novel and relevant avenues to reach customers)
- On-Demand** (deliver goods in real-time whenever or wherever they are desired)
- Go Direct** (skip traditional retail channels and connect directly with customers)
- Other**

INNOVATION SURVEY

What are three critical BRAND aspects that can lead to achieving a disruptive innovation?

Brand = How you represent your offerings and business

- Transparency** (let customers see into your operations and participate with your brand and offerings)
- Values Alignment** (make your brand stand for a big idea or a set of values and express them consistently in all aspects of your company)
- Technology Push** (Research and development in new technology, drives the development of new products)
- Brand Leverage** ("lend" your credibility and allow others to use your name - thus extending your brands reach)
- Co-Branding** (combine brands to mutually reinforce key attributes or enhance the credibility of an offering)
- Sustainability** (managing the triple bottom line - a process by which companies manage their financial, social and environmental risks, obligations and opportunities)
- Private Label** (provide goods made by others under your company's brand)
- Component Branding** (brand an integral component to make a final offering appear more valuable)
- Certification** (develop a brand or mark that signifies and ensures certain characteristics in third-party offerings)
- Brand Extension** (offer a new product or service under the umbrella of an existing brand)
- Technology Pull** (need/requirement for a new product or a solution to a problem, which comes from the market place)
- Other**

INNOVATION SURVEY

What are three critical CUSTOMER ENGAGEMENT aspects that can lead to achieving a disruptive innovation?

Customer engagement = How you foster compelling interactions

- Personalisation** (alter a standard offering to allow the projection of the customer's identity)
- Status and Recognition** (offer cues that infer meaning, allowing users to develop and nurture aspects of their identity)
- Process Automation** (remove the burden of repetitive tasks from the user to simplify life and make new experiences seem magical)
- Whimsy and Personality** (humanise your offering with small flourishes of on-brand, on-message ways of seeming alive)
- Experience Simplification** (reduce complexity and focus on delivering specific experiences exceptionally well)
- Autonomy and Authority** (grant users the power to use your offerings to shape their own experience)
- Community and Belonging** (facilitate visceral connections to make people feel they are part of a group or movement)
- Mastery** (help customers to obtain great skill or deep knowledge of some activity or subject)
- Curation** (use a distinct point of view to separate the proverbial wheat from the chaff and in the process create a strong identity for yourself and your followers)
- Other**

INNOVATION SURVEY

In what country are you CURRENTLY based/working predominantly?

- | | | |
|---------------------------------|---------------------------------|--|
| <input type="radio"/> Singapore | <input type="radio"/> Australia | <input type="radio"/> India |
| <input type="radio"/> China | <input type="radio"/> USA | <input type="radio"/> Ireland |
| <input type="radio"/> France | <input type="radio"/> Taiwan | <input type="radio"/> New Zealand |
| <input type="radio"/> UK | <input type="radio"/> Japan | <input type="radio"/> Other <input style="width: 100px; height: 20px;" type="text"/> |
| <input type="radio"/> Germany | | |

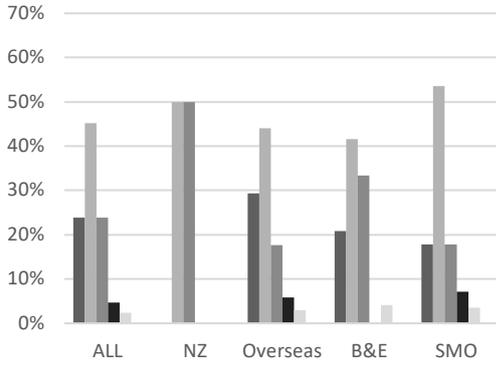
Rate the commercial environment of the country named above in enabling innovation from the following aspects

	Excellent	Good	Average	Poor	Terrible	Don't know
Availability of talent	<input type="radio"/>					
Access to tech infrastructure	<input type="radio"/>					
Access to alliances	<input type="radio"/>					
Access to capital	<input type="radio"/>					
Customer growth (Domestic)	<input type="radio"/>					
Customer growth (International)	<input type="radio"/>					
Development of disruptive technology breakthroughs	<input type="radio"/>					
Mentoring	<input type="radio"/>					
Networks	<input type="radio"/>					
Education system	<input type="radio"/>					
Government incentives	<input type="radio"/>					
Availability of high skill management	<input type="radio"/>					

APPENDIX C: COMMERCIAL ENVIRONMENT DATA

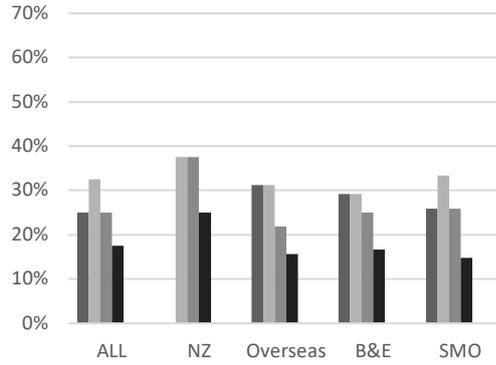
(A)

Availability of talent



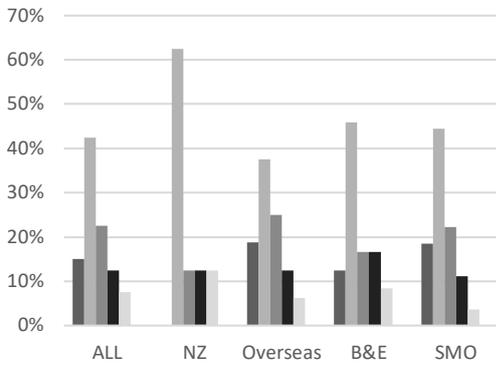
(B)

Access to tech infrastructure



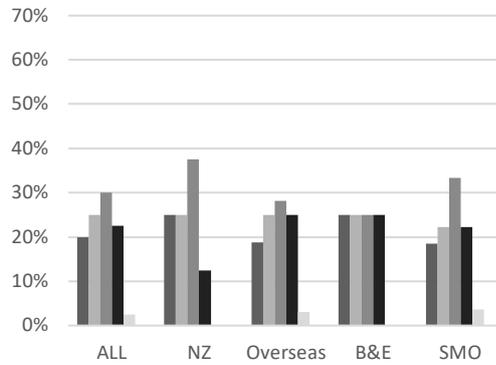
(C)

Education system



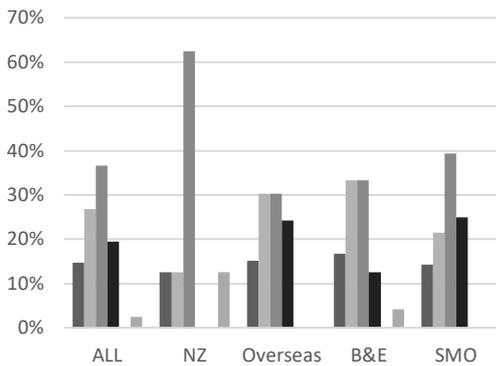
(D)

Networks



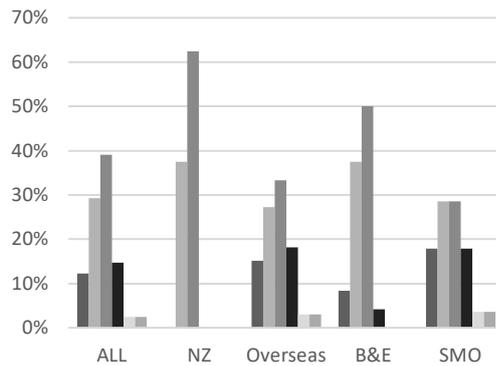
(E)

Access to alliances



(F)

Customer growth (international)



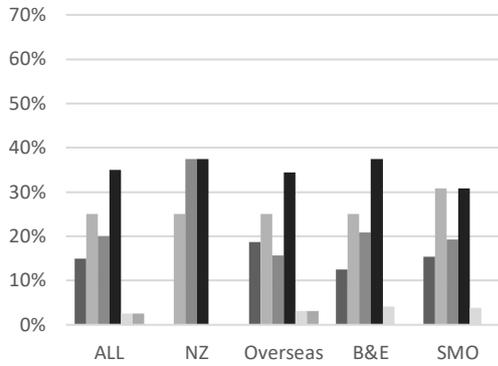
■ Excellent ■ Good ■ Average ■ Poor ■ Terrible ■ Don't know

ALL = Complete data
 NZ = Based in New Zealand
 Overseas = Based internationally
 B&E = Board and executives
 SMO = Senior and middle management and other

Continued

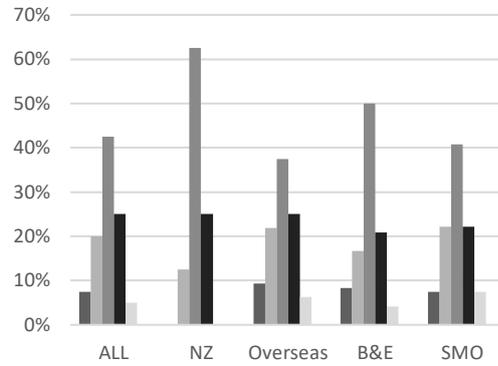
(G)

Availability of high skill management



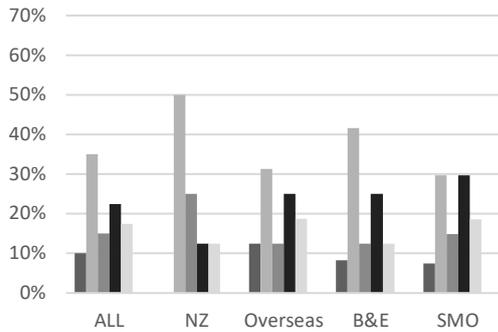
(H)

Mentoring



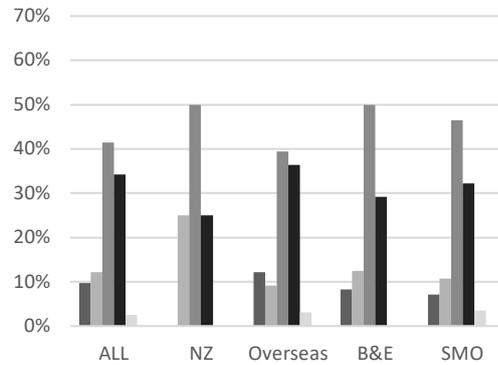
(I)

Development of disruptive technology breakthroughs



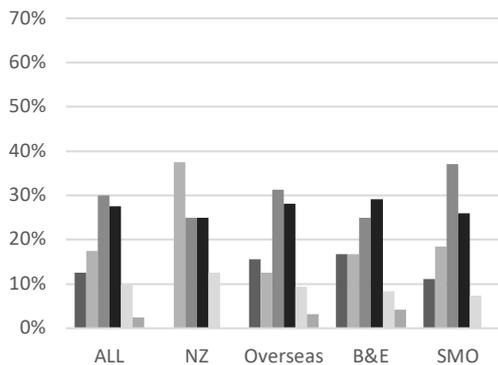
(J)

Customer growth (Domestic)



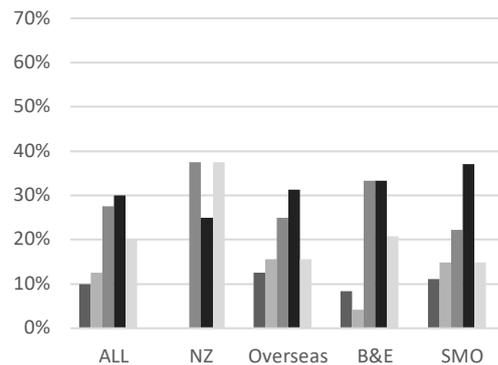
(K)

Government incentives



(L)

Access to capital



■ Excellent ■ Good ■ Average ■ Poor ■ Terrible ■ Don't know

ALL = Complete data
 NZ = Based in New Zealand
 Overseas = Based internationally
 B&E = Board and executives
 SMO = Senior and middle management and other

APPENDIX D: NEW ZEALAND BIOTECH SECTOR BREAKDOWN

New Zealand AgBio Companies

- 1 Abron
- 2 Advanced Animal Technology•
- 3 AgBioResearch
- 4 AGPRO NZ
- 5 AgResearch
- 6 Agricom
- 7 Agri-Fert
- 8 AgriGenesis Biosciences•
- 9 Agrimm Technologies
- 10 Agrissentials NZ
- 11 AGRITEK
- 12 AgVax Developments•
- 13 Alleva Animal Health
- 14 Ancare New Zealand•
- 15 Androgenix•
- 16 Animal Control Products
- 17 Animal Diagnostics•
- 18 Argenta
- 19 Asia Pacific Seeds (NZ)
- 20 Auckland BioSciences
- 21 Avoca
- 22 Bell-Booth
- 23 Bennett Fertilisers
- 24 Bioboost
- 25 Biobrew
- 26 Biochar
- 27 Biodiscovery New Zealand
- 28 Biogenesis•
- 29 BioGro
- 30 Biohelp
- 31 Biolumic
- 32 Biostart
- 33 Biotelliga
- 34 BioTest Diagnostics•
- 35 Bomac Laboratories•
- 36 Botry Zen•
- 37 Botry-Zen (2010)
- 38 Brookby Herbs
- 39 BSL
- 40 Carrfields
- 41 Catapult Genetics•
- 42 Cates Grain & Seed
- 43 Coast Biologicals•
- 44 Connovation
- 45 Covita•
- 46 Cropmark seeds
- 47 Deosan New Zealand
- 48 Egmont Seed Co
- 49 EMNZ
- 50 Engender Technologies
- 51 Environmental Fertilisers
- 52 Equibreed
- 53 ETEC Crop Solutions
- 54 Fertco
- 55 Fertile Fields
- 56 Fertilizer New Zealand
- 57 FIL
- 58 Focus Genetics
- 59 Genetic Technologies
- 60 GoBio
- 61 Grasslanz Technology



- 62 Gro-Chem Horticulture
- 63 Hatuma Fertilisers
- 64 Healthy Soils•
- 65 Hill Laboratories
- 66 Hortigro
- 67 HuMates
- 68 Indigo Biotech
- 69 ESR
- 70 GNS
- 71 Kiwi Fertiliser Co
- 72 Koru Diagnostics
- 73 Landcare Research
- 74 Lasadex•
- 75 Lifetech Laboratories
- 76 Linnaeus Laboratory
- 77 Mainland Minerals
- 78 Mastaplex
- 79 Midlands Seed
- 80 Multiflora Laboratories
- 81 NZ Forest Research Institute
- 82 Nutritech International
- 83 Orbis Diagnostics
- 84 Orion AgriScience
- 85 Osflo
- 86 OsGro
- 87 Outgro
- 88 Ovita•
- 89 Pacific BioFert
- 90 ParaCo Technology•
- 91 Pasture First Research
- 92 PGG Wrightson
- 93 Pheromite
- 94 Plant Research NZ
- 95 Plasma Biotec Solutions
- 96 Proteomics Discovery Centre
- 97 Radiata Pine Breeding Company
- 98 Rapid Animalside Diagnostics•
- 99 SealesWinslow
- 100 Soil Foodweb NZ
- 101 Southern Humates
- 102 Stockguard Animal Health
- 103 Stockguard Laboratories (NZ)
- 104 Synthase Biotech
- 105 Tararua Breeding Centre
- 106 Techion Group
- 107 TerraCare Fertilisers
- 108 HortResearch•
- 109 Plant & Food Research
- 110 The Tree Lab
- 111 Totalfert
- 112 Transgenic Proteins New Zealand•
- 113 True Health
- 114 Veterinary Professional Services
- 115 Vetpak
- 116 Vialactia Biosciences (NZ)•
- 117 Vitec Nutrition
- 118 Zebra Biotech
- 119 Zelam

Note: • Inactive • Holding

New Zealand Health Companies

- 1 Absolute Essential
- 2 Advanced Biotech NZ
- 3 AFT Pharmaceuticals
- 4 Aire Natural Science Labs
- 5 Antipodes New Zealand
- 6 Anzamine
- 7 Aotea Pathology
- 8 Aroa Biosurgery
- 9 AROTEC Diagnostics
- 10 Auramer Bio
- 11 Avalia Immunotherapies
- 12 Bacteriological & Chemical Laboratories
- 13 BELTAS
- 14 Bio International
- 15 BioCell Corporation



- 16 Bio-diagnostic
- 17 Biomatters
- 18 Biomed Ltd
- 19 BioStore NZ
- 20 BLIS Technologies
- 21 Caldera Health
- 22 Canterbury Scientific
- 23 Carina Chemical Laboratories
- 24 Carol Priest Natural Cosmetics NZ
- 25 Chitogel
- 26 CoDa Therapeutics
- 27 Colloidal Health Solutions
- 28 CuroNZ
- 29 Decima Health
- 30 Diagnostic Medlab
- 31 Diasense
- 32 Diatranz Otsuka
- 33 dnature diagnostics & research
- 34 Douglas Pharmaceuticals
- 35 Ecostore
- 36 Evolu
- 37 Febris Biotech
- 38 Fertility Associates
- 39 GeneDetect.com
- 40 Genesis R&D Corporation
- 41 Glycosyn

- 42 Helius Therapeutics
- 43 Hi-Aspect
- 44 ICP Biotechnology
- 45 Immune Solutions
- 46 Kea Therapeutics
- 47 Keratec
- 48 Kode Biotech
- 49 Living Cell Technologies
- 50 Living Nature
- 51 Long White Cloud Genetics
- 52 Mende Biotech
- 53 Migco Pharmaceuticals
- 54 MitoQ
- 55 Neuren Pharmaceuticals
- 56 NeuronZ
- 57 NZ Medical and Scientific
- 58 NZ Skin Care Company
- 59 NZeno
- 60 NZP
- 61 Obodies
- 62 Ora Pharm
- 63 Orico
- 64 Otakaro Pathways
- 65 Pacific Edge
- 66 Pathway Therapeutics
- 67 Pauling Industries

- 68 Pharmaceutical Solutions
- 69 Pictor
- 70 Planter Developments
- 71 PolyBatics
- 72 Proacta Therapeutics
- 73 Protomix Corporation
- 74 PSM Healthcare
- 75 Repromed
- 76 Saratan Therapeutics
- 77 SC Bio
- 78 SETEK Therapeutics
- 79 Snowberry
- 80 South Pacific Sera
- 81 Southern Community Laboratories
- 82 Symansis
- 83 Synergens
- 84 Tercica Inc
- 85 The Herb Farm
- 86 Theranostics Lab
- 87 Trilogy Natural Products
- 88 Trinity Bioactives
- 89 Upside Biotechnologies
- 90 Upstream Medical Technologies
- 91 XR Pharmaceuticals
- 92 Zenith Technology Corporation
- 93 ZyGEM Corporation

Note: • Inactive ◻ Holding

New Zealand Nutrition Companies



- | | | |
|-------------------------------|----------------------------------|---------------------------------|
| 1 1Above | 24 Hibiscus Agencies• | 47 PharmaZen |
| 2 About Health Supplements | 25 Hibiscus Solutions | 48 Phytomed Medicinal Herbs |
| 3 Alaron | 26 Horleys (Naturalac Nutrition) | 49 Promisia |
| 4 Alpha Laboratories (NZ) | 27 Hubris International | 50 Pure Vitality |
| 5 Anagenix | 28 Integria Healthcare | 51 Pureland |
| 6 ANZCO Foods | 29 Jenkins Biolabs | 52 Quantec |
| 7 Artemis | 30 Just the Berries• | 53 Red Seal Natural Health |
| 8 Asure New Zealand• | 31 Kirker Health | 54 Seperex Nutritionals |
| 9 AsureQuality | 32 Maxamena Nutraceuticals◻ | 55 Silberhorn |
| 10 Bio Oils Ashburton | 33 Milk Test NZ | 56 Skybright Health |
| 11 BioVit GMP Laboratories | 34 MOLAB◻ | 57 Somnaceutics• |
| 12 BioVittoria | 35 Natural Health NZ 2002 | 58 Starboardbio |
| 13 Carne Technologies | 36 New Image | 59 T J Clark NZ (2001) |
| 14 Comvita | 37 New Zealand Extracts | 60 Tairawhiti Pharmaceuticals |
| 15 Deep Blue Health NZ | 38 NZ Health Manufacturing | 61 Tasman Extracts• |
| 16 Doxcon Pharmaceuticals• | 39 Nubiotics Nutritionals• | 62 Unitech Industries |
| 17 Enzo Nutraceuticals | 40 Nutra-Life Health & Fitness• | 63 Vitaco Health |
| 18 Food Link International | 41 Nutrizeal• | 64 Vital Food Processors• |
| 19 Forest Herbs Research | 42 Nutrizone | 65 Waitaki Biosciences• |
| 20 Functional Nutraceuticals• | 43 O2B Healthy | 66 Xtend Life-Natural Products |
| 21 Genesis Biolaboratory | 44 Oceania Natural• | 67 Zealand Health Manufacturing |
| 22 GO Healthy New Zealand | 45 Oritain | 68 Zymus International |
| 23 Good Health Products | 46 PharmaNZ | |

Note: • Inactive ◻ Holding

New Zealand Medical Device Companies



- | | | |
|-------------------------------|-----------------------|---------------------------------|
| 1 Adept Medical | 17 iZon Science | 32 RayLab• |
| 2 Adherium (NZ) | 18 Kahne• | 33 Rex Bionics |
| 3 Aranz Healthcare | 19 Kerr Scientific | 34 Simcro |
| 4 Avice | 20 KM Medical | 35 Smith-Biolab International |
| 5 Biotronics Otago◦ | 21 Lifeonics | 36 Southern Lights Biomaterials |
| 6 Bodystance | 22 Magritek | 37 StretchSense |
| 7 BrainZ Instruments• | 23 MARS Bioimaging | 38 Surgionix |
| 8 Breathe Easy Therapeutics◦ | 24 Medica• | 39 Surgisplint |
| 9 DEC International NZ | 25 Medi'Ray | 40 Syft Technologies |
| 10 eBonz• | 26 Menixis | 41 Telemetry Research |
| 11 Electrospinz | 27 Molteno Ophthalmic | 42 Twisted Citrus• |
| 12 Enztec | 28 Objective Acuity | 43 Ubiquitome |
| 13 Fisher & Paykel Healthcare | 29 Ossid | 44 Veriphi |
| 14 Footfalls and Heartbeats | 30 Plade Holdings• | 45 Veritide |
| 15 Graftoss• | 31 Pulsecor• | 46 Volpara Health Technologies |
| 16 imeasureu | | |

Note: • Inactive ◦ Holding

New Zealand Industrial Companies



- | | | |
|-------------------------------|-----------------------|-------------------------------|
| 1 Aduro Biopolymers LP | 14 Ecodiesel• | 27 Lignin Polymers◻ |
| 2 BDG Synthesis• | 15 EnCoate◻ | 28 Marlborough Renewable Oils |
| 3 BDG Synthesis (2014) | 16 Enzyme services | 29 Micronz |
| 4 Bio Works | 17 FILTEC | 30 Mint Innovation |
| 5 Biojoule• | 18 Green Fuels NZ | 31 Nouvoa• |
| 6 Biome Innovation• | 19 Greenlane Biogas• | 32 Novatein◻ |
| 7 Biopolymer Network | 20 Heliase Genomics | 33 NXT Fuels |
| 8 Blue Marble Polymers | 21 HTS-110• | 34 NZ Bio Forestry |
| 9 Canesis Network• | 22 HydrOxSys | 35 Revolution Fibres |
| 10 Carbonscape | 23 Jaychem Industries | 36 SciTOX• |
| 11 Chemcolour Industries (NZ) | 24 Lanaco | 37 Solray Systems |
| 12 CRL Energy | 25 Lanzatech | 38 Solvent Rescue |
| 13 EcoCover• | 26 Ligar | 39 Wetox |

Note: • Inactive ◻ Holding

New Zealand Marine Companies



- | | | |
|-----------------------|----------------------|------------------------|
| 1 AgriSea New Zealand | 6 Maclab (NZ) | 11 Photonz Corporation |
| 2 Aqvi-s New Zealand | 7 NIWA | 12 R&N Beattie |
| 3 Bio Marinus | 8 Ocean Organics | 13 Seadragon |
| 4 Cawthron Institute | 9 Pacifica Salmon | 14 Supreme Health |
| 5 En'Zaq Aquaculture | 10 Pacifica Seafoods | 15 Waikaitu |

Note: ▪ Inactive ◻ Holding