

Factors Influencing the Adoption of Nature Inspired Innovation for Sustainability in Multinational Corporations

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Abstract

In recent decades, many multinational corporations have used nature inspired innovation (NII) strategies as a mechanism of sustainability-oriented innovation (SOI). In this context, these activities are typically initiated by sustainability or innovation managers who are seeking to utilise novel tools and approaches but generally do not have specific innovation goals. For some, NII is viewed as a new product development tool and for others, it is a broad perspective that defines a larger sustainability narrative for the organisation. This analysis of six cases describes the diversity of innovation types of NII in multinational corporations aiming to apply these models to sustainability-oriented innovation at multiple levels. Data was collected via semi-structured interviews (n=45) with NII team members from both inside and outside of the organisation. Additional data included internal project documents and web-based content associated with the NII projects. Cases were then compared and contrasted to identify patterns and anomalies of factors that influence the adoption of NII. While perceptions of NII were relatively consistent across cases, several factors were identified related to sustainability perspectives, the role of management, organisational structures, and innovation culture that influenced adoption. This thesis makes an original contribution to knowledge within the NII, sustainability-oriented innovation, and innovation adoption literatures by differentiating NII as an approach to SOI in MNCs, establishing an innovation typology in this context, and identifying three SOI narratives that influence the adoption of NII. Specific factors related to sustainability narratives, innovation culture and infrastructure, and management styles that support and inhibit SOI and NII in MNCs are used to distinguish three unique SOI narratives – Ambiguous, Accountable, and Aspirational. Conclusions suggest a NII readiness assessment may facilitate the adoption of NII by identifying the most effective approaches depending on the narrative of SOI within the company.

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On a personal note, thank you to my parents who supported my family in the final months of the PhD, caring for our young son, and generally making life easier by doing everything that needed to be done on a daily basis. And finally, thank you to my incredibly supportive husband, D. Scott, who took the leap across the pond to make this opportunity possible for our family and me.

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List of Abbreviations

B2B.....	Business to Business Sales
B2C.....	Business to Consumer Sales
CSR.....	Corporate Social Responsibility
EU.....	European Union
GMO.....	Genetically Modified Organism
ICT.....	Information and Communications Technology
KIBS.....	Knowledge Intensive Business Services
MNC.....	Multinational Corporation
NGO.....	Non-Governmental Organisation
NID.....	Nature Inspired Design
NII.....	Nature Inspired Innovations
NPD.....	New Product Development
PET.....	Polyethene terephthalate
R&D.....	Research and Development
ROI.....	Return on Investment
SES.....	Socioecological Systems
SME.....	Small and Medium-Sized Enterprise
SOI.....	Sustainability-Oriented Innovations
US.....	United States of America

Chapter 1: Introduction

Background

According to many natural scientists, the earth has entered a new geologic epoch, the Anthropocene, in which humans are the dominant ecological and geological force shaping the biosphere (Corlett, 2014; Steffen, Broadgate, Deutsch, Gaffney, & Ludwig, 2015). The most recent research to define the limits of growth on a finite planet, the Planetary Boundaries Framework, suggests that human activities are currently surpassing at least four of the nine critical thresholds for maintaining the functionality of socioecological systems (SES) that support human life and are approaching the thresholds for several others (Steffen, Richardson, et al., 2015). In light of these planetary limitations, there have been many calls for sustainable development (e.g., World Commission on Environment and Development, 1987), corporate accountability to planetary boundaries (e.g., Whiteman et al., 2013) and more responsible approaches to innovation and technological development (e.g., Owen & Bessant, 2013). The concept of sustainability, which was once an idealised end-goal of development, has matured in the last 30 years to be viewed as a dynamic property of multiple interacting systems (Clayton & Radcliffe, 1996; Faber, Jorna, & Van Engelen, 2005; Gaziulusoy & Brezet, 2015).

Accordingly, various approaches to organisational sustainability in the context of SES have been developed in the previous 50 years. For instance, Shrivastava and Hart (1995) assert that

Sustainability requires different organisational cultures and processes. Cultural values must emphasise harmonious co-existence with the natural world, view humans as part of the natural world, and acknowledge the rights of nature to exist. Only when environmental considerations [nature] is integrated into day-to-day operations, can an organisation approach sustainability. (p. 157)

One increasingly common model for sustainability in an organisational context is the practice of learning from nature. In the modern era, nature-based approaches take on many identities such as biomimicry, cradle-to-cradle, circular economy, and industrial ecology, all of which are inspired by biological models. However, the application of biological inspiration to human design and

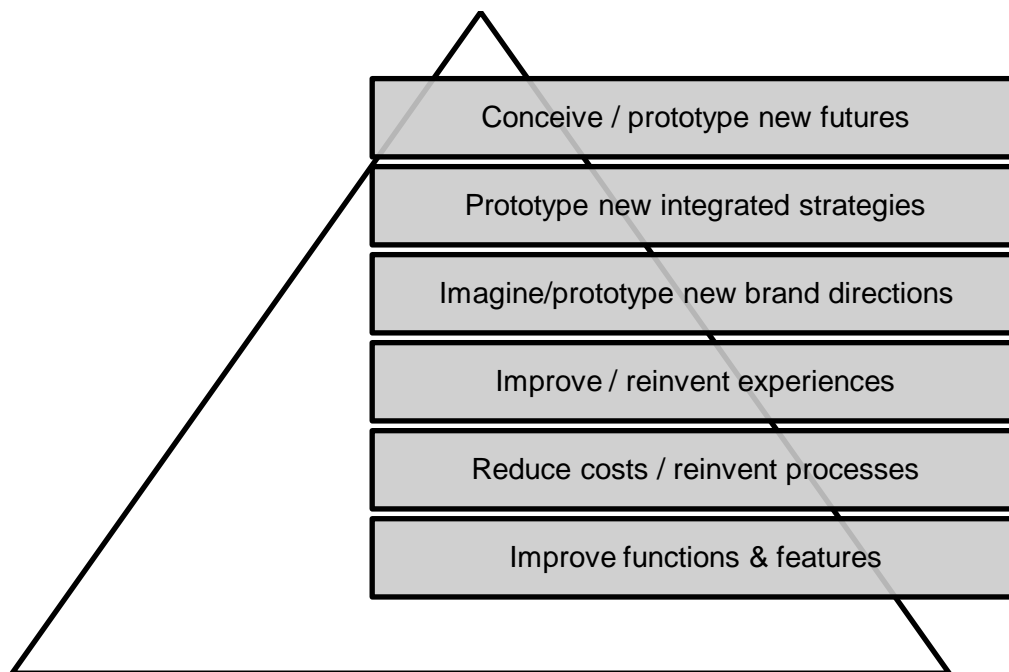
innovation dates back to prehistory, and more recently, Leonardo DiVinci was famously known for seeking innovative strategies for human flight based on the morphology of birds (Romei, 2008). In the 20th Century, Nature-Inspired Innovation (NII) has come into its own as a broad approach to innovation in several disciplines ranging from material science (e.g., Nychka & Chen, 2012) to architecture (e.g., Knippers & Speck, 2012) to national defence (e.g., Armstrong, 2010) to management (e.g., Patel & Mehta, 2011). As a result, patents in this area of research have grown exponentially within the last 30 years (Bonser, 2006). With parallel origins in ecological design, organisational studies, and engineering, NII exists today as a broad approach to innovation and problem solving that spans disciplinary boundaries and includes various tools and methodologies developed in the private sector and academia.

For the purposes of this research, NII will include disciplines that have been popularised under the auspices of other titles but still originate in the basic framing of innovation inspired by nature. As further described in Chapter 2, the term NII will be used in the broadest sense to include biomimicry, biomimetics, bionics, circular economy, cradle-to-cradle design, industrial ecology, and similarly related fields of study.

Much of the rhetoric amongst modern proponents of NII touts the evolutionary history of life on earth as evidence that the natural world has developed inherently sustainable innovation strategies. Benyus (1997), whose work has been largely credited with the sustainability orientation of nature inspired innovation since the mid-1990s, positions “nature as model, measure and mentor.” This is a common belief in which “design strategies found in non-human natural systems are unique and superior to human capabilities”, and which has come to be known as the “Biomimetic Promise” (Gleich, Pade, Petschow, & Pissarskoi, 2010, p.5). However, with the assumption that something is good because it is natural, many who promote NII commit a “naturalistic fallacy” that needs to be reconciled if NII theorisation is to progress to more effectively address sustainability issues (Blok & Gremmen, 2016). While questions of the inherent sustainability of “life” are well beyond the scope of this research, it is important to note how NII theory is contributing to shifting narratives of sustainability in many areas of research, design, and innovation.

The application of NII can be contextualised for various scales in corporate environments. NII can influence decision-making at multiple levels of corporate strategy (e.g., Anderson, 1998) or for product innovators (e.g., Harman, 2013). For many corporate innovators and leaders, an idea as broad as NII influences decisions beyond the realm of design and inspires solutions in the larger spheres of business operations and management. Doblin describes these levels as *sources of value* (Figure 1) and positions these values as a hierarchy ranging from minimal changes in functions and features towards a highest value of conceiving or prototyping new futures. This model, created for a design audience, offers insight into the study of sustainability-oriented innovation (SOI) and relatedly, NII. It demonstrates the range of potential leverage points that NII, a provocative vision, can have on the innovation process and ways that NII can provide value in an SOI process.

Figure 1: A Hierarchy - Sources of Value



(Adapted from Doblin Innovation Consultants, 2007)

Since the mid-1990s, NII has gained increasing prominence in the private sector as a tool for SOI. According to the popular media, many innovation and sustainability managers are using this approach as a means to solve problems in their organisational context. However, research to accompany the uptake of

this innovation process within organisations is lacking. Research in academic settings to test the methodologies of NII and its application as an ideation process is common. Similarly, primary research on transferable biological strategies is prolific in material science, chemistry, and engineering (Snell-Rood, 2016). However, with a few recent exceptions (i.e., Kennedy & Marting, 2016; Tempelman, de Pauw, van der Grinten, Ernst-Jan, & Grevers, 2015), the literature is lacking investigation into the innovation process and sustainability performance of NII within the companies that are claiming to utilise this innovation strategy. This is particularly true amongst multinational corporations (MNCs) where the introduction and use of novel innovation approaches and tools is commonplace. For instance, one of the most well-recognised NII consultancies, Biomimicry 3.8, claims to have worked with several dozen large MNCs (Biomimicry 3.8, 2017), but aside from one exceptional example, little documentation of this work can be found in the academic literature.

Furthermore, MNCs were chosen as the type of organisation for this study due to the large potential sustainability impact that is possible with their successful adoption of advanced SOI approaches such as NII. When applied with a perspective that is inclusive of SESs, NII has been consequential for various aspects of energy efficiency, improved product performance, responsible supply chain management, and directly solving sustainability challenges such as water or air purification. When NII is applied at the scale of a global company, the resulting impacts are also of global potential. This research aims to further inform this global potential.

Statement of the Problem

Although NII has been studied for some time as a theoretical and metaphorical lens for management and innovation, no research has been done through the lenses of SOI and innovation adoption theories to understand the role that NII plays in SOI within corporations.

Aims and Objectives

The aim of this thesis is to investigate the ways in which biological insights influence SOI in the context of a multinational organisation. In order to address this research aim, the following objectives were pursued:

Objective 1: To create a SOI typology of NII that is relatable to innovation management, particularly as it is used by multinational organisations.

Objective 2: To identify the factors that influence the adoption of NII in a multinational context as a way to support, accelerate, and clarify the NII process in large organisations.

Research Questions

Following from these Research Aims and Objectives, it was necessary to more clearly align the Research Questions (RQs) with the existing literature. While several bodies of literature and research questions were explored, the arrival at research questions was ultimately a practical one that reflected the limited breadth and depth of NII in management studies. The available studies connecting NII to innovation studies were few and the need for these questions is high in practical settings. In light of this contemporary need, the following research questions were pursued:

RQ1: What types of nature inspired innovations are attempted and achieved in multinational companies?

RQ2: What factors influence the adoption of nature inspired innovation in multinational companies?

Originality

Based on a literature review that spanned an interdisciplinary scope of NII (biomimicry, bionics, biomimetics, cradle-to-cradle, circular economy and industrial ecology), corporate sustainability, SOI, and innovation adoption theories, there were no studies identified that specifically attempted to address the aforementioned research questions.

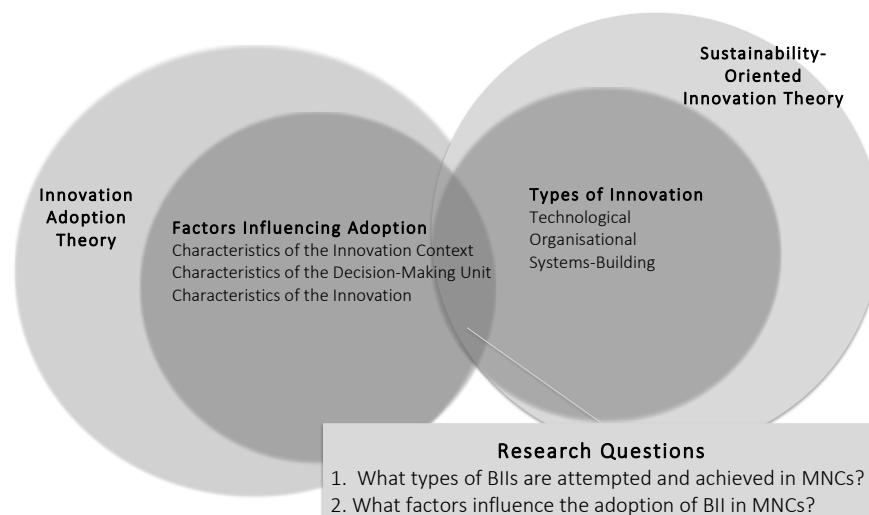
Research Design

Conceptual Framework for the Study

Although a wide array of existing theory was explored, the final research questions were chosen due to a practical need of organisations and practitioners adopting NII and external consultants promoting NII within MNCs. This practical need gave way to a large body of theory related to innovation

management (particularly to the adoption of innovations) and to an emerging body of theory related to SOI. To date, there is very little existing research specifically on the adoption of SOI as it relates to adoption theory. The following conceptual framework (Figure 2) models the overlap of these two bodies of theory and the positioning of the research questions in relation to this theory.

Figure 2: Conceptual Framework



Methods

The manuscript follows a linear-analytic structure (Yin, 2009), as is traditionally used in a thesis. In addition to some epistemological considerations, specific methods included case studies of six MNCs that applied NII for SOI, thematic analysis originating from the SOI and innovation adoption literatures, and a cross-case analysis to compare and contrast cases. Data analysis involved “systematic combining” (Dubois & Gadde, 2002) of data sources with existing literature. Data analysis is followed by reflective discussion related to the existing literature. Conclusions and implications include contributions to the literature and implications for NII practitioners and researchers.

Organisation of the Study

In addition to this introductory chapter, this structure includes the following sequence: 1) Identification of the issue or problem (Chapter 1); 2) Review of the relevant prior literature (Chapter 2); 3) Overview of methods used (Chapter 3); 4) Results and analysis of data (Chapters 4-6); and 5) Discussion, conclusions and implications (Chapters 7-8).

The literature review chapter is divided into three parts: NII, SOI, and Innovation Adoption Theory. The NII section provides a high-level overview of some of the terms used and origins of the concepts included under the umbrella of NII for the purposes of this research. The SOI section discusses the various terms used to describe NII, some of the similarities and differences with “traditional” innovation theory, and some categories used to describe NII for the purposes of analysis. The section regarding the adoption of innovations discusses the types of influences (as perceived by the users of innovations) on innovation decision-making. It addresses influential factors related to the innovation context, the decision-making unit, and perceptions of the innovation itself.

The methods chapter includes two sections: 1) Theory of knowledge and 2) Methodological considerations and choices for this multi-case study. The epistemology section discusses issues and discrepancies related to the study of NIIs and organisations in the context of SESs. It briefly approaches some of the epistemological challenges of applying biological models derived from reductionist approaches to socially-constructed design principles that then go on to be realised in practical settings. This *epistemological slide* leads NII practitioners with erroneous assumptions about NII in the context of SES and sustainable development, raising broader questions about the use of NII in corporate contexts. The methods section of this chapter discusses a description of the case study process, the selection of participants, the process for collecting data, and the approach to analysis and discussion.

The results are divided into three chapters: Results by Case, Cross-Case Analysis, and Detailed Analysis of Results. The Results by Case are divided into thematic categories in response to the research questions, and data are organised by subjects identified in the literature. The Cross-Case Analysis chapter then compares and contrasts each of the six cases to identify emergent patterns that reflect existing literature and to identify novel patterns that have not yet been described related to the adoption of SOI and NII. And finally, the detailed Analysis of Results provides a greater level of interpretive analysis and preliminary reflections on the existing literature.

The Discussion Chapter compares the Results by Case, the Cross-Case Analysis, and the Detailed Analysis of Results against the existing literature, again arranged by themes derived from the findings. This section is intended to have the greatest level of generalisability, progressing from the results of each case to the cross case analysis, to a detailed analysis, and then to the comparison with existing literature. It also provides a detailed description of the most relevant factors, i.e., the norms demonstrated in each of the three SOI narratives of NII adopters: Ambiguous, Accountable, and Aspirational. These SOI narratives and the identified norms of each provide insights into practical issues related to adoption and suggest that each organisational type should be approached differently when attempting to use a NII approach.

The Conclusion Chapter provides several details to return to the broader goals of the thesis. The first section is a review of the research aims and objectives followed by a brief discussion of how those objectives were met in the thesis. The next section summarises the main argument of the thesis and offers contributions to NII, SOI, and innovation adoption theories. The chapter concludes with limitations of the research, the implications of the findings for academics and practitioners, suggestions for further research related to NII and SOI, and final concluding remarks. The overall research design is presented in Table 1.

Table 1: Research Design Overview

Research Objective (RO)	Research Question (RQ)	Related Theory (Chapter 2)	Coding strategy (Chapter 2)	Organisation of Findings		
				Results By Case (Chapter 4)	Cross-Case Analysis (Chapter 5)	Detailed Analysis of Results (Chapter 6)
RO1: To create a SOI typology of NIIs that is relatable to innovation management, particularly as it is used by multinational organisations.	RQ1: What types of nature inspired innovations are attempted and achieved in multinational companies?	Sustainability-Oriented Innovation	Types of NIIs Attempted and Achieved: Technological Innovations Organisational Innovations Systems Building Innovations	Resources Inc.: Types of NIIs Factors Influencing Adoption ICT Inc.: Types of NIIs Factors Influencing Adoption Electronics Inc.; Types of NIIs Factors Influencing Adoption	Commonalities Amongst All Cases	NIIs Attempted and Achieved
RO2: To identify the factors that influence the adoption of NIIs in a multinational context as a way to support, accelerate, and clarify the NII process in large organisations.	RQ2: What factors influence the adoption of nature inspired innovation in multinational companies?	Innovation Adoption	Factors Influencing Adoption: Characteristics Of The Innovation Context Characteristics Of The Decision-Making Unit Characteristics Of The Innovation	Cosmetics Inc.: Types of NIIs Factors Influencing Adoption Clean Inc.: Types of NIIs Factors Influencing Adoption Textiles Inc.: Types of NIIs Factors Influencing Adoption	NIIs Attempted and Achieved Factors Influencing Adoption	Factors Influencing Adoption

Significance of the Study

This study is relevant because the body of theory related to NII is scattered around various disciplines with little overarching conceptualisation dedicated to its application in practical contexts with practical sustainability goals. Furthermore, this study contributes to a nascent body of research related to SOI and fulfils an urgent need to expand the reach and impact of MNCs as positive contributors to sustainable development. To date, the connections between NII and MNCs have been documented in very few cases. This comparative analysis expands the body of knowledge in this area by including analyses of both successful and failed applications of NII. The lessons in failure, though rarely discussed, are equally, if not more, important to understand than those cases of success. This thesis sheds light on the differences amongst NII user organisations and what factors contribute to the adoption of NII.

Conclusion

This chapter has provided an overview of the thesis and several introductory components. Included were: a background and introduction to the problem, aims and objectives, research questions, limitations, research design overview, and the significance of the study. The following chapter, the Literature Review, will further introduce the theoretical foundations of the research.

Chapter 2: Literature Review

Introduction

The purpose of this chapter is to present an overview of NII followed by the two bodies of research that support the research questions. The overview of NII briefly addresses the philosophical roots of learning from nature and then the various innovation approaches that are included under this umbrella term. Two bodies of literature - SOI and innovation adoption - are presented to support the research questions. In response to RQ1, the SOI literature is used to create a typology to categorise the innovations that result from NII processes: Technological, Organisational, and Systems Building. In response to RQ2, the second body of literature, supplemented by additional SOI and NII literature, presents a framework to analyse the factors that influence the adoption of NII: 1) Characteristics of the innovation context; 2) Characteristics of the decision-making unit; and 3) Characteristics of the innovation (Rogers, 2003). These three bodies of literature were combined to arrive at a coding strategy that was applied to each case.

Overview of Nature Inspired Innovation

For some, the NII era will be known in history as “The Biological Age” (Dubberly, 2012). With the amount of information that we know about the biological world doubling every five years (Rifkin, 1999), it is reasonable that many scholars perceive a social and scientific paradigm shift that is more aligned with ecological and systems theories that has paved the way for NII's influence in various disciplines. As Kuhn (1962) argued, any era of scientific exploration is subsumed by the dominant narratives of cultural discourse and is consequently subject to normative interpretations of appropriate courses of inquiry for any particular era. The paradigms or worldviews that dominate a particular era shape the lines of scientific discourse by the very language that guides the questions themselves. Worldviews frequently remain unnoticed in daily interactions, yet silently they “channel attention, filter information, categorise experience, anchor interpretation, orient learning, establish mood, secrete norms and legitimate narratives, ideologies and power structures” (Gladwin, Newberry, & Reiskin, 1997). The same phenomenon regarding the influence of dominant worldviews holds true for the dominant paradigms of the present era.

Both enabling NII and enabled by NII, several authors posit that we are in the midst of a paradigm shift from a mechanistic worldview to an ecological worldview in multiple sectors simultaneously. Authors from diverse fields such as physics (e.g., Capra & Luisi, 2014), design (e.g., Benne & Mang, 2014; Du Plessis & Brandon, 2014; Dubberly, 2012), leadership (e.g., Schein, 2015) and even finance (e.g., Hock, 1995) are recognising the impact that this perspective is having on the theory and practice of their disciplines. Du Plessis and Brandon (2014) describe how this perspectives positions humans in relation to natural systems:

...Consider the world as a whole - an interdependent and interconnected living system in which humans are an integral part of nature and partners in the processes of co-creation and co-evolution. Humans, their social structures, and their biophysical environment, form one integrated social-ecological system in which humans and their artefacts are an indivisible part of the biosphere and they, like any other organism, participate in and co-create the metabolic and change processes that shape the biosphere. However, the addition of the human mind introduces properties of self-reflection and symbolic thought that allows the intentional creation of novelty and the ability to direct change within the system (p.55).

This view is in contrast with other worldviews which position society and business as disparate and separate from nature (as described by Marcus et al. 2010). Several authors within management have suggested a similar shift in corporate social responsibility narratives (Borland & Lindgreen, 2012; Gladwin, Kennelly, Krause, & Hugo, 1995; Marcus et al., 2010; Shrivastava, 1995), though these narratives are far from common in the mainstream management literature.

In this emerging setting of ecocentric thinking (i.e., a perspective that places intrinsic - rather than utilitarian - value in living organisms and natural systems), it is no surprise that the use of biological metaphor and analogy as a source of inspiration for human innovation has grown exponentially in recent years. Between 1985 and 2005, the number of patents related to biological inspiration increased at a greater rate in proportion to all published patents (Bonser, 2006). The Fermanian Institute has gone so far as to create an economic index to track the progression of NII in the economy (Fermanian Business & Economic Institute, 2011). The International

Standards Organisation (commonly known as ISO) is developing industry standards related to NII (Mead & Hoeller, 2014) and NII is slowly permeating the European policy landscape with efforts such as the Green Deal in the Netherlands (Biomimicry NL, 2013). The international sustainable development think tanks such as the Worldwatch Institute (Worldwatch Institute, 2012) and the International Union for Conservation of Nature (Adams and Jeanrenaud, 2008) have identified NII as a potential pathway for sustainable development. International communities of practice are emerging globally in a network of networks (e.g., Biomimicry Institute, European Biomimicry Alliance), and in the last 20 years, several degree programs and journals dedicated to the subject have emerged in various disciplines. The first indications of the entrance of an ecocentric era in business are beginning to emerge, with some businesses adopting cradle-to-cradle and biomimicry (Pina, Rego, & Vieira, 2007).

NII is an umbrella term for several related fields of study in which nature is viewed as the source of inspiration for design and innovation in material, social, and economic systems. It includes fields of study of various origins such as biomimetics, as coined by Jack Steele in 1969 (Bar-Cohen, 2006; louguina et al., 2014), biomimicry (Benyus, 1997), cradle-to-cradle design (Braungart & McDonough, 2009), circular economy (Ellen MacArthur Foundation, 2012), and industrial ecology (Frosch & Gallopoulos, 1989; Layton, Bras, & Weissburg, 2016). Additionally, there have been recent efforts to combine various subsets of these terms into one overarching discipline with names such as “bio-inspired design” (Hoeller, Goel, Freixas, Anway, & Upward, 2010), “Biologically Informed Disciplines” (louguina et al., 2014), “Nature-Inspired Design” (De Pauw, Kandachar, Karana, & Peck, 2010) and others in diverse bodies of literature. In another article, Fogarty, et al. tie together key aspects of biomimicry, industrial ecology and organisational ecology to create guidelines for corporate sustainability (Fogarty, Villamagna, Whitley, & Pippins, 2013). Conversely, industrial ecology has been contrasted with biomimicry by referring to a system rather than a product scale (Layton et al., 2016).

Additionally, NII has been differentiated as a distinct term to encompass a broader range of innovation approaches than have been previously defined in the literature (e.g. “nature inspired design” (de Pauw, 2015) and “biologically inspired disciplines” (louguina et al., 2014)). The word ‘nature’ was chosen to distinguish the inclusion of

both the living (i.e., biotic) and non-living (i.e., abiotic) aspects of non-human systems, rather than 'biological' which is defined more narrowly as living systems amongst scholars and practitioners in related fields of study. Additionally, 'innovation' was used as an alternative to 'design' or 'discipline', which are both rather narrowly defined per the cited works above. While the term 'innovation' can also be used synonymously with design in some academic conversations, it is distinctly differentiated in the context of the innovation management literature. The innovation management literature refers to innovation at levels such as product, process, system, management, and organisation. While design might suffice as a term that is interchangeable with innovation at these categorical levels, "Nature Inspired Design" has already been narrowly defined in the literature to include biomimicry, natural capitalism, and cradle-to-cradle by de Pauw (2015). It is for these reasons that a unique term - Nature Inspired Innovation - was used in this analysis.

The use of NII has a long and winding path emerging from multiple disciplines, both with and without socioecological system objectives as primary performance criteria. With origins in both engineering and ecological design, the NII approach has arrived at the present day with theory, tools, and methods from a wide array of perspectives. The contributions of biomimicry, cradle-to-cradle, industrial ecology, and circular economy related to the ecocentric worldview are highlighted here.

Benyus (1997), whose work has been largely credited with the sustainability orientation of NII since the mid-1990s, positions "nature as model, measure and mentor." (The term *biomimicry* first appeared in the literature in 1982 within the dentistry literature (Lange-Merrill, 1982), but was later popularised in its modern day context in 1997 by Janine Benyus.) Biomimicry is "an innovation method that seeks sustainable solutions to human challenges by emulating nature's time-tested phenomena, patterns, and principles. The goal is to create well-adapted products, processes, designs, and policies by mimicking how living organisms have survived and thrived over the 3.8 billion years life has existed on Earth" (Biomimicry 3.8, 2013). Some examples include Pax Scientific's impellers, fans and mixers that emulate the Fibonacci sequence found in numerous organisms (Harman, 2013); Colombia Forest Products's Purebond non-toxic glue that mimics the chemistry of

blue mussel byssus; and Sto's Lotusan paint that mimics the self-cleaning bumps of a lotus leaf, reducing the need for cleaning agents on building facades.

Benyus's (1997) conception of biomimicry positions humans as a part of nature rather than separate from it and describes NII as a shift in the human perspective of nature from a utilitarian perspective to one in which nature is viewed as a source of inspiration from which humans can learn:

1. Nature as model: Biomimicry is a new science that studies nature's models and then imitates or takes inspiration from these design and processes to solve human problems (...).
2. Nature as measure: Biomimicry uses an ecological standard to judge the 'rightness' of our innovations. After 3.8 billion years of evolution, nature has learned: What works. What is appropriate. What lasts.
3. Nature as mentor: Biomimicry is a new way of viewing and valuing nature. It introduces an era based not on what we can *extract* from it, but what we can *learn* from it (1997, Front pages).

This repositioning was a critical component in connecting inspiration from nature to the conservation of nature. NII invites a form of management logic based on ecological understanding and a greater diversity of values for nature beyond utilitarian views common in management discourse. In a traditional corporate innovation setting, the typical forms of rationality for decision-making revolve around technical and economic forms of rationality to drive competitive advantage. However, BII creates an entry point for the introduction of *ecological rationality* into a corporate innovation process that may or may not be otherwise present. "Ecologically rational behaviour on the part of an agent (such as a human being) may be defined as behaviour which promotes or protects the functional rationality of ecosystems—their stability or homeostasis" (Dryzek, 1983). In addition to this rationality, viewing nature as 'model, measure and mentor' (Benyus, 1997) also shifts the typically utilitarian value of nature in corporate settings to other types of values. In a discussion of the Biophillic hypothesis, Kellert (1995) introduces nine common values of nature that can be found in Table 2.

Table 2: A Typology of Biophilia Values

Term	Definition	Function
Utilitarian	Practical and material exploitation of nature	Physical sustenance/security
Naturalistic	Satisfaction from direct experience/contact with nature	Curiosity, outdoor skills, mental/physical development
Ecologistic-Scientific	Systematic study of structure, function, and relationship in nature	Knowledge, understanding, observational skills
Aesthetic	Physical appeal and beauty of nature	Inspiration, harmony, peace, security
Symbolic	Use of nature for metaphorical expression, language, expressive thought	Communication, mental development
Humanistic	Strong affection, emotional attachment, “love” for nature	Group bonding, sharing, cooperation, companionship
Moralistic	Strong affinity, spiritual reverence, ethical concern for nature	Order and meaning in life, kinship and affiliational ties
Dominionistic	Mastery, physical control, dominance of nature	Mechanical skills, physical prowess, ability to subdue
Negativistic	Fear, aversion, alienation from nature	Security, protection, safety

Adapted from (Kellert, 1995)

Whereas greening and sustainability models of corporate strategy rely heavily on *Utilitarian* and *Moralistic/Dominionistic* values of nature, respectively, BII invites *Ecologistic-Scientific* and *Symbolic* values into SOI processes. This subtle shift in narrative regarding human-nature relations opens the dialogue for more advanced conceptions of corporate participation in socioecological systems.

While an extensive discussion of the various values of nature is beyond the scope of this thesis, it is important to note that the culturally accepted perceptions of nature and biology are shaped by the normative assumptions and social paradigms of a particular moment in history, as Kaye (1997) asserts in “The Social Meaning of Modern Biology”.

Benyus’s framing of biomimicry, heavily reliant on *Ecologistic-Scientific* and *Symbolic* values, included industrial ecology explicitly and was arguably the conceptual precursor of cradle-to-cradle design and circular economy. The cradle-to-cradle

approach to production and consumption proposes to “create more inspiring engagement – a partnership – with nature”, and to “build factories whose products and by-products nourish ecosystems with biodegradable material and recirculate technical materials instead of dumping, burning, or burying them” (Braungart & McDonough, 2009 p.156). The concept, first proposed by Walter Stahel (Stahel & Reday-Mulvey, 1981), is a biomimetic approach to the design of products and systems for a circular product life cycle rather than a linear approach to production and consumption. Braungart and McDonough, who later popularised the term, compare eco-efficiency models of design, which seek to do less harm by creating the same products by using less resources and energy, to an eco-effective model, which eliminates the concept of waste altogether, instead proposing technical and biological metabolic loops of production and consumption which have a net positive effect on SES. They propose that “instead of using nature as a mere tool for human purposes, we can strive to become tools of nature who serve its agenda too” (p.156), thereby serving as regenerative agents in a biophysical world (Braungart & McDonough, 2009). As described by Gaziulusoy (2015), “Eco-effectiveness, in contrast to eco-efficiency which puts emphasis on reducing environmental impact through improvement of resource consumption efficiency, puts emphasis on a regenerative (rather than depletive) approach by the industry. The concept of eco-effectiveness is operationalised with the ‘waste equals food’ concept which was in fact put forward in the industrial ecology field” (p.12).

Industrial ecology is an analogical construct applying the principles of ecological systems to methods of production and consumption. Rather than viewing nature in terms of ‘a sack of resources’ or ‘biophysical limit’, this perspective offers nature as a model for industrial systems and their integration with nature (Isenmann, 2003). Active research includes measures of industrial metabolism, material and energy flow analysis, life cycle analysis of products, industrial symbiosis (waste of one manufacturer is raw material for another), study of ecoindustrial parks (e.g., Ehrenfeld & Gertler, 1997), and determinations of how the processes of dematerialisation are enabling novel business models. While many of these rely only on analogous analysis (Ehrenfeld, 2004), some research makes explicit connections to the integration of technological systems with ecosystem services by proposing

that life cycle assessments should include ecosystem services (Bakshi & Small, 2011).

The circular economy model, as described by the Ellen MacArthur Foundation, could be viewed as a more detailed approach to the regenerative models of economics that focuses on the material aspects of production and consumption. This recently popularised notion is a nature-inspired approach to economic development in multiple sectors (Ellen MacArthur Foundation, 2012). As described in a recent report, “The closed loop is a biomimetic approach, a school of thought that takes nature as an example and considers that our systems should work like organisms, processing nutrients that can be fed back in to the cycle – hence the ‘closed loop’ or ‘regenerative’ terms usually associated with it” (Ellen MacArthur Foundation, 2015). Although this concept has recently benefited from a substantial gain in attention from researchers and policy makers, some of those early adopters of NII have been experimenting with and describing circular business models for some time (e.g., Anderson, 1998; Phillips, 2015; Stahel & Reday-Mulvey, 1981).

NII Research in Innovation Management

As noted above, NII has benefited from significant attention in the popular media and academic journals in the last two decades. Popular media coverage includes stories of entrepreneurs and inventors developing novel technological approaches to water purification, surface coatings, and other technical solutions (e.g. Harman, 2013). Several propositional pieces have been written about the untapped potential of applying biological models to organisational innovations as well (e.g. Hutchins, 2012). The management literature is also interspersed with biological metaphor and ecological models for theorising organisational behavior and interactions. Proponents of these approaches make far-reaching claims about the value of biological metaphor for corporate social responsibility and business performance. For instance, the book *The Keystone Advantage* (Iansiti & Levien, 2004) describes how managers could view their organisations as part of an ecosystem of organisations and subsequently strive to develop a niche as a keystone species. (In ecology, a keystone species is one that has a disproportionate effect on its environment compared to its size and number.) While this metaphor may be helpful

for managers, it is notable that these authors make no connections to the sustainability of SES.

As critics note, there are various cultural interpretations of biological and ecological processes that have scant connections with SES and in some instances to the opposite extreme, these cultural interpretations have been used for destructive purposes (Johnson, 2011; Kaye 1997). NII has been critiqued as a 'technocentric' approach which is a valuable tool for innovation, but lacks an 'ecocentric' perspective that frames nature as having intrinsic value and connects humans to natural systems (Marshall & Lozeva, 2009). And indeed, without careful consideration of biophysical and social consequences, NII can be a pathway for perpetuating the current unsustainable means of production and consumption under the pretense of 'natural' systems (Mathews, 2011). This practice has been referred to as "Weak Biomimicry", which emphasises sophisticated high-tech solutions that can be created in the technological translation of biological strategy to materials and devices. In comparison, "Strong Biomimicry" is motivated by solving design challenges and relies on natural models to define appropriate technologies with bioinclusive ethics (Blok & Gremmen, 2016). For the purposes of this thesis, the literature and selected cases emphasise Strong Biomimicry and position NII as a tool for SOI. Other perspectives of Weak Biomimicry, while relevant and timely, will be considered peripheral to the central thesis.

Although there has been considerable coverage of the "Biomimetic Promise" of more sustainable, better performing design solutions based on nature in recent years (Gleich et al., 2010), the empirical literature on NII in management is lagging behind the state of the art in practice that has been covered by the popular media. The depth at which companies are utilising NII and the effectiveness of the approach is not thoroughly understood. Consequently, within the realm of management NII has been under-theorised beyond broad metaphorical contributions, and case studies of specific applications of NII in management have yet to be developed. This literature review is intended to establish NII as a broad method of SOI used by multinational corporations (MNCs). It will set the stage for an in-depth case analysis of six companies that have used NII as a SOI process. The following sections will discuss:

1) The types of innovations that are influenced by NII in MNCs; and 2) The factors that influence the adoption processes that lead to NII.

Types of Innovations

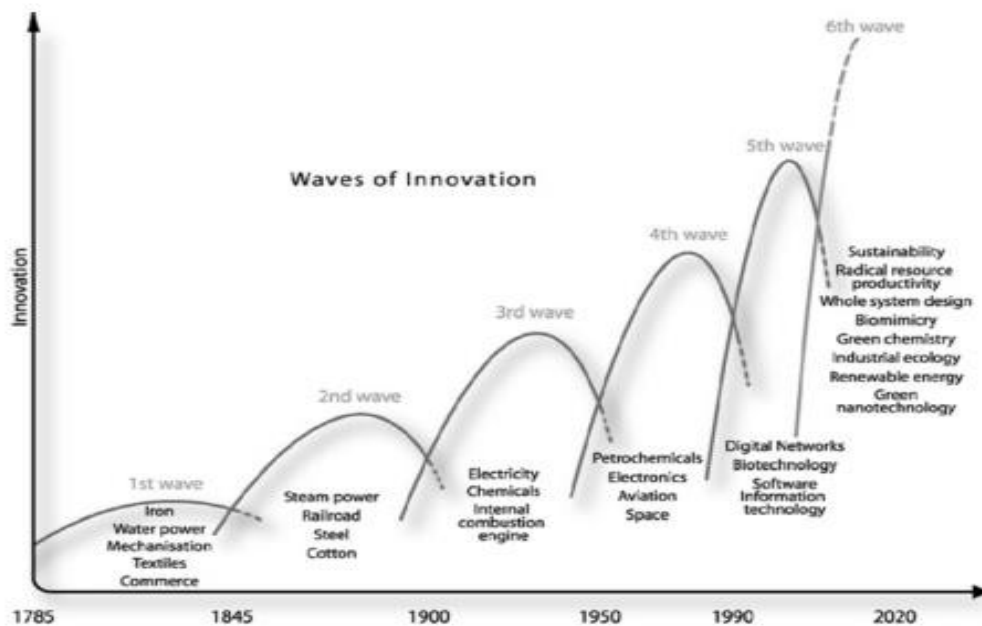
Although a contested notion (Franceschini & Pansera, 2015; Huesemann, 2003), innovation is frequently seen as a driver of change for sustainability. As Pansera explains, “the notion of innovation has assumed a fundamental importance in the debate around sustainability and is often invoked as an essential tool to guide the transition to a sustainable society” (Pansera, 2012). Paradoxically, companies are often incited to create novel innovations for sustainability while at the same time being a source of negative externalities for SES (Mohr, Price, & Rindfleisch, 2015). Technological change has long been considered both the source and solution for many ecological challenges, and consequently, a shift in innovation trajectories has been considered a critical factor in supporting SES (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). As summarised by Ginsberg, et al: "Designed things are a synthesis of ideas and values" (Ginsberg, Calvert, Schyfter, Eflick, & Endy, 2014).

Nevertheless, companies, NGOs, and academics now view sustainability as a major driver of innovation and corporate strategy (Adams, Jeanrenaud, Bessant, Overy, & Denyer, 2013; Nidumolu, Prahalad, & Rangaswami, 2009; Senge & Carstedt, 2001). In fact, some of these same authors refer to NII as a strategy for innovation (Senge & Carstedt, 2001). Sustainability, including NII specifically, has also been described as the 6th Kondratiev Wave or the next major driver of economic upswing that lies ahead (Figure 3) (Hargroves & Smith, 2013). Furthermore, recent research has found a positive relationship between SOI practices and overall improved organisational performance (i.e., total quality management) (Gomišček, Maletič, & Maletič, 2017).

Existing theory in this area specifies distinctions that differentiate between several categories of innovation based on their emphasis on social and ecological factors. To date, this body of research includes terms such as eco-efficiency, eco-innovation, ecological innovation, green innovation, green product innovation, environmental innovation, sustainable innovation, responsible innovation, frugal innovation, jugaad innovation, inclusive innovation, social innovation, and sustainability-oriented,

sustainability-driven, and sustainability-related innovation. There are varying degrees of inclusion of social and environmental issues ranging from merely greater material and energy efficiency (i.e., ecological modernisation) to holistic consideration of the social and environmental implications of SOIs across diverse groups of stakeholders in global communities (Adams et al., 2013). Some innovations tend to be sustainability-enhancing while others merely alleviate unsustainable circumstances (Varadarajan, 2015). Several comparisons of definitions and usage of these terms have been undertaken in recent years as the body of theory has grown (Franceschini, Faria, & Jurowetzki, 2016; Pansera, 2012; Schiederig, Tietze, & Herstatt, 2012; Varadarajan, 2015). Analysts disagree regarding the level of variability amongst the terms, but acknowledge that sub-cultures do exist around specific terms (Franceschini et al., 2016). For the purposes of this study, sustainability-oriented innovation will be defined as, “making intentional changes to an organisation’s philosophy and values, as well as to its products, processes or practices, to serve the specific purpose of creating and realising social and environmental value in addition to economic returns” (Adams et al. 2015 p. 2).

Figure 3: Sustainability as the 6th ‘Long Wave’ of Innovation



(Hargroves & Smith, 2013)

Part of the reason for the great deal of ambiguity and uncertainty around the definitions of SOI is because of its forward-looking scope. It is unfeasible to determine whether SOIs are producing more sustainable results, as the long-term effects remain unknown (i.e., the future has yet to happen and unforeseen circumstances are impossible to know). As such, SOI should not be considered a qualitatively new form of innovation, but rather a statement of intent about the innovation in question, instead of a definitive evaluation (Genç & Di Benedetto, 2015; Hansen, Grosse-dunker, & Reichwald, 2009). Sartorius notes that it is impossible to predict the sustainability of specific innovations and suggests that a technological and regulatory environment that allows for trial and error without technological lock-in is essential for future adaptability. He offers the following view: “Sustainability as viewed from this evolutionary perspective is ... better understood as the general capability to adapt...to readily change from less to more sustainable technological trajectories” (Sartorius, 2006 p.268).

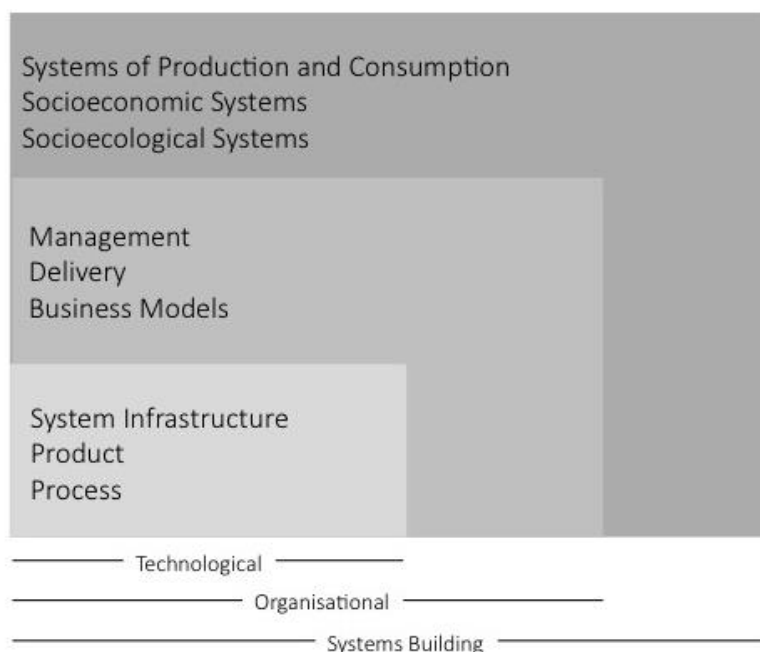
Relatedly, ecological economics offers a theory of *co-evolutionary innovation*, which broadly frames innovation using an embedded view of SES. Innovation is thereby a process of change through time in which the technology is in constant interaction and co-evolving with social, cultural, economic and ecological conditions (Røpke, 2005). The coevolutionary view of technological innovation characterises an interdependent relationship between socio-techno systems and biophysical systems. In this model, human innovations are shaping biophysical systems while biophysical systems are concurrently shaping human innovations on multiple levels of analysis ranging from the cell to the biosphere (Gual & Norgaard, 2010; Kallis & Norgaard, 2010).

Innovation categories (or types, etc.) have been described with a variety of terms and described by many authors (e.g., Tidd & Bessant 2011; Ashford & Hall 2011; Klewitz & Hansen 2014). Given the diverse applicability of NII concepts across a variety of disciplines, there is a great deal of scale-jumping to consider when analysing its applications in various circumstances. Types or scales of SOI applications mentioned in the literature include: form, product, process, operational, organisational, positional, inter-organisational, delivery and business model, production and consumption system, system infrastructure, paradigm, and societal

innovations (Adams et al., 2013; Benyus, 1997; Boons & Lüdeke-Freund, 2013; Crossan & Apaydin, 2010; Jay & Gerard, 2015; Klewitz & Hansen, 2014; Tidd & Bessant, 2011). The following section – based largely on Jay and Gerard (2015) - creates a typology to categorise the implementation of NII in MNCs.

The adapted, comprised model below (based on Jay & Gerard, 2015; Ashford and Hall, 2011; and Adams et al., 2015), defines the categories of Technological, Organisational, and Systems Building Innovations and will be used to describe the types of NII in each case (see Figure 4).

Figure 4: Modified Model of Innovation Categories for Case Analysis



(Adapted from Adams et al., 2016; Ashford & Hall, 2011; Jay & Gerard, 2015).

Technological Innovations

Technological innovations include product, process, and system infrastructure interventions that result in more sustainable conditions in a physical sense. Product innovations are usually defined as “new products or services introduced to meet an external user need” whereas “process innovations are defined as new elements introduced into a firm’s production or service operation to produce a product or render a service” (Damanpour & Aravind, 2012 p.246). This can include

manufacturing processes, distribution processes, and others. For those companies engaging specifically in NII, technological benefits of a NII process include higher product quality, closing of technical and biological resource loops, improved recyclability of products, and additional beneficial product functions such as improving indoor air quality, capturing CO₂, or filtering water (Tempelman et al., 2015). Hellström (2007) describes several potential sources of innovation related to processes and products as, “aspects of the manufacturing process (e.g. reduction of material in the product, number of parts in the product and number of different materials in the product), product usage (e.g. reduction in usage of water, energy, and detergents), end-of-life (e.g. design for longer life, re-use of components and design for upgradability, recyclability/ease of separation) and function redesign (e.g. redesigning of an activity)” (p151).

Tools such as cradle-to-cradle, eco-design (Pigosso, Zanette, Filho, Ometto, & Rozenfeld, 2010), life cycle analysis, and ecological certifications (Sharma & Vredenburg, 1998) all contribute to the advancement of technological innovations. Technological innovations are generally easier to achieve than the other categories, however, they also have a lower potential for environmental benefits (OECD, 2009). This also applies specifically to NII as demonstrated by evidence that the emulation of only biological shape or process limits the possible positive sustainability effects of the innovation (Reap, 2009). This implies the need for systems-level application of biological knowledge to inform systemic innovation for sustainability (Tempelman et al., 2015).

Organisational Innovations

Organisational innovations, on the other hand, have a higher potential for socioecological benefits but are more difficult to coordinate than technological innovations (OECD, 2009). Application of the term *organisational innovation* is diverse and lacks continuity in the literature. In some contexts, it refers to the ability of an organisation to innovate or the innovative behavior of the organisation (Wolfe, 1994), or more generally, it refers to “the creation or adoption of an idea or behavior new to the organisation.” (Lam, 2004). It is also closely related to *managerial* (Damanpour & Aravind, 2012) or *management innovations* (Birkinshaw, Hamel, & Mol, 2008). Management innovation is defined as “the invention and implementation

of a management practice, process, structure, or technique that is new to the state of the art and is intended to further organisational goals” (Birkinshaw, Hamel, & Mol, 2008, p.825). For the purposes of this research, organisational innovation is defined as a new organisational method for business management within an organisation and/or between an organisation and an external agent (OECD, 2005).

D’Amato and Roome (2009) relate management innovations to CSR as follows: “Management innovation in general, and corporate responsibility in particular, are held to be part of a complex process related to the way in which individuals, organisations, the business world, and society interpret the new role of business in society, responsible business, and sustainable development” (p. 424). Both CSR and non-CSR related research suggests that successful innovation is the result of the interaction of process and management changes (Hollen, Van Den Bosch, & Volberda, 2013; Klewitz & Hansen, 2014). Several authors have documented how management innovations play an important role in shaping a firm’s environmental impact (D’Amato & Roome, 2009; Hollen, Van Den Bosch, Volberda, & Heij, 2013; Martin, Muûls, de Preux, & Wagner, 2012; Theyel, 2000). Management innovations can reduce the amount of codification of organisational routines when a new technology is introduced at the same time increasing the technology’s ability to be assimilated into the organisation (Khanagha, Volberda, Sidhu, & Oshri, 2013). Additionally, although management innovations frequently have impacts and involve partner organisations from outside the organisation, the primary objectives are internally focused and do not fundamentally shift the nature of the relationships amongst organisations. To compare, Systems Building Innovations include other organisations and involve other types of innovations.

A recent study of NII found that the principles, methods, and tools that companies use to engage with NII “seem to affect the companies beyond the traditional scope of sustainable product design, up to the point of influencing corporate missions” (Tempelman, de Pauw, van der Grinten, Ernst-Jan, & Grevers, 2015 p.327). Similarly, Mohr, et al. (2015), propose that NII itself can provide a new logic for innovation which introduces several ecological principles into innovation theory including relational fluidity/permeability, complex adaptive systems thinking, resilience in the face of vulnerability, lexicon in the organisation that reflects the

natural world, and the identification of mutualisms and symbiosis. An example of a management NII might be the application of swarm theory to the management of a project team or a nature-inspired business model might include product-leasing arrangements as suggested by circular economy principles.

Systems Building Innovations

The Systems Building approach represents a philosophical shift that reframes the overall purpose of business to proactively improving society and the environment by engaging with novel partners to create novel value and new configurations of knowledge. Also sometimes referred to as institutional and social innovations, this category includes the following: socio-economic systems that span sectors; systems of production, consumption, and waste; eco-socio-techno-systems (Adams et al., 2016; Jay & Gerard, 2015); and socio-technical systems (Gaziulusoy & Brezet, 2015). These types of innovations span beyond the unit of a corporate entity or governmental body and include multiple types of organisations. They frequently include groups with legal and social identities outside of the organisation such as corporations, governments, cooperatives, academic institutions, and non-governmental organisations. According to Gaziulusoy (2015), “Radical innovation at paradigmatic level is far more challenging than radical innovation at company/product level as it also requires complementary institutional, organisational, and social/cultural/behavioural innovations to enable investment, research, and diffusion” (p. 372). Related innovation categories include sustainability-oriented innovation systems (Altenburg & Pegels, 2012), systems innovation (Mulgan & Leadbeater, 2013), and sustainability transitions (Geels, 2010).

Furthermore, Systems Building Innovations includes activities of many actors and institutions that themselves are “interconnected set[s] of innovations, where each influences the other, with innovation both in the parts of the system and in the ways in which they interconnect” (Mulgan & Leadbeater, 2013 p.4). Sustainability challenges that are situated in the global commons (e.g., climate change, ocean pollution, chemical pollution, etc.) require diverse collaborations for radical innovation projects and transformative solutions that can be enabled by a systems building approach. In summary, “[Systems Builders] not only focus internally, but also look to

lead and inspire change in the wider societal, economic, technical, and environmental management systems through strong and visionary leadership and the mobilisation of dynamic capabilities. Much of this, though, remains aspirational or at least empirically untested” (Adams et al., 2015 p.15).

One of the main benefits of this model of Technological, Organisational and Systems Building Innovations (and others specifically related to NII, i.e., Mead, 2014), is its arrangement as nested systems. As asserted by several authors (e.g., Seebode, Jeanrenaud, & Bessant, 2012), innovation for sustainability must be viewed in a larger systems context. Gaziulusoy contextualizes this further by arguing “sustainability is a system property; therefore, products/services/technologies/organisations cannot be sustainable on their own but they may be elements of sustainable systems” (2015 p.366). Specifically,

“...Products, services, technologies or organisations individually cannot be defined as sustainable or unsustainable and they should be considered within the systems they are embedded. Only if the systems of concern are sustainable, then the products, services and technologies therein can be regarded as sustainable... Therefore, design and innovation for sustainability should adopt a systems thinking approach as a reference to evaluate product/service concepts within which the system they will be produced/consumed” (Gaziulusoy, 2015, p.7-8).

Adams et al list NII innovation approaches such as ‘closed-loop production’ (Pigozzo et al., 2010), ‘circular economy’ (Ellen MacArthur Foundation, 2012) and ‘net positive’ contributions like those promoted by a cradle-to-cradle approach (Braungart & McDonough, 2009) as pathways for Systems Building Innovations. To the contrary, Gaziulusoy et al. (2015) identify the limitations of biomimicry and cradle-to-cradle as it is conceptualised by some users:

Although biomimicry is a valid approach to acquire inspiration for design and innovation, the resulting innovations are not sustainable per se for isolating a principle, structure, or process from nature and imitating it does not necessarily result in elimination of all environmental and/or social impacts of a product. In addition, although evolutionary history resulted in harmonious working of ecosystems, evolution is not a mechanism generating perfection but instead effectiveness, which is valid locally and at system level. Although, a biomimicry approach focusing on systems of nature rather than individual mechanisms, properties, or processes could potentially enable systemic transformations, the [biomimicry] approach addresses

isolated problems through a technologically-optimistic and product-focused engineering perspective. Therefore, some innovations developed using this approach can be regarded as radical technological innovations but it is hard to conclude that [biomimicry] has an explicit reference to socio-technical system transformations. The idea of use of nature as a mentor, on the other hand, is aligned with strong sustainability criterion. If this can be implemented with a broader perspective than focusing on singular functions, a systemic approach to generating solutions may be encouraged. Nevertheless, [biomimicry] does not prescribe or imply the necessity of longer-term planning periods in conducting business or seem to have an agenda for organisational mind-set change. It is clear that both [cradle-to-cradle] and [biomimicry] have strengths in relation to encouraging alternative approaches to design and innovation for sustainability especially if not promoted and perceived as potential panaceas and when combined with other tools available for design and innovation teams, such as life-cycle assessment, to compensate for their shortcomings. Nevertheless, the inherent politics of [cradle-to-cradle] and [biomimicry] make these approaches unviable for enabling design and innovation teams to plan for and act towards innovating for systemic transformations as neither of these approaches challenge consumption patterns and they demonstrate technological optimism (p.12-13).

This explanation summarises the impetus to create NII as a separate term for this analysis - to transcend the minutia of these arguments and emphasise the larger narrative of learning from nature. For some scholars and users of NII, the distinction between biomimicry, cradle-to-cradle, circular economy, and industrial ecology is quite significant to their research (e.g., Gaziulusoy & Brezet 2015; Tempelman et al. 2015). For others, it is inconsequential and the concept of simply learning from nature dominates the innovation process (e.g., Pauw et al. 2010; Louguina et al. 2014). While this research does not intend to take a firm stance on this position, the cases exemplify the breadth of possibilities described in the literature and explore the types of NIIs that are attempted and achieved in MNCs.

In summary, there is currently a high level of ambiguity regarding the types of NIIs applied in business contexts. While Benyus's (1997) biology-driven model of emulating form, process, or system may be relevant for some audiences, it does little to meet the needs of innovation and sustainability managers in their corporate working contexts. Additionally, many innovators set out to "do biomimicry" with little consideration for intended goals and results. This study aims to address this gap by

creating a typology of NIIs that can be used to describe the intended goals and results of NII in a corporate innovation context, as explored in RQ1.

Factors Influencing the Adoption of NII

One area of NII and SOI research currently under-investigated are the factors that influence adoption in MNCs¹. While there is an abundance of research investigating conventional approaches to innovation, inquiries addressing NII and SOI are recent and few. As Jakobson and Clausen observe, “scholars have argued that while there may be similarities between ‘environmental’ and ‘non-environmental’ innovation processes, research and theorising about innovation in general does not cover the whole complexity of environmental innovations” (2015, p.1). Given that SOI creates unique challenges to the innovation process that may deserve alternative lenses of analysis (Adams et al., 2016), traditional innovation adoption models will be supplemented with criteria from the SOI literature highlighting factors unique to SOI adoption.

In each of the six cases analysed, the application of NII begins with an agent such as a designer or an innovation or sustainability manager within an organisation viewing *learning from nature* as a possible source of innovation for various types of challenges. (This agent has been referred to as the *Innovator* within the interview data.) From this original inspiration, NII is the subject of analysis despite the initial ambiguity of potential applications of NII in the innovation process. Greenhalgh, et al (2004) summarise this dynamic well:

¹ Several studies have analysed components of the NII process whilst in use by designers and engineers. These studies have dissected the various aspects of the conceptual transfer from the biological sciences to engineering applications and vice versa. Additionally, researchers have developed tools and tested their use in hypothetical design situations, adding valuable insights in to the intricacies and uniqueness of the NII process, particularly at the front end of the innovation process (Helms, Vattam, & Goe, 2010; Helms, Vattam, Goel, & Yen, 2011; Helms et al., 2009; S. Vattam et al., 2008; S. Vattam, Wiltgen, Helms, Goel, & Yen, 2010; S. S. Vattam, Helms, & Goel, 2010). However, with a few notable exceptions (i.e., Kennedy & Marting, 2016; Pauw, Karana, & Kandachar, 2012; Tempelman et al., 2015) most of these studies are related to analogical and metaphorical transfer of biological principles to engineering applications and conducted in classroom settings with university students. In these studies, students are not subjected to the same levels of infrastructural and financial constraint that are found within existing organisations and consequently, the applicability of these studies in multinational innovation settings is questionable and will not be included in this analysis.

People are not passive recipients of innovations. Rather (and to a greater or lesser extent in different persons), they seek innovations, experiment with them, evaluate them, find (or fail to find) meaning in them, develop feelings (positive or negative) about them, challenge them, worry about them, complain about them, “work around” them, gain experience with them, modify them to fit particular tasks, and try to improve or redesign them – often through dialogue with other users. (p.598)

Similarly, as explained by Carrillo-Hermosilla, del Río, & Könnölä, “innovation arises through a systemic process that refers to the interconnectedness and dynamic interaction between different actors and internal and external factors influencing the innovation process” (2010, p.1075). Similarly, Rogers (2003) summarises three basic categories of factors that influence the innovation process: 1) Characteristics of the innovation context; 2) Characteristics of the decision-making unit; and 3) Characteristics of the innovation. Furthering the framework created by Rogers’s (2003) broad categorisation, an analysis of the innovation adoption and SOI literatures revealed the following factors that might influence the adoption of NII, summarised in Table 3.

Table 3: Factors Influencing the Adoption of NII

Characteristics of the Innovation Context	Norms of the Social System External Knowledge Sourcing Informal Social Network Collaboration Leadership
Characteristics of the Decision-Making Unit	Attitudes Towards Innovativeness Formality of Organisational Structures Professional Training Selective Perception and Exposure
Characteristics of the Innovation	Perceived Relative Advantage Observability Complexity Triability Compatibility

Characteristics Of The Innovation Context

The characteristics of the innovation context are divided into four categories that are relevant to NII: 1) The norms of the social system; 2) External knowledge sourcing; 3) Informal social collaboration; and 4) Supportive leadership.

Norms of the Social System

Generally speaking, norms refer to the established behaviors, spoken or unspoken, that are expected and considered acceptable by members of a social system (Rogers, 2003). In the case of SOI, the social norms of an organisation are strongly influenced by its existing sustainability norms and environmental objectives (Linnenluecke, Russell, & Griffi, 2009). SOI requires integrated thinking that includes social, environmental, and economic dimensions of sustainability (Adams et al., 2016) and for companies that frequently engage in SOI, these types of innovations are intrinsically, ethically, and economically motivated (Blattel-Mink, 1998). SOI is due to “a systematic process of 'internalisation' of external effects combined with an ecological conscience as a cultural specific of ... companies” (Blattel-Mink, 1998 p.50). Along these lines, Jakobsen and Clausen (2015) propose that companies enter into *environmental innovation mode* based on environmental objectives at the company level that influence product and process innovations.

Additionally, “a high level of sustainable innovation orientation over a period of time can be expected to result in a firm accumulating resources and capabilities that are crucial to developing and implementing superior sustainable process innovations and product innovations” (Varadarajan, 2015, p.18). Firms with an environmental strategy are known to demonstrate capabilities such as higher-order learning, continuous innovation, and experimentation behaviors related to SOI (Sharma & Vredenburg, 1998). Furthermore, an organisation’s social consciousness is positively associated with organisational innovativeness (Dibrell, Craig, Kim, & Johnson, 2014). In short, “Ecological innovations are part of a continuing improvement and learning process of a company” (Blattel-Mink, 1998, p.50).

As described above, the terms related to SOI such as environmental, sustainable, ecological, etc. are used with varied intention, connotation, and normative assumptions. Additionally, there is considerable overlap amongst these terms. Although a thorough review of these terms was conducted as part of the overall literature search, a comparison of terms added little value to literature review and has therefore been omitted.

External Knowledge Sourcing

External knowledge sourcing, the use of knowledge gained from outside sources for innovation, is an important factor for determining innovation capacity and is accentuated in the pursuit of SOI (Horbach, Rammer, & Rennings, 2012; Jakobsen & Clausen, 2016). Organisations frequently utilise skills to implement SOI that extend beyond the core competencies of the firm, requiring that they search for completely new knowledge and solutions (Horbach et al., 2012) and heuristics that favour radical sustainability solutions as necessary for radical SOI (Kennedy, Whiteman, & Van den Ende, 2013). Cooperative inter-organisational relationships with partners outside of their supply chain such as knowledge intensive business services (KIBS), universities, research institutions, and competitors are critical to developing competencies beyond the existing organisational capability and to the success of SOI (Cainelli, De Marchi, & Grandinetti, 2015; De Marchi, 2012; De Marchi & Grandinetti, 2013). Similarly, companies that engage in open innovation are more likely to be successful with radical SOI (Kennedy et al., 2013).

Recent research specifically regarding NII found that the inclusion of a biomimicry specialist in the front-end of innovation processes had a positive effect on the new product development process, considerably expanding the possible innovation outcomes, improving the quality of novel concepts, and accelerating the front-end development process (Kennedy & Marting, 2016). Similarly, Tempelman et al (2015) found that design teams that received specialist support for NII were more effective at its implementation in the product design process than those who did not have this type of support. Several firms using NII attempted to integrate specialist expertise such as a biologist or chemist in the design process and gained valuable knowledge from this engagement. However, the information generated was not easy to assimilate into the design process, and further in-depth or application-based knowledge needed to be generated by the companies or within their value chains (Tempelman et al., 2015).

Informal Social Collaboration

It has been well established that organisational practices are strongly influenced by informal social collaborations and communities of practice that span organisational boundaries (Brown & Duguid, 1991). “Informal social networks can generally be

defined as a set of relationships or linkages among individuals, each of which has a varying degree of significance to the wider network. Each individual is linked to a set of other individuals, and a number of individuals within one set may be linked to networks of people in other sets, and so on. In this sense, the breadth of a network can be quite expansive” (Government of Canada, 2013). Furthermore, in an innovation context, “an organisation is more likely to adopt an innovation if those people who have significant social ties both inside and outside the organisation are able and willing to link the organisation to the outside world in relation to this particular innovation” (Greenhalgh, Robert, MacFarlane, Bate, and Kyriakidou 2004). In some previously studied cases, collaboration was an important component of NII, happening earlier, more intentionally, and with greater intensity than in standard design projects (Tempelman et al., 2015). Informal social networks are highly influential on adoption processes by facilitating the spread of information about an innovation (Frambach & Schillewaert, 2002).

Leadership

Leadership in a corporate context generally refers to a hierarchical structure of authority, responsibility, and accountability within the organisation. It is usually categorised as senior or executive leadership, middle managers, and other similar titles. Leadership research suggests that transformational leadership that emphasises motivational practices based on visionary, long-term corporate strategies are more likely to facilitate organisational innovation (Jung, Chow, & Wu, 2003). Also, those companies and leaders that embrace sustainability, value intangible benefits, and integrate sustainability throughout company without siloing tend to be more successful with innovation practices (Cole, 2012; Haanaes et al., 2011). These two factors are part of a categorisation scheme that Haanes, et al (2011) use to separate the “Cautious Adopters” from the “Sustainability Embracers.” At a minimum, top management must be supportive of SOI initiatives, and middle managers can encourage SOI with informal integration of environmental considerations via clear directional statements. In short, top-down support of SOI enables bottom-up SOI activities to emerge (Eccles, Perkins, & Serafeim, 2012; Wagner & Llerena, 2011). Existing NII research is consistent with these findings. This is demonstrated by NII processes, for when they:

...were not supported by senior management [they] had less design freedom and suffered more difficulties than the cases that did receive support. Individual vision and persistence could drive [nature-inspired design] even in the absence of top-down support, and innovative results were still obtained, but the designers experienced frustration with both the complexity of [nature-inspired design] and the lack of support from their company. In contrast, cases in which [nature-inspired design] matched with the company vision or ambition showed how design processes were adapted to integrate [nature-inspired design], and how even ambitious design goals could be met (Tempelman et al., 2015, p.340).

This finding related to NII is in support of a broader finding in which lack of an environmentally-oriented culture in management and a managerial focus on competitive strategies rather than environmental considerations have been found to be barriers to SOI (Biondi, Iraldo, Filippetti, & Meredith, 2002). Specifically, “insularity of high powered individuals within the firm who have been invested in building the firm to current conditions resist transformation” and inhibit organisational change (Francis, Bessant, & Hobday, 2003). Further research is needed to understand management practices which can support NII in corporate settings (Tempelman et al., 2015).

Characteristics of the Decision-Making Unit

Scholars have proposed a wide array of possible characteristics of the decision-making unit, many of which overlap considerably with those factors described in the Innovation Context above (most notably the Norms of the Social System). In addition to the aforementioned characteristics, several other characteristics of the decision-making unit influence adoption, including attitudes towards innovativeness, formality of organisational structures, professional training, and selective perception and exposure.

Attitudes Towards Innovativeness

Existing attitudes towards innovativeness within the organisation also have significant influence in the innovation decision-making process. For example, the degree to which an organisation is receptive to new products or ideas will influence its propensity to adopt new products” (Frambach & Schillewaert, 2002 p.165). Similarly, “an organisation that is systematically able to identify, capture, interpret, share, reframe, and recodify new knowledge; to link it with its own existing

knowledge base; and to put it to appropriate use will be better able to assimilate innovations” (Greenhalgh, Robert, MacFarlane, Bate, and Kyriakidou 2004). Conversely, “an organisational culture that impedes creativity through internal political problems, harsh criticism of new ideas, destructive internal competition, an avoidance of risk, and an overemphasis on the status quo” was found to inhibit organisational creativity (Kimberly & Evanisko, 1981). Additional barriers to organisational transformation include episodic innovation that lacks continuity of efforts and emphasising steady state or incremental innovation that does not enable transformational change (Francis et al., 2003).

Formality of Organisational Structures

Organisational structures, defined as the network of relationships, rules, and procedures amongst various positions and position holders within an organisation, vary significantly depending on organisational size, managerial styles, types of work performed, and other factors. One common belief amongst innovation researchers is that “decentralised and informal organisational structures facilitate innovativeness. The flexibility and openness of these types of organisations, is believed to enhance innovativeness by encouraging new ideas. Conversely, the concentration of power in centralised organisations is considered to be a major impediment to the adoption of innovations” (Subramanian & Nilakanta, 1996, p.634). In addition, flexibility in resource use and allocation is also believed to encourage experimentation with new innovations (Subramanian & Nilakanta, 1996). Although larger firms are better able to adopt and implement innovations because of their more abundant resources, the more formalised and centralised structures common in large organisations limit their ability to initiate innovation adoption (Damanpour, 1992; Hojnik & Ruzzier, 2016; Kim, 1980; Zaltman, Duncan, & Holbek, 1973). The opposite is true of organisations which are smaller, highly complex, or highly specialised (Damanpour, 1992).

Professional Training

Broadly speaking, professional training in specific subject areas has a positive effect on organisational innovation (Hage, 2016; Kim, 1980; Kimberly & Evanisko, 1981). Adams et al. (2015) propose that SOI is uniquely complex, demanding special attention to learning and knowledge management. As such, organisational learning related to ecological systems and environmental problems is necessary for SOI at the organisational level (Purser, Park, & Montuori, 1995). Training specifically to

support environmental innovations (Cainelli et al., 2015) and especially cross-functional integration of expertise (Genç & Di Benedetto, 2015) has a positive impact on innovation outcomes. Tempelman et al. (2015) found that designers who received NII training “seem to have captured the potential of [nature-inspired design] better” (p.338), and this finding is in support of several studies that suggest the application of NII requires that innovators develop new knowledge and expertise (Bakker, Wever, Teoh, & De Clercq, 2010; Helms, Vattam, & Goel, 2009; Rossi, Charon, Wing, & Ewell, 2006).

Selective Exposure and Perception

Following on from social norms and professional training, an innovation is more likely to be adopted if it is compatible with the values and past experiences of the adopter (Adams & Bessant, 2008). *Selective exposure* to innovations is common, in which “individuals tend to expose themselves to ideas that are in accordance with their interests, needs, and existing attitudes” (p.171). Whether consciously or unconsciously, individuals tend to avoid messages that conflict with their existing beliefs and predispositions (Rogers, 2003). Additionally, in light of the likelihood of *selective perception* – “the tendency to interpret communication messages in terms of the individual’s existing attitudes and beliefs” (Rogers, 2003 p.171) – NII users are likely to perceive NII through their pre-existing filters related to sustainability, innovation, and CSR as described above in the context of Social Norms. Additionally, adopters are likely to be influenced by their exposure to and previous experiences with similar innovations (Rogers, 2003).

Characteristics of the Innovation

Throughout the process of adoption, individuals gather information to reduce uncertainty about the innovations expected benefits and consequences. Individuals form opinions rooted in their existing mental frameworks that are based on several factors including the opinions of peers, experience with the innovation, and previous experiences with similar innovations. Moreover, during the adoption process, any new information obtained is likely to justify, affirm, or modify an individuals existing perceptions of an innovation (Seligman, 2006). The adopter interacts frequently with the innovation and may “reinvent” the innovation to suit the environment and application where it is being adopted (Rogers, 2003; Seligman, 2006). Given the breadth of possible applications of NII and this possibility of reinvention, the analysis

of each case is divided into the types of innovations described in the previous section – Technological, Organisational, and Systems Building. The characteristics of NII are then categorised by Rogers's (2003) five characteristics of an innovation that influence its adoption: Perceived relative advantage, Observability, Complexity, Trialability, and Compatibility.

Perceived relative advantage

“Perceived relative advantage is the degree to which an innovation is perceived as better than an idea that supersedes it” (Rogers 2003, p.15). Perceptions of relative advantage related to NII vary greatly across contexts and tools used. “When discussing the added value of [nature-inspired design], a larger percentage of the companies working with biomimicry reported ‘insights from nature’ and the ‘communicative value’ of [nature-inspired design], whereas companies working with cradle-to-cradle more frequently referred to the ‘strategic direction’ and ‘cooperation with suppliers’ as added values of [nature-inspired design]” (Tempelman et al., 2015, p.341). Although the sample size was very small, this research suggests that innovators in larger companies value NII for expansive innovation and ideation compared to smaller firms and further research on this subject is needed (Tempelman et al., 2015). One interviewee who had used a NII process suggested that there was “much more to [nature-inspired design] than they got out of it so far” (Tempelman et al., 2015, p.340).

Observability

“Observability is the degree to which the results of an innovation are visible to others. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt” (Rogers 2003, p.16). Although data regarding this factor related to NII and SOI is sparse, Tempelman et al. (2015) found that “Cradle-to-cradle offers a concise number of ‘system-level’ design principles, and more clearly emphasises the ambitious goals for changing the product-system, whereas biomimicry provides knowledge and inspiration for addressing product shape and function as well as more detailed ecosystem principles” (p.341). An additional suggested factor that improves the adoptability of some SOIs (e.g., product-service systems) is a clear project vision that can align expectations and demonstrate strategic direction for the development of the innovation (Ceschin, 2013). Knowledge that is ambiguous, lacks specificity, and is considered complex is more difficult to transfer from one

organisation to another (Simonin, 1997). In Tempelman's (2015) study of NII, a best practice of designers in a NII project included the establishment of ambitious and straightforward goals for new product development using biomimicry and cradle-to-cradle as design approaches.

Complexity

"Complexity is the degree to which an innovation is perceived as difficult to understand and use" (Rogers 2003, p.16). Perceived complexity has also been described as higher for SOI than for traditional innovation efforts. "Using concepts developed by innovation management scholars when assessing the complexity of an innovation, it is possible to assert that [environmental innovations] are, on average, characterised by higher levels of novelty, uncertainty, and variety with respect to the traditional technological or market domain the firm usually competes within" (Cainelli et al., 2015 p.212). In the case of NII, some research suggests that even those innovators who receive training and/or support from a subject specialist would benefit from additional tools to guide the integration of NII throughout the design process (Tempelman et al., 2015), which in turn suggests exceptional levels of complexity.

Trialability

"Trialability is the degree to which an innovation may be experimented with on a limited basis" (Rogers 2003, p.16). For many organisations, this requires a balance of short- and long-term investments in SOI and the demonstrable return on these investments; unclear short-term returns on innovation investment is an established barrier to SOI (Biondi et al., 2002). "Innovation planning periods are limited by business planning periods which are very short compared to the long-term outlook required for socio-technical transformations to occur. Therefore, it is hard to judge the potential of [SOIs] to push innovation towards the system level" (Gaziulusoy, 2015 p.11). Some research suggests that organisations resist adoption due to economic constraints (Adams & Bessant, 2008), despite evidence that investment in R&D is one of the most important factors to build technological capabilities (Horbach et al., 2012; Jakobsen & Clausen, 2016). For SOIs to be effective in the long term, societal visions of sustainability must be linked with short-term strategies and this is not currently widely practiced in technological approaches to SOI.

Compatibility

Compatibility is “the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. An idea that is incompatible with the values and norms of a social system will not be adopted as rapidly as an innovation that is compatible. The adoption of an incompatible innovation often requires the prior adoption of a new value system, which is a relatively slow process” (Rogers 2003, p.15). The interplay between these two factors – the innovation and the value system/social norms – is a recurring theme throughout this review of the literature and permeates throughout the Results and Discussion Chapters.

Additionally, the creation of strategic sustainability goals and objectives is influential in the innovation processes of SOI in technological categories (Eccles et al., 2012; Hallstedt, Thompson, & Lindahl, 2013; Jakobsen & Clausen, 2016). In several organisations in the manufacturing sector, SOI resulted from innovation activities that were integrated with longer-term corporate focus on mega-trends such as energy or water supply. Deliberate and systematic inclusion of environmental criteria in the innovation process also improves SOI results. “The realisation of eco-innovation is often an activity originating at the micro-level that however requires simultaneous integration of environmental aspects with the overall corporate strategy” (Wagner & Llerena, 2011, p.748). Tempelman (2015) specifically notes that the incorporation of NII into strategic sustainability goals improved its adoptability. And finally, the influences of innovation itself can be transformative for the individual. “If the innovation is desirable, the individual may alter his identification of himself, other people, or objects in his environment in order to justify adoption” (Seligman, 2006, p.116).

In summary, very little is known about the factors that support and inhibit the adoption of NII specifically and SOI more broadly. This study addresses this gap in RQ2 by analysing the specific factors that influence the adoption of NII in the context of MNCs. Some of these factors are likely more broadly applicable to SOI, which is also under-theorised in the SOI literature.

Conclusion

Considering the attention given to NII in the popular media, the theoretical development within an innovation context is surprisingly underdeveloped. With the exception of two very recent studies (Kennedy & Marting, 2016; Tempelman et al., 2015), no other research has been conducted to address the innovation process of NII within MNCs. The majority of the research that does exist in management and innovation is hypothetical and forward-looking rather than analyses of existing case studies.

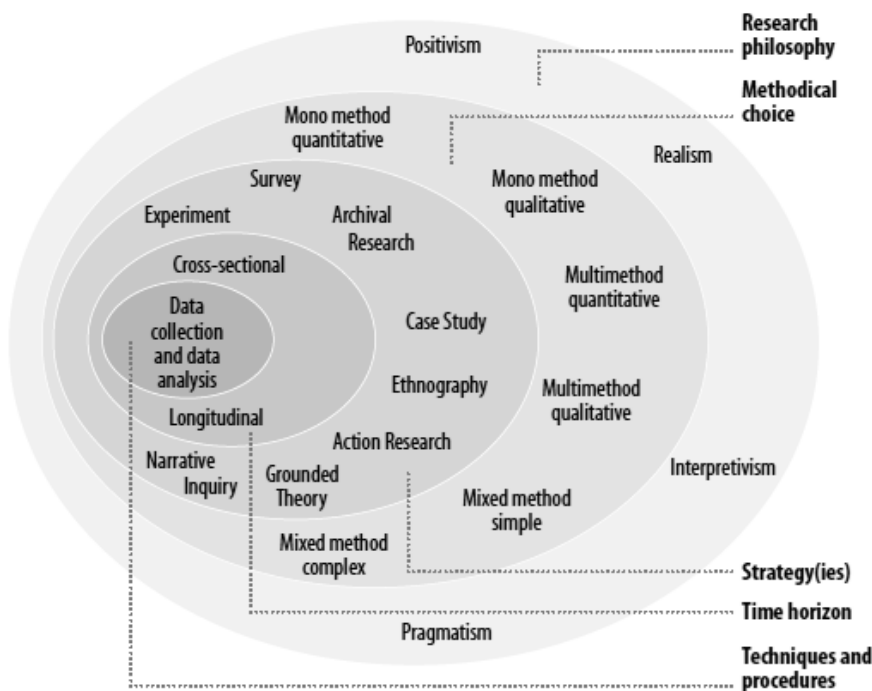
This chapter has addressed two main aspects of the SOI and innovation literatures that will be used to frame the NII experience in MNCs in each of the six cases. The first section created innovation categories to describe the types of NIIs that are implemented in MNCs. The second section addressed the factors that influence the adoption process within an organisation. The later Results Chapters will use this basis to frame the results of each of the six cases.

Chapter 3: Methods

Introduction

This chapter outlines the main methods used in this study. In alignment with the structure of the Research Onion (Figure 5), it contains five parts: 1) Research philosophy; 2) Methodological choice; 3) Research strategies; 4) Time horizon considerations; and 5) Data collection and analysis strategies (Saunders & Tosey, 2012). Each component is detailed in the following sections.

Figure 5: The Research Onion



(Saunders & Tosey, 2012)

Research Philosophy: Realist Epistemology and Transdisciplinarity

Sustainability Research and 'The Realist Turn'

While a complete discussion of the ontological and epistemological issues that plague NII as a method for SOI are well-beyond the scope of this study and are better suited for a thesis in science and technology studies, a brief glimpse into these subjects is necessary to justify the methodological choices of the research design. Given the researcher's interdisciplinary background in both the natural and social

sciences, the decisions related to epistemological and ontological approaches required careful consideration. This is in line with a growing body of theory that raises questions about the transdisciplinary circumstances of sustainability as a practical and empirical matter, and the necessary epistemological and methodological pluralism that is a foundational component of sustainability research (Blättel-Mink & Kastenholz, 2005; T. R. Miller et al., 2008; Schaltegger, Beckmann, & Hansen, 2013). As Alf Hornborg (2012), a Human Ecologist at the University of Lund, suggests,

Over the years, I have been struck by the paradox that the researchers who are most concerned about protecting the biosphere against anthropogenic damage (the biologists and ecologists) are the least equipped to analytically understand the origins of such damage, while those best equipped to do so (the social scientists) are the least concerned with an objective biophysical environment. [Natural scientists] are not equipped to understand the driving forces of environmental degradation e.g., in culture, politics, and economy. Conversely, social scientists trained to think in terms of 'social constructions of nature' are ill equipped to visualise a biophysical environment objectively endangered by human activity.

The following comparisons of epistemological approaches lays the foundation to justify a realist perspective that considers transdisciplinary research methods and the need for pluralistic approaches to research related to SOI.

Positivism

As is standard for training in the natural sciences, a core aspect of the researcher's undergraduate curriculum in biology was the process, rigor, and application of the hypothesis-driven scientific method to conduct research. According to a positivist approach, reality is an obvious and knowable phenomena that can be understood through observation and validated by measurement (Newton, Deetz, & Reed, 2011). This logical positivism is based on four key assumptions: 1) "methods of understanding reality are independent of culture"; 2) "reality is independent of methods of understanding"; 3) "reality can be understood in terms of universal laws"; and 4) "reality can be understood through one set of universal laws" (Norgaard, 1989, p.43-44). A positivist approach requires reproducibility as a key criterion, allowing for others to come to identical conclusions using an identical experimental model (T. R. Miller et al., 2008). Computer-generated and mathematical modeling of complex data sets can provide insights into natural phenomena that are not possible

to understand as isolated data points. As the technological sophistication of our tools increases, our ability to understand the biophysical world through a positivist lens also increases at an exponential rate (Marx, 2013).

However, other authors have pointed out that while a well-designed study includes controls to temper our tendency towards confirmation bias, neutrality in science is never an absolute (Klayman et al., 1987). One reason for this is because we are simultaneously guided by the matter that we are studying and the paradigm of science from which we view it (Kuhn, 1962). An unexamined positivist approach can produce a level of reductionism that simplifies the complexity of reality and isolates variables that are influenced by human agents (Bullock, Trombley, & Lawrie, 1999). This simplification can lead to decontextualised knowledge that lacks relevance to timely societal issues, particularly in the case of sustainability research that is frequently positioned in a setting of socioecological systems (Miller et al., 2008). In light of this issue of human agency, interpretivist and constructivist perspectives have become increasingly influential in sustainability research, particularly in management and innovation studies.

Constructivism

Through the lens of constructivism, human perceptions (mediated through language) create knowledge of the world, and our understanding is always a human and social construction. According to this view, the world is independent of human minds, but it cannot be understood without the use of individual and social constructions (Berger & Luckmann, 1966). Thus, the primary emphasis when studying society is a focus on how individuals construct society itself (Alvesson, 2009).

Constructivism to an extreme, however, creates a view in which "the natural world has a small or non-existent role in the construction of scientific knowledge" (Collins 1981, p.3). As explored below, such a separation of human systems from ecological systems creates epistemological divides across disciplines that exacerbate the irreconcilability of human impacts on socioecological systems (Carolan, 2005). As prominent American biologist E.O Wilson pointed out, "environmental ... science [was] still regarded widely, all the way up to the White House, as just another worldview" (Newton et al., 2011, p.11).

The positivist/constructivist divide produces a body of knowledge that, on the one hand, is constantly defining the intricacies and functionality of socioecological systems, and, on the other hand, another body of knowledge that characterises these perceptions of natural systems as social constructions that are open for interpretation. As the quote below suggests, the notion of human exceptionalism, which is accentuated by constructivism, has caused considerable misconception about the role of humans in biophysical systems (Dunlap, Liere, Mertig, & Jones, 2000; Foster, 2012; Heikkurinen, Rinkinen, Järvensivu, Wilén, & Ruuska, 2016). Furthermore, these distinctions are of consequence for advancement of discipline-specific research and positively reinforced by silos of disciplinary research agendas. As Heikkurinen, et al. (2016) explains,

The ontologies in organisation studies have recently been heavily influenced by the cultural, linguistic, post-structural, or postmodern approaches that build on an idea of socially constructed realities. For an ecocentric inquiry, this development can be considered problematic because, in the antirealist ontology, a world does not exist independent of human perception, and because the proponents of antirealism do not subscribe to any causal scientific independence of matters of fact in the world. To put it bluntly, if the causality of human action and ecological harm cannot be propounded with any degree of certainty, then protective measures (e.g., conservation efforts) are difficult to justify and legitimise (p.2).

Although these debates are related to sustainability research, a similar dialogue is on-going amongst management scholars, making this dialogue relevant to the study of SOI and NII specifically. Many management scholars have taken a position of realism, considering multiple layers of reality as an approach to scientific inquiry.

The 'Realist Turn'

The above summary is symbolic of the 'Realist Turn' in organisational and management studies that began shaping a new trajectory of inquiry in recent years (Mingers, 2000; Reed, 2005). Prior to this 'turn', organisational and management studies were subject to on-going epistemological debates with regard to whether it was best viewed as a science or a technology, and if it was a science, whether it was a natural, social, or critical science (Mingers, 2000). Several authors have since gone on to establish realist approaches to research, utilising a range of methods in organisational and management studies (Easton, 2010; Miller & Tsang, 2010;

Modell, 2009; Reed, 2005; Smith & Elger, 2012; Tsang, 1999). Saunders and Tosey (2012) describe realism as follows:

Like positivism, realism is a philosophical position associated with scientific enquiry. Realism states that reality exists independent of the mind and that what a researcher's senses show her or him is the truth, although the researcher is influenced by worldviews and their own experiences. Philosophers distinguish between two forms of realism: direct realism and critical realism. A researcher reflecting a direct realist position argues that what is experienced through our senses provides an accurate representation. In contrast, a researcher reflecting a critical realist position argues that what is initially experienced through the senses is subsequently processed subjectively by the mind. For the critical realist researcher this means that there is a need to find out both what is immediately experienced and the structures and relationships that lie beneath this; in other words to consider the underlying complexity. (p.58)

Critical realists view reality as mind-independent, with its own inherent order, and in this regard, organisations are also real in their boundaries, goals, purposes, resources, and members. The behaviour of the organisation and its various components is a result of the structured relationships amongst them (Tsang, 1999). Critical realists share with positivists a value of the objective world, its patterns, and related generalisations. However, similarly to constructivists, realism critiques positivism as being too shallow in its limitations to observable phenomena and suggests that the unobservable mechanisms that produce a phenomenon are undervalued. Critical realists do not differentiate between theory and observation and are not interested in discovering and naming universal laws. They are more interested in the theoretical and observable complexities that underlie social phenomena (Alvesson, 2009). Concurrently, critical realism is also aligned with social constructivism in that there is not simply one observable reality that can be described and measured. However, it departs from this view with the proposition that the material aspects shape the social aspects of the world (Newton et al., 2011). In this view, the role of science is to identify the relationships "between what we experience, what actually happens, and the underlying mechanisms that produce the events in the world" (Danemark, 2002, p.21).

The realist turn in management studies has been of considerable consequence for methodological trajectories in organisational and innovation research. As described above, numerous epistemological influences continue to affect this research that go

unacknowledged. Much of the business literature maintains an ambiguous position of human exceptionalism, particularly as it relates to corporate sustainability research. However, many business scholars have also called for the return of nature to the social sciences for several decades and theoretical advancements continue to develop the role of human agency that reflects engagement with ecological systems across disciplines (Marcus et al., 2010; Whiteman & Cooper, 2000). Heikkurinen et al. (2016) continue:

In ontological terms, an ecologically substantive understanding of 'being' in the Anthropocene epoch thus calls for a more realist approach in organisation studies. Considering an organisation merely as a socially constructed phenomenon might lead to overlooking the material basis of all human activity in the ecosystem. Any such exclusion of materiality and non-human objects from the analysis is not only scientifically limited, but also highly dangerous if it propounds a worldview where ecological destruction is not considered problematic beyond human interests...Moreover, denying reality independent of the human subject is disturbingly anthropocentric, which again is shown to be limited in its usefulness in solving the complex ecological problems that organisations now face. (p.3)

A more ecocentric view places human agents fixedly in the natural world and invites novel epistemological and methodological approaches to sustainability research. In management studies, notions such as ecological embeddedness and ecological sensemaking have advanced theory that promotes the apperceptive participation of human agents in socioecological systems, paving the way for novel methodological approaches (Whiteman & Cooper, 2000; Whiteman & Cooper, 2011). In short, "when people take their interpretations seriously and act on them, the material world may cohere in a different way than it did before" (Weick, 1995, p.108).

Considerations for NII as a Transdisciplinary Research Subject

While the arrival at an epistemological position required substantial research and careful consideration, a realist approach provided a foundation to consider multiple disciplinary methodological preferences and options. Epistemological pluralism, the application of multiple epistemological and methodological lenses to the same phenomena, has become necessary to manage the process of scientific inquiry in the study of socioecological systems (Miller et al., 2008). As a reflective multidisciplinary scholar (with undergraduate degrees in environmental science and environmental studies and now pending management studies) and former

practitioner of NII, I have found throughout the PhD process that viewing my research as a transdisciplinary approach (albeit acting alone for the purposes of this thesis) has been a helpful framework for positioning my experiences in relation to my interpretations of data collected. Lang et al. (2012) describe transdisciplinary research as “(a) focusing on societally relevant problems; (b) enabling mutual learning processes among researchers from different disciplines [...], as well as actors from outside academia; and (c) aiming at creating knowledge that is solution-oriented, socially robust, and transferable to both the scientific and societal practice” (p.27). I have attempted to be as transparent as possible about this approach whenever applicable throughout the process of designing the research, conducting interviews, and analysing data. A realist approach has also helped to define the layers of analysis necessary to explain the practical experiences brought to the research process, make sense of my relationship to the data, and furthermore, provide a framework to create separation from the data to provide an objective analysis. This is not a simple task in any methodological approach, and I intend to make this transparent as a methodological consideration by establishing a realist agenda

The Epistemological Slide of NII

Transdisciplinary methodological approaches to science are becoming increasingly common as a pluralistic means of addressing sustainability challenges in management studies (Lang et al., 2012; Schaltegger et al., 2013), and this is particularly the case as an epistemological approach to practicing and teaching NII (Martini, Loddo, & Coscia, 2013; Mcgregor, 2013). The very process of NII takes the user seamlessly across epistemological and ontological boundaries, without acknowledging that these boundaries exist whatsoever. The bio-inspired design process has been characterised as having three basic steps: Observation of biological phenomena (generally a positivist approach), translation of phenomena into a design principle (a constructivist approach), and creation of new innovation based on the design principle (realist consequence) (Goel et al., 2011; Jacobs, Nichol, & Helms, 2014; S. Vattam, Helms, Goel, Yen, & Weissburg, 2008).

Throughout each step of this *Epistemological Slide*, NII users are unknowingly and inconsistently applying epistemological interpretations to their design and research processes. A lack of recognition of this slide from one epistemological perspective to

the next has material consequence in socioecological systems. However, NII practitioners are largely unaware of this transition from objective observations that have resulted from reductionist methods to normative applications embodied in a novel technological application. Furthermore, each of these steps has methodologically unique characteristics from the other steps, requiring a transdisciplinary research design process. This is especially evident in the academic literature where NII research is scattered across several discipline-specific journals, which in turn makes a meaningful and cohesive research strategy in innovation studies an ambiguous and challenging endeavor.

Following from this inquiry of the various epistemological positions, a transdisciplinary realist research philosophy was used to establish a platform for the specific methods used to investigate each of the six case studies in further detail. A complete description and justification of the methods used are described in the following sections.

Methodological Choice: Multi-Method Qualitative

Research Logic

Blaikie (2007) categorises four different logics that guide choice of research methods: Deductive, Inductive, Retroductive, and Abductive (See Table 4 below). Since both abductive and retroductive approaches have been deemed appropriate within a realist epistemology (Clark, 2008; Easton, 2010; Miller & Tsang, 2010), one is left to choose which approach is best suited for the proposed research questions. Given that the research questions specifically address the NII users' experiences, users' perceptions of sustainability, descriptions of innovation results, and patterns of influential factors, an abductive approach was used to describe and understand the experiences of the organisation through everyday language and concepts, and systematic combining of various data sources was applied in the analysis phase (Dubois & Gadde, 2002). In line with a realist approach, the results themselves are not overly descriptive, but rather provide an explanation of the emergent patterns in the data with a recognition of the complexity and interactions amongst various factors (Clark, 2008). As suggested in Table 4, the research has investigated the use of lay concepts and translated them into technical accounts, which will result in theory development that can continue to be tested in future iterations.

Table 4: Four Research Logics and Associated Epistemologies

Process	Inductive	Deductive	Retroductive	Abductive
Aim:	To establish a universal generalisation to be used as pattern explanations	To test theories, to eliminate false ones and corroborate the survivor	To discover underlying mechanisms to explain observed regularities	To describe and understand social life in terms of social actors' motives and understanding
Start:	Accumulate observations or data	Identify a regularity to be explained	Document and model a regularity	Discover everyday lay concepts, meanings and motives
	Produce generalisations	Construct a theory and deduce hypotheses	Construct a hypothetical model of a mechanism	Produce a technical account from lay accounts
Finish:	Use these 'laws' as patterns to further explain observations	Test the hypotheses by matching them with data	Find the real mechanism by observation and/or experiment	Develop a theory and test it iteratively
Research Philosophy	Constructivist Interpretivist	Reductionist	Realist	Realist

(Adapted from Blaikie, 2007)

Methods

As suggested by Eisenhardt (1989), case study data included a multi-method qualitative design using semi-structured interviews, analysis of project documents from inside the project team, publicly available web-based materials (such as websites and brochures), and autobiographical and topical books written by interviewees and case study representatives. Internal and external documents provided by interviewees were not used as verbatim accounts of the cases, but rather were used to corroborate with the interview data as suggested by methodological recommendations (Yin, 2009). An iterative analysis method was used to further develop existing theory by comparing and contrasting emerging data and existing theory, per the methodological recommendations of Lewis (1998). This abductive approach, referred to as *systematic combining*, is defined as “a nonlinear, path-dependent process of combining efforts with the ultimate objective of matching theory and reality” (Dubois and Gadde, 2002, p.556). Systematic combining is therefore a dialogue between the research framework, data sources, and analysis

that results in a more comprehensive description of the data, emerging theory, and reality. This iterative approach to theory building is based on the several sources of corroborated data mentioned above (as suggested by Dubois & Gadde, 2002; Smith & Elger, 2012). It has also resulted in the development of an innovation typology (as reflected in RQ1) and the further development of existing SOI and innovation adoption theories (in response to RQ2).

Similar existing studies were identified as methodological models to analyse SOI. For instance, Wagner and Llerena (2011) studied eco-innovation across three sectors using a comparative case study methodology. They state,

The case studies mostly draw on interviews with several members responsible at senior management level for sustainability and/or innovation aspects in each organisation that were carried out based on qualitative interview guidelines. To triangulate and supplement the findings from these interviews, corporate reports and press releases, archival data and publicly available third-party information were additionally used in the analysis. (Wagner & Llerena, 2011, p.752)

In the latter phases of the thesis development, a similar study was published that addressed questions specifically related to NII in product case studies, reaffirming the validity of the research methodology for this research topic (i.e., Tempelman et al., 2015).

Research Strategies

Strategy For Approaching the Literature Review

Given the variety of disciplines that utilise NII, the literature review portion of the research was approached as three separate sections: NII, SOI, and Innovation Adoption Theory. This interdisciplinary review was done throughout the course of the research. Procedurally, .PDF files of relevant academic papers were saved on DropBox, backed up on an external hard drive, and organised on Mendeley reference management software.

Nature-Inspired Innovation

Despite the diversity of disciplines that generate NII research, emphasis was placed primarily on studies related to NII within the management literature. While there are various theoretical papers that apply biological models to organisational design, there are few empirical studies of NII as an innovation method within organisations.

This primary focus yielded rather limited results, and as such, the search was expanded to include publications within NII-specific journals, sustainability, design, and innovation publications, and publications in several other subject areas to due to the breadth of NII studies. Studies that were included in the literature review were those that discussed: 1) the processes of NII as a design tool; 2) the state of the art of the discipline; 3) NIIs connection with sustainability; and 4) NIIs use in the context of the firm. A few articles awaiting publication were sourced from professional contacts conducting current research in this field. The study most closely related to this thesis was published in 2015 after the completion of the data collection phase; findings were then analysed against this updated study, which is a more representative baseline than any previous research identified in the initial literature review (i.e., Tempelman, de Pauw, van der Grinten, Ernst-Jan, & Grevers, 2015).

The majority of exclusions were technical articles related to specific technologies and primary research being conducted on biological strategies that can inform technical translation. One research thread in the engineering literature that is closely related to the analysis of the NII innovation process was found in a series of studies analysing the student-user experience of a NII methodology for technical translation. While this research is peripherally related, the unit of analysis is not applicable, as it is limited to the experience of the individual in the context of a classroom at the front-end of the NII innovation process and only for technical applications.

Sustainability-Oriented Innovation

The identification of the overlap between NII and SOI perspectives was perhaps the most challenging aspect of the entire thesis process and required several iterations. The eventual question that emerged by combining the NII literature and the SOI literature was: What types of NIIs are attempted and achieved in MNCs? This question resulted in a review of innovation types described in the SOI literature and the creation of a framework to categorise the types of innovations in the cases.

Innovation Adoption Theory

Innovation adoption theory was selected as an analytical frame to explore the factors that influenced the adoption of NII in MNCs. This led to an initial broad review of the innovation literature including the well-developed area of diffusion of innovations. SOI criteria were used to supplement innovation theory, because while there is some

overlap between the two bodies, there are also some indications of conceptual departure that were necessarily incorporated. In these situations, the SOI literature was positioned as a sub-category of the innovation literature, and the two bodies of theory were blended in the review.

In summary, the literature review included three parts: 1) NII; 2) NII in the context of SOI; and 3) NII in the context of innovation adoption theory. Given the multidisciplinary nature of these subjects, the literature review reflects a diversity of disciplines that range from natural sciences to design to business.

Phenomenological Case Study Methods

Justification

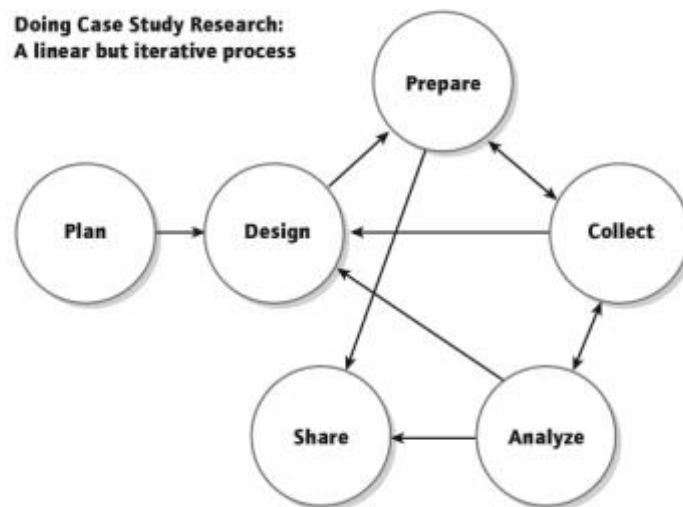
Since the application of NII in multinationals has gained popularity in just the last two decades, there are few accounts of this practice from the perspective of users and facilitators of the method beyond those accounts in popular media. Yin advocates the case study as an appropriate method for an empirical enquiry that “investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident,” and it also “copes with technically distinctive situations in which there will be many more variables of interest than data points, and [...] relies on multiple sources of evidence” (Yin, 2009, p.18). In addition, adequate sample size for quantitative survey analysis could not be achieved given the novelty of the subject. To date, most research contributions analysing NII for organisational innovation have been hypothetical and theoretical rather than empirical. This thesis aimed to address this gap by creating technical accounts of six cases of NII projects in multiple sectors.

The present research is intended to be primarily exploratory, asking questions such as “What is the experience of NII adopters? What are the results of NII projects? What factors influence these results?” Following a phenomenological approach (Groenewald, 2004), the experience of adopting NII is understood from the perspective of the participant. Each case reflects the NII adopters’ and innovators’ experiences within the context of their organisations, a scenario in which the boundary distinction between the individual and the organisation is not easily discernable. Interview data was collected and combined with privately and publicly

available documents to develop contextually relevant descriptions of each case. Following from a critical realist epistemological approach, this strategy resulted in an emphasis on “adequate conceptualisation, rigorous description, and convincing explanation” (Clark, 2008, p.2).

Yin (2009) proposes that case study design is iterative in nature, with each case providing further insight into the structure of the next case (Figure 6). As such, a pilot study with one case was used to test the study design before launching into interviews with the remaining cases. Following this pilot, interview questions and methods were critiqued and reviewed. This early iteration of the research design included propositions that were to be tested in the interviews; however, these propositions were based on suppositions from personal experience – not based on the literature – and were later abandoned.

Figure 6: Doing Case Study Research: A Linear But Iterative Process



(Yin, 2009)

A few common critiques of case study methodology are worth addressing. One common critique of case studies is a lack of data sets large enough to be generalisable. Yin (2009) cautions that generalisations across cases can be limited to surface level observations and therefore lack causal depth. However, other

research suggests that organisations can be understood more holistically when the patterns of a phenomena are identified and studied, as opposed to a singular phenomena that is distinct to an individual organisation (Fox-Wolfgramm, 1997; Tsang, 1999). So while these findings are not intended to create generalised theory, one aim of this study was to identify emergent patterns across the cases that could be suggestive of generalisable theory. Consequently, six cases were identified and a cross-case analysis was used as a means of limited replication. Yin (2009) advocates for analysis of at least two cases, as doing so is likely to be easier and the findings are likely to be more robust, with a greater number of cases further strengthening the findings. Clark (2008) notes that “careful selection of similar individuals with different outcomes can provide case-based comparisons that can illuminate factors in the real domain of prime importance. Sample sizes should be sufficiently large to allow meaningful comparisons to be made” (p.2). Since cases in this study had varied levels of effectiveness utilising NII, the intention of the research was to identify the variables that influence these outcomes.

A second critique is a bias toward verification of the researcher’s expectations (Flyvbjerg, 2006). As a critical realist researcher, the aim of this study was to avoid an imposition of researcher preconceptions or ideology on the data. The cross-case comparison was intended to reduce researcher bias and develop a data set that allowed for patterns to emerge across multiple cases.

Participants

When Les Back, an experienced qualitative researcher, was asked how many interviews are enough for a credible sample size, his response was “well...it depends!” (Baker & Edwards, 2012, p.12). In this thesis, the objective was to understand the circumstances and experiences of the individuals involved in the NII activities. As such, the most relevant interviewees were those who were directly involved in the process, either as internal innovators, project team members, supportive managers, or external consultants. Interviews were conducted with 3-8 individuals from each of the six organisations, depending on the availability of research subjects and their willingness to participate. Additionally, interviews were conducted with members of an outside consultancy that specialises in NII, and

though the inclusion of this data was minimal, they preferred not to comment on specific cases due to non-disclosure agreements with their clients.

Smith and Elgers (2012) offer words of caution when choosing interview participants, noting that an elevated position within the organisation may not necessarily lead to a more thorough understanding of the organisation. For instance, senior level managers may have a limited view on particular aspects of operations that mid- and entry-level managers may know more intimately. Also, some participants, such as top executives and consultants, are very experienced in presenting their views and activities to media outlets and consequently provide “polished but strongly edited accounts” of their experiences (p. 17). These tendencies were apparent amongst several interviewees, and contributions from multiple interviewees were therefore used to balance this effect.

The unit of analysis for each case was the innovation or sustainability team that utilised NII within the organisation. The first round of data collection and analysis included eight cases and interviews from 66 participants. However, after the first cross-case analysis, this number was reduced to six cases and only included interviews from 45 participants. This was because the types of organisations of the seventh and eighth cases were substantially different from the other six cases and could potentially cause an outlier effect in the data. The sampling strategy was a convenience sampling and then snowballing from interviewee recommendations. Interviewees and their organisations were anonymised in the thesis and in any publications made publicly available unless disclosure was otherwise agreed to in writing with the organisation.

MNCs were chosen as the type of company for the cases because of their disproportionate influence on sustainability issues within their supply chains and the unique challenges in large complex organisations engaging in SOI. Additionally, many of these companies are utilising NII as part of their brand and sustainability identity and make broad-reaching claims about their use of NII. These claims have received much praise and much criticism, but little critical analysis. The cross-case analysis aims to establish a more robust dialogue regarding these claims.

Birkinshaw et al. (2008) recommend that research on organisational innovation be done on contemporary cases to avoid retrospective sensemaking bias. Concurrently, however, the authors point out that it is sometimes difficult to recognise an organisational innovation until after the process has been successful, as they are often only recognisable in hindsight, creating a paradoxical situation for the researcher. The cases selected for this research included examples of both retrospective and current activities in an effort to balance the effects of retrospective sensemaking bias.

In the originally contracted agreement for the research project, a large information technology services firm was the intended research partner and action research would have been the preferred methodology. However, as the study progressed, the interested individuals involved in establishing the initial agreement moved on to other ventures, putting the general research strategy with that partner organisation into question and other options were explored. The final six cases were selected based on previous professional contacts and accessibility to interested and cooperative interviewees who had utilised NII as a method for SOI within the context of a multinational organisation.

Role of Researcher

As stated above, I was acutely aware of the potential influence of my personal experiences with NII in the interpretation of my case study data. The primary strategy for minimising this influence was by selecting a cross-case analysis method, which supplied multiple perspectives and facilitated the identification of emergent patterns in the data. I was aiming to limit the interjection of my personal perspectives in to the data set except when explicitly stated.

Given my past experiences, I was intimately familiar with a few of the cases and have attempted to be explicit and transparent about these affiliations whenever it was relevant to the case study. In light of my participation in one of the cases as an outside consultant and existing professional relations with several of the interviewees, there are additional issues of bias and influences on retrospective accounts that should be noted. On the one hand, individuals may have felt obligated to provide positive feedback on their experiences or may not have fully disclosed

their views because of our shared relationship to the NII project. On the other hand, interviewees may have felt more comfortable sharing difficult subjects in the interviews because of the existing trust in our professional relationship. It was a practical impossibility to measure how much these relationships have influenced the data collection process and all interview contributions were accepted at face value.

Research Ethics

All interviewees were offered informed consent forms that entitled them to guaranteed anonymity as part of the interview and publication process. Since some interviews were conducted virtually, not all respondents returned signed informed consent forms. Others replied via email that they accepted the terms of the informed consent in lieu of an actual signature.

Additionally, each company was given a generic pseudonym that represented their industry but does not reveal their identity. In the future, if the company would like for their case to be publicly known, we will reconsider this arrangement in favour of a mutually agreed upon publication strategy that reflects an appropriate level of transparency for the company. This would be arranged in writing.

Time Horizon: Cross-Sectional

The sampling method is cross-sectional in that it includes only six cases of the many MNCs that are using NII for SOI and reflects the status of those projects only at the time of interview. The timeframe for each case begins when the innovator takes interest in using NII and begins the process of “doing biomimicry”. For some companies, this “doing” of NII was only a singular attempted project and for others, it has spanned over many years, included multiple projects, and continues in future projects. For the purposes of the study, the NII project types will be described as they were during interview phase of the research, concluding in April 2015.

Techniques and Procedures

Data Collection

Semi-structured expert interviews were chosen as the preferred method of data collection for the primary research. The interviews were informed by a literature-derived analytical structure that guided questions, framed answers, and probed

directions for deeper research. The interviews were also additional sources of information that contributed to research design and participant selection in an iterative process (Smith & Elger, 2012).

Procedures

The intended approach for the research was to address each case systematically and in-depth during a one-month time span for each case, with all preliminary research on company profiles, interviews, data analysis, and compilation done within the same span. However, due to extenuating circumstances and scheduling availability, this was not possible and the data collection process was iterative for each case, with some snowballing to identify new interviewees as the interviews progressed.

Interview medium in order of preference was: 1) In-person; 2) Video conferencing (e.g., Skype); and 3) Telephone. Interviews were recorded with 2-3 recorders for the majority of interviews, with some variability depending on the interview venue (outdoors, via Skype, via telephone, etc.). The three recording devices were: 1) a Livescribe digital recorder with corresponding notes; 2) iPhone recording app; and 3) GarageBand software available on Apple computers. Interviews were guided by a series of questions, found in Appendix 1. Interview recordings were saved using an anonymised naming protocol and then transcribed by an external agency. Transcripts and interview recordings were simultaneously reviewed for accuracy throughout the analysis and corrections to the transcripts were made as necessary.

Additional documents used in systematic combining were collected in various ways. Some documents such as biographical books, promotional materials, and website content were publicly available and collected as part of the background research into each case. For some cases, interviewees made confidential project documents available and those were kept in hard copy and digital files for each case, where appropriate.

Case analysis was begun in NVivo qualitative data software. However, given technical issues with the timing of new software development for Apple computers, NVivo was ultimately too unreliable and unstable to be used for coding.

Instead, an analysis framework was generated from the literature and other themes that emerged in the data. This framework also went through several iterations as the data analysis progressed and the research questions were refined. The preliminary coding structure (see Appendix 2) included more than 100 initial codes that were derived from the existing literature related to SOI, CSR, sustainable development, and innovation adoption. Additionally, codes were created to capture existing literature and media related to specific cases. After a first round of application of codes to a pilot case, the number of codes were reduced and the literature review further defined. This process was done iteratively throughout the analysis until the final coding strategy was settled upon (see Appendix 3: Final Coding Strategy). This final coding strategy provides enough data to demonstrate cohesive case studies, but not excessive data and detail that might overwhelm the reader and distract from the research questions. Appendix 4 provides a sample of how this coding process was applied to Case 1.

Data Analysis and Theoretical Contributions

Of Yin's (2009) five techniques for case study analysis, this study utilises pattern matching, explanation building, and cross-case synthesis. Systematic combining of data sources at this phase was a key component (Dubois & Gadde, 2002). The results were divided into three chapters, one for individual case analysis (Chapter 4: Results by Case), a second for cross-case analysis (Chapter 5: Cross Case Analysis) and a third as a more in-depth analysis of findings comparing across cases in light of some existing research (Chapter 6: Detailed Analysis of Results).

Case Studies

Results for each case study were divided into three sections, reflecting an overall narrative and analysis of each case in light of the research questions. Those three sections are:

- 1) The experiences of organisations NII interpreted into an overall narrative of the case including contextual factors of the organisation.
- 2) Descriptions of the types of NII projects attempted and achieved.
- 3) Factors that influence the adoptability of NII as a method of SOI.

The accounts generated were not viewed as discreet narratives, but rather were contextualised with other sources of data, assessed for comparison and completeness, and used to develop theories that explain phenomena, as recommended by Smith & Elger (2012). This approach produces “thick descriptions” which aim to make behaviors of individuals more meaningful to the reader by describing them in a particular context (Geertz, 1973).

Interviews

Interview data was the primary data source for each of the cases, supplemented by the other documents described above because:

...Interviews provide one important basis for gaining access not only to the attitudes and emotions of informants but crucially to richly textured accounts of events, experiences, and underlying conditions or processes, which represent different facets of a complex and multi-layered social reality (Smith & Elger, 2012 p.14).

This complexity and richness, while dense, generated relevant data that could then be compared against the existing literature.

Smith and Elger (2012) describe “the interview as a process of human interaction [which] involves the mutual construction of meanings and the possibility of the joint construction of knowledge about experiences, events, and activities” (p.5-6). Accordingly, the interview as a research method is part of a larger construction of reality that consists of social relations, structures, and contexts that is layered and complex. In the process of the interview itself, a critical realist approach is one of an active interviewer. As such, the interviewer is actively engaged in creating and shaping the conversational interview to activate the interviewee’s ability to respond with their knowledge and experiences (Gubrium & Holstein, 1997). The interviews were conducted to build rapport, facilitate dialogue, and execute the interview agenda in a flexible manner responsive to the interviewee’s contributions. Interview questions were adapted to overcome initial resistance or vagueness, to clarify claims, and to address misleading responses per recommendations in the literature (Hammersley & Atkinson, 2007). Semi-structured interviews were preferred over more focused interview techniques because of the novelty of the subject area and the need for respondents to provide descriptive data that may be limited by overly structured sessions.

Epistemological Concerns In Interview Data Analysis

Conducting interviews with a realist perspective requires some unique epistemological considerations that may not be readily apparent and are worthy of discussion as a comparison with other epistemologies. Positivists, for instance, aim to limit the amount of variability in the interview process by tightly controlling the questioning sequence and remaining a neutral interviewer. Data is then analysed such that it demonstrates statistical significance and “law-like generalisations” are extracted (Smith & Elger, 2012 p.6). Conversely, constructivists view interview responses as subjective understandings of social relations and events that cannot be assessed against an objective reality independent of individual interpretations. Given the layered ontology of realism, it follows that interview data alone may not reveal the causes of actions and only present a partial picture of reality. However, the world as experienced by various actors is the only means by which to investigate a phenomena and as such, the interview is a valuable technique to gather these insights. In contrast to constructivist views, realism rejects the objective-subjective split and allows that individuals are shaping their social realities just as those realities are shaping them (Smith & Elger, 2012).

An additional benefit of a realist approach over a constructivist approach is incorporation and acceptance of complexity in the findings. Embracing complexity allows for a deeper understanding of the underlying mechanisms that shape organisational behaviors (Smith & Elger, 2012). Per Clark’s (2008) recommendations, deep and rich explanations of mechanisms are not necessarily overly descriptive, but demonstrate and explain patterns in the data. Throughout the Results by Case Chapter, the complexity of each case is readily apparent and later more detailed sensemaking is made apparent in the Cross-Case Analysis and Detailed Analysis Chapters.

Cross-Case Analysis

Early on in the research process, it was intended to use a method of comparative analysis described as the SAPPHO method (Curnow & Moring, 1968) in which innovation results are characterised as a ‘success’ or ‘failure’ based on specific criteria. Most often, the criteria that are used to justify success and failure of an innovation in the innovation literature are based on financial returns and economic

impacts. Given that the emphasis of this research is SOI, this singular economic measure of success does not accurately represent the multidimensional criteria of sustainability (social, environmental, and economic) and consequently, determinations of success and failure are less clear. As the early piloting of the interview questions came to a close, it became clear that there would be little value in simplifying the results of NII into a limited to a categorisation of *success versus failure*. The richness of the interviewees' narratives revealed a complexity of innovation results that forced a reevaluation of the model of innovation types and further definition of the subtleties of the results. As the analysis framework moved further from the dichotomy of pass/fail, the interview process became much more fluid and the data began to relate to the literature in new ways. The greater ability to describe a diversity of possible innovation types to research participants, the easier it became to engage in a meaningful dialogue regarding experiences with NII. From this point onward, a cross-case analysis was used as the primary tool of analysis instead of the SAPPHO method. The cross-case analysis method enabled comparisons with existing literature, pattern recognition, and theory generation both within and between cases.

Theory Development

There is significant debate about the methodological choices of research in management studies, including the role of theory building and theory testing, verifying and falsification, appropriate sample sizes, and types of data (Miller & Tsang, 2010). Per the advice of case study proponents and critics alike (e.g., Dubois & Gadde, 2002), Tsang (1999) suggests that researchers should be wary of results that are so descriptive and detailed that they ultimately say nothing about the findings of the research. Also, although replication does not lead to conclusive verification or falsification, it can be used to support or discredit theory (Tsang, 1999). The intended goal of this thesis was more theory building than theory testing, although some theory testing was also used when comparing with previous research. Should some spontaneous causal clarity have appeared in the course of the interviews, it was not rejected, however it is not the aim of the research to isolate and test causal relations. Instead, the research produced a set of descriptive, technical accounts of lay experiences that can be developed into theory that can be tested iteratively, as is described by Blaikie (2007). Furthermore, "The theory [was]

emergent in the sense that it is situated in and developed by recognising patterns of relationships among constructs within and across cases and their underlying logical arguments” (Eisenhardt 2007 p.25).

Reflections on the Research Process

Upon retrospection, a few methodological choices would likely have been different from the beginning of the project, given the opportunity to begin again. First, the conceptual framework that shaped the writing phase of the thesis was the product of several iterations of literature review and reflection. This caused considerable delay and confusion in the overall research process. While this is a common occurrence amongst early career scholars, a preferred path would have been to solidify a conceptual framework much earlier in the process that would have more clearly illuminated a series of questions to guide the interviews.

Second, while this is multi-method in the sense of using multiple sources of data, an additional data set has been excluded due to the disjunctive process of literature review and research design. In the early phases of the literature review, it was difficult to clearly define what sustainability meant in the context of this research. This was primarily due to the disconnection between existing definitions in the management and sustainability literatures and the alternate sustainability narratives proposed by proponents of NII. In an effort to better understand NII users perspectives on the connections between NII and sustainability, an exploratory online survey was distributed. Sixty-eight participants responded to an open call on social media channels that targeted NII users and a diversity of perspectives and approaches were offered. Some interviewees from the cases herein were responsive when approached with the survey, but not enough to create a reliable data set. While this data set was useful to substantiate the researcher’s hunches about the gaps in the literature related to this issue, it did not relate directly to the cases and required an additional literature review that did not clearly align with the trajectory of the thesis. Nevertheless, the literature review for this topic was completed and the data compiled into a paper published in a special issue of the journal *Bioinspired, Biomimetic and Nanobiomaterials* (see Mead & Jeanrenaud, 2017). In retrospect, this would have been a more valuable component of the research if it had been

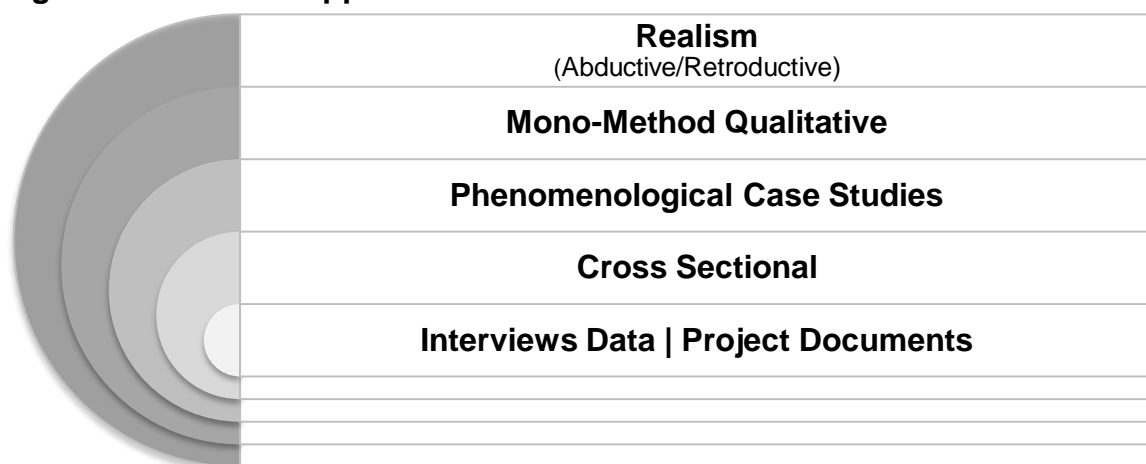
designed to specifically target interviewees and their responses were cross-referenced with the interview data.

A third retrospective consideration was related to the flow of the interview questions, the number of cases analysed in the study, and the initial ambiguity of the direction of the research. Given the opportunity to further this research, interview questions (Appendix 1) could have been better directed to evoke concise responses from participants, streamlining the research process, and enabling the inclusion of a greater number of cases. While six cases are generally considered sufficient for this type of qualitative research, the study may have benefited from a greater number of cases to validate findings and conclusions.

Conclusion

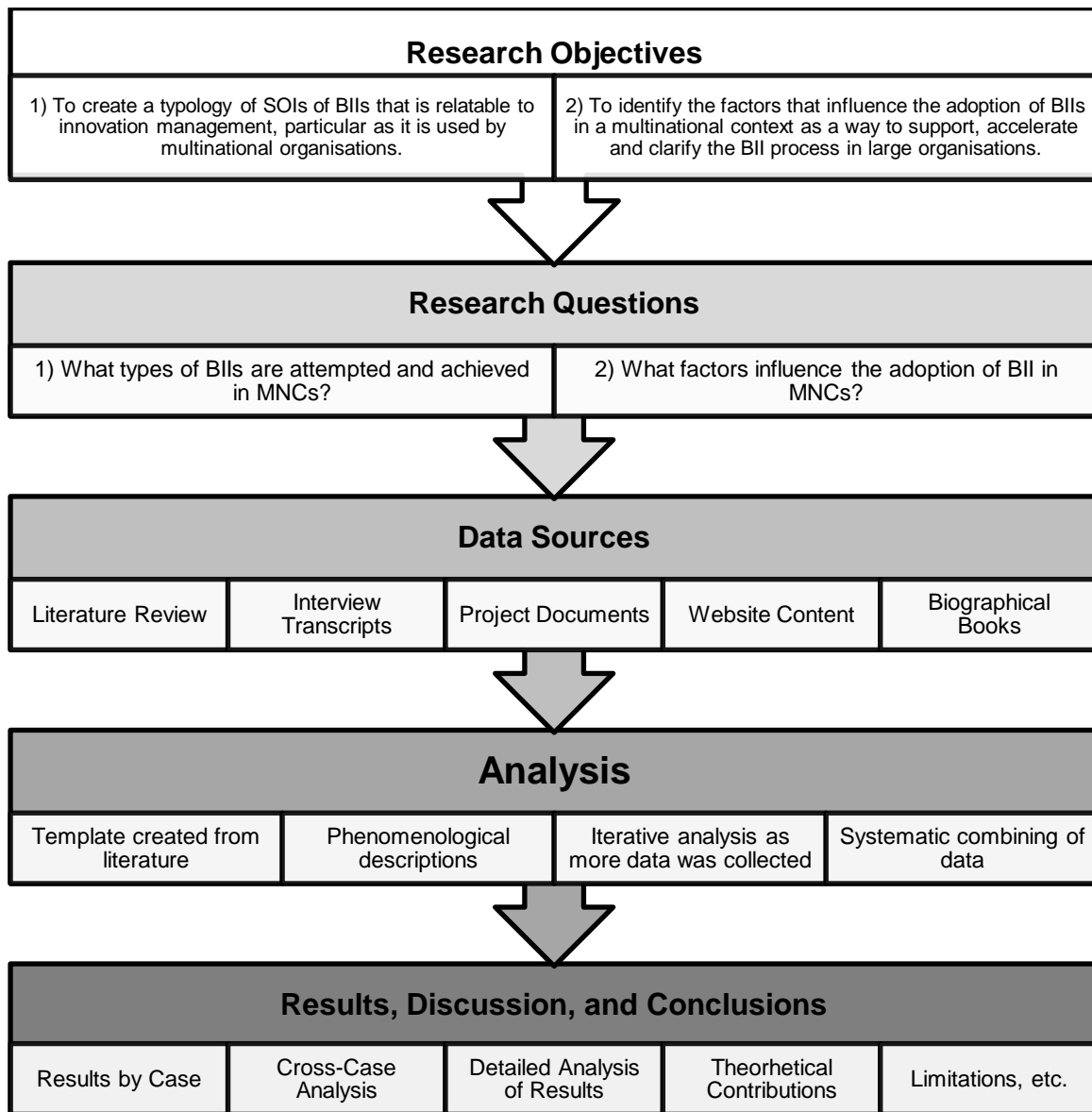
In summary, the research methods include the documentation of six case studies of NII in MNCs and a cross-case analysis of these cases. Several forms of data were collected for each case, enabling systematic combining that facilitated the theory-building phase. Figure 7, a modification of the Research Onion (Saunders & Tosey, 2012) summarises this methodological approach.

Figure 7: Research Approach Based on the Research Onion



A linear summary representation of the Research Process (versus the Research Approach in Figure 7), beginning with the Research Objectives and ending with Results, Discussion and Conclusion, can be found in Figure 8.

Figure 8: Summary of Research Process



Chapter 4: Results by Case

Introduction

This Results by Case chapter presents data from each case organised by individual case, while the following Cross-Case Analysis Chapter is organised cross-sectionally (first, in response to RQ1 by innovation types and second, in response to RQ2 by factors that influence adoption). The results in this Results by Case Chapter are presented in a thematic hierarchy generated from the literature review that spans the gap between the lay understanding of NII users' experiences and the guiding conceptual framework found in the literature. Each case is described in three parts: 1) An overview Case Description that sets a broader context of the organisation and introduces the NII activities; 2) Descriptions of innovation types in response to RQ1; and 3) Factors that influence the adoption of NII in response to RQ2. Within each question, data is divided into subheadings based on thematic analysis from the literature review. Data included represent the most relevant descriptions, quotations, and paraphrases to address the research questions and advance theorisation. The results of the six cases are then followed by a cross case analysis in Chapter 5. There were several commonalities amongst all cases, and for the sake of brevity, details of these commonalities were excluded within the individual cases but are summarised in Chapter 5. A general descriptive overview of all cases can be found in Table 5.

Table 5: Overview of Cases

Case No.	Case Name	Employees	Year Founded	Ownership	Annual Revenue
Case 1	Resources Inc.	90,000	1912	Public	>\$250bil
Case 2	ICT Inc.	90,000	1988	Public	\$13bil
Case 3	Electronics Inc.	115,000	1891	Public	\$25bil
Case 4	Cosmetics Inc.	17,000	1969	Public	\$4bil
Case 5	Clean Inc.	250	1979	Private	\$200mil
Case 6	Textiles Inc.	3000	1973	Public	\$932mil

Case 1: Resources Inc.

Case Description

This transnational company with more than 90,000 employees is well-established and highly profitable. It is ranked in the top five of Fortune 500 companies and claimed more than US\$250 billion in revenue in 2015. With a history dating back to the early 1900s, its primary business is resource extraction and processing of raw materials. The business unit under study, an open innovation team, is charged with identifying novel innovations in their sector from outside of the organisation that have demonstrated proof of concept, and they also act as an “angel investor” to develop the concept with the innovator. Additionally, they are interested in identifying emerging technologies and disruptive innovations relevant to their business so they “don’t get blindsided” by these types of advancements.

The NII activities included a few engagements with various staff members in North America and Europe. Accounts of current activity vary depending on the respondent, but at the time of interview, there was no apparent NII activity beyond the testing and possible adoption of a nature inspired technology that could be purchased “off the shelf.” The initial activities took place in 2009 and, according to interviewees, are mostly inactive today. However, the external NII consultant who worked with this company recently published further progress on their website, calling into question the thoroughness of the interviewees disclosures.

There were three interviewees from the team who participated in the NII activities.

The project team involved in the workshop was interdisciplinary, but primarily focused on research and engineering. The interviewees included the following:

Interviewee 1: Mechanical Engineering

Interviewee 2: Chemical Engineering, Biology

Interviewee 3: Psychology, Communication, Business, Biomimicry (post-employment)

Despite multiple, varied attempts to identify and interview other participants, no other interviewees came forward to discuss the NII effort.

RQ1: NIIs Attempted and Achieved

Technological Innovations

Technological Innovation 1(Attempted)

T1 Synopsis: Purchasing of an 'off the shelf' product that could be used in their supply chain to prevent scaling in pipes.

Innovators 1 and 2 contracted with a NII consultant team to engage in an internal innovation process based out of their offices in North America. The intended purpose of the engagement was to identify existing disruptive technologies that could be advanced more fully with the support of Resources Inc. These activities included a research process to identify the company's resource-based challenges as well as possible biological and technological strategies for addressing these challenges. This research was delivered via an on-site workshop organised around the resource-based challenge areas selected by the consultant team and the innovators. Workshop participants included interdisciplinary team members (chemists, biologists, engineers, and communications staff) who were chosen because their areas of expertise aligned with the workshop topics (i.e., CO₂ reduction, preventing corrosion, freshwater use, etc.) and because they were identified as having "innovative mindsets."

No novel, disruptive, existing technologies were identified that were developed enough to be pursued further by Resources Inc., as required as selection criteria in the adopting business unit. At the time of interview, one NII was still being pursued as an 'off the shelf' technology for the physical infrastructure of the company's supply chain. Based on the brief description, it is likely an anti-scaling technology that mimics the texture of sharkskin, but the specifics of the applications of NII were not described in detail and, to the contrary, were actively withheld. As one interviewee remarked "We've been exploring applications for [a Nature-inspired technology] in our industry, basically. That's probably all I can say about it." It was unclear if there was an environmental advantage to using this technology compared to the industry standard. Without a greater degree of specificity and due to a general unwillingness to discuss the NII project openly, it was difficult to extract much detail regarding this innovation.

Organisational Innovations (None)

Systems Building Innovations (Attempted)

SB1 Synopsis: “We look at waste streams, hoping to create something valuable from somebody else's waste stream.”

Interviewee 2 commented that they pursue some aspects of an industrial ecology model: “One of the things we do [...] is we look at waste streams and hope to create something valuable from somebody else's waste stream.” However, when approached for further details about this effort, the interviewee did not respond to several requests.

RQ2: Factors Influencing Adoption

Factors: Characteristics of the Innovation Context

1. Norms Of The Social System: Perceptions Of Sustainability

Although the corporate website has pages dedicated to CSR and sustainability, there was no specific messaging from the NII project team about sustainability norms that provided any clear articulation of their values and perceptions. Instead, the website offered a set of mixed descriptions without any commonly established norms.

Furthermore, there was hesitation in some interviewees' ability to articulate their own views on sustainability. Interviewee 1 explained, “It's kind of a disadvantage for the word [sustainability] because it's so broadly defined. It's hard to implement because it's such a broad word.” All three interviewees expressed personal perspectives on sustainability that they distinguished as separate from sustainability at the organisation. For instance, Interviewee 1 described her views on agricultural production and other subjects that were aligned with sustainability, but did not link it to her work directly.

There was significant hesitation when asked about connections between NII and sustainability amongst the one employee who was still employed at Resources Inc. According to Interviewee 1, a company-wide effort to reduce water use and CO₂ impacts is indicative of their sustainability strategy. She hesitantly explained, “[Resource Inc.]'s work is nearly all targeted to reduce footprints of CO₂, water ...Um

you know the, the kind of um I guess the, I ... so, I mean, to me it is, it's a lot of a sustainability, it's the kind of footprint we leave on the world."

To the contrary, Interviewee 2 (former employee) continued to apply some of the biological principles to other projects informally (e.g., to decision-making within the group outside of the designated NII activities): "I really liked biomimicry 'cause on the sustainability side, obviously nature is sustainable. It's sort of everything intertwined or interlinked, and what I particularly liked is that nature only takes what it needs."

All interviewees also described various "political" issues related to the NII project, suggesting that sustainability is considered to be a politically motivated topic. Interviewee 3 commented, "Some people felt that there was too much political agenda behind the story of [the consultants], ... I didn't feel that way, but I know others did." Interviewee 1 similarly stated: "[My colleague who participated in the NII workshop is a biologist] and his area of expertise is genetics. And there's an interesting tension between GMOs and biomimicry. And so I'm not sure he would support biomimicry."

2. External Knowledge Sourcing

Resources Inc. relied on a team of external NII specialist consultants (two biologists and one chemist) to deliver NII content and facilitate an innovation process, including a workshop and research project. There was no apparent consideration of including design expertise into the NII project, and the participants were predominantly engineers and research scientists. Interviewees expressed satisfaction with the overall delivery of the workshops and the quality of the content. However, interviewees commented that substantial engagement beyond the capacity of the consultant team would have been necessary to advance the NII concepts further. The in-progress adoption of the existing product could be viewed as an engagement with an external specialist related to NII, but they did not disclose enough information to come to this conclusion definitively.

3. Informal Social Network Collaboration

After the NII activities were mostly complete internally, and due to the economic downturn, Interviewee 3, based in Europe, was given the option to reapply for her job

in a substantial downsizing and instead opted to take a severance package. She has since gone on to complete intensive training in NII and become a NII consultant with other clients in Europe. She has also worked with her national government's sustainability unit to create a policy-based initiative to promote NII at the national level. These efforts, however, are outside of the organisation itself. Interviewee 3 formed close relationships with other NII experts, but this was after she resigned from Resources Inc. No other such relationships were apparent in the interviews.

4. Leadership

There was little engagement with leadership at any time in the NII activities. Interviewee 3 was disappointed that the senior leadership expressed their support for the project verbally, but did not demonstrate leadership in the workshop and innovation activities, commenting, "If this is something you really want to adopt as a team for a better future, why not participate fully?" The manager of the business unit was only present at the workshop during the introduction and concluding sessions and did not demonstrate commitment to the overall program.

Interviewee 1, the most senior of the three interviewees, described a different view on intangible benefits, though she was somewhat discrediting of NII as a process or tool: "I think it's important to appreciate [nature] and preserve it, but I always have felt in my life [that] engineering is biomimicry, really. That's what engineers do. They create structures and designs and things to either mimic or celebrate [...] really everything that engineers do is inspired by nature, even if they don't acknowledge it. I just think that the bridge needs to be stronger."

Although she was a team member located in a different country office from where the NII project was being led by more senior employees, Interviewee 3 felt she had more ownership over and enthusiasm for the project than the more senior staff leading it.

Factors: Characteristics of the Decision-Making Unit

1. Attitudes Towards Innovativeness

According to two of the three interviewees, most of the business is driven by incremental innovation, but the mandate of this particular unit was to identify and

develop emerging technologies in their sector. Despite this mandate, the technologies that they pursued (in partnership with external inventors) needed to be developed well enough to demonstrate proof of concept. This was also evident by other comments regarding their experiences with NII. In the NII project, they didn't view any of the concepts presented as developed well enough to pursue further.

Regarding NII, Interviewee 1 advised "just do it". He resigned from the organisation after his interview, during which he expressed frustration with the risk aversion of the business unit. Interviewee 3 further described how other workshop participants had difficulty with some of the NII workshop content: "I also remember, for some people I think it was hard to think that nature would have better strategies or ideas to live with. I think that sort of ego was also there."

All three interviewees expressed opinions about other members of staff being competitive, self-interested, and disengaged. For example, one interviewee described how she had progressed within the organisation: "I'm fairly expensive. [...] I didn't worry you with all the things I've done but I've had an amazingly interesting career at [Resources Inc.]". Interviewee 2 (resigned) claimed that the project did not advance because his colleague, who was managing the effort, "sat on" the ideas generated in the workshop. He thought his colleague had political motivations for stalling the project that included ensuring the advancement of her own career. He escalated his concerns about her resistance to his manager. However, he had little success and the project did not move forward. In further suggestions of the company's competitive culture, two interviewees claimed to have introduced the concept into Resources Inc., one in North America and one in Europe.

2. Formality of Organisational Structures

Although the NII project was attempted in an experimental innovation space, the procedures within this space were still formalised enough that participants could not see clear pathways to proceed with the project as it had been initially conceived, nor could they attempt to reconceive it. The unit itself seemed to have a procedural rigidity that limited the adoptability of NII due to the need for further conceptual development before it would be accepted into their innovation pipeline.

3. Professional Training

All team members interviewed had been trained in NII. Two staff members attended a one-week immersive training with an outside NII consultancy. The NII consultancy offered NII training in the innovation workshop, but Resources Inc. declined this component of the engagement. After engaging with NII in the workshop setting within Resources Inc., Interviewee 3 took a severance package and pursued a 1-year certification program.

4. Selective Exposure and Perception

Interviewees did not comment on other similar innovation approaches that they had used, but they did mention in passing that part of their sustainability plan was to use waste materials as raw materials for other applications (i.e., an industrial ecology approach). Indicators of selective perception were scant. Only Interviewee 3 described how it supported her personal views on sustainability: “I feel it can bring about additional paradigm shifts and how we, as a species, can better relate to all the others. But that’s probably more of a belief system [that] it can help people relate to nature a bit more and see how everything is [interconnected] ... you are dependent on [other organisms]”.

To the contrary, several comments were made that suggested selective perception was hindering the adoption of NII. Reiterating three comments from above, Interviewee 3 commented that: “Some people felt that there was too much political agenda behind the story of [the consultants], ... I didn’t feel that way, but I know others did.” Interviewee 1 described how conflicting beliefs limited some employees’ participation: “[My colleague who participated in the NII workshop is a biologist], and his area of expertise is genetics. And there’s an interesting tension between GMO and biomimicry. And so I’m not sure he would support biomimicry.” She also described how she viewed biomimicry as an extension of her existing engineering skill set: “I think it’s important to appreciate [nature] and preserve it but I always have felt in my life, engineering is biomimicry really [...].”

Factors: Characteristics of the Innovation

1. Perceived Relative Advantage

Given that the business unit was well funded, lack of a financial return on investment (ROI) was not a significant factor. Interviewee 2 described how they had a multi-million dollar budget to support innovators to take concepts and inventions to proof of concept, indicating money was not a limiting factor for this business unit. Although the economic downturn was very influential shortly after the NII activities by forcing considerable budget and employee cuts, the business unit did not seem to be excessively concerned about the expenditures on NII.

Other types of values were also described. For instance, all interviewees described NII as a valuable tool to be more innovative and to consider new possible solutions. Interviewee 3 said: "It can be a very [helpful] to come up with more innovative solutions." Interviewee 2 further elaborated: "So is [nature] innovative? It's probably just innovative by looking at what nature does but obviously it's something just very innovative, seeing that for billions and billions of years."

Although the interviewees did not cooperate with suppliers for novel materials to incorporate into their products, the NII process motivated them to purchase a new product from a NII supplier. No specific details were provided about implementation, however.

2. Observability

According to interviewees, Resources Inc. was under the impression upon entering the NII project that the technologies promoted by the NII consultancy were further developed than they actually had been. They were anticipating more of a catalogue of possible NIIs to choose from while the consultant team was offering more of an ideation session. The final content of the report included biological strategies and solution concepts that required substantial development to be viable. Interviewee 2 described some early misunderstanding about what the consultants could and could not offer. The company was seeking solutions that were well developed, but the consultants were not able to deliver well-developed solutions, nor were they able to broker relationships with individuals who were developing the new technologies. Consequently, there was difficulty identifying clear next steps to advance the NII

project, and more tangible results were therefore not within the scope of the engagement.

Concurrently, however, there was a broader understanding of the intended objectives of NII as an approach. Interviewee 3, who had trained extensively in NII since she left Resources Inc., expressed connectivity between humans and nature and NII as an approach to system-level design: “[The value of NII] is not only making the connections for humans to have with the natural world, but also from all the systems that are helpful”. However, this was not directly applied to work within the company.

3. Complexity

Given the skills and purpose of the business unit, there were difficulties in transferring the dense biological information presented by the NII consultants into tangible next steps. Interviewee 3 commented that the biological components of the NII process were difficult to interpret and implement.

4. Trialability

Trialability was likely a significant issue in this case due to the inability of Resources Inc. to develop the NII concepts internally. The early misunderstanding about goals and intentions of the NII project likely created trialability issues. Although no interviewees clearly articulated conflict between investments and innovation efforts, there was a significant downsizing that took place that likely influenced the implementation of projects such as this one. Due to the economic downturn, the company went through a downsizing process that resulted in a reduction in one business unit from 15,000 to 10,000 internationally, and all interviewees had to re-apply for their jobs. The business unit that utilised NII downsized from 112 to 12 employees globally, significantly reducing its scope and capacity.

5. Compatibility

No interviewees expressed familiarity with organisational sustainability goals, so presumably the NII project was not linked in any strategic way. There was no other indication that NII was linked to broader organisational goals in a clearly defined way.

Case 2: ICT Inc.

Case Description

The company is a large transnational information technology firm that specialises in custom ICT consulting solutions for varied customer types. They have approximately 90,000 employees globally with the majority of their business being conducted in Europe. The company has a relatively short history, being founded in the late 1980s and quickly growing in size in a series of mergers and acquisitions. In 2015, they claimed \$13 billion in revenue.

The NII activities, initiated by members of the sustainability and marketing teams, were intended to engage new and existing clients in the creation of new services and business solutions for sustainability and were funded primarily by a marketing budget. The NII activities began in the mid-2000s when the Innovator began to take clients to a local botanical garden to engage in a more creative environment and to help his clients to think in novel ways. From these initial activities, he attended a course on NII and contacted practitioners of NII in his home country. The NII projects followed from these activities. At the time of interview, the NII activities were mostly dormant.

Following the NII projects, the Innovator left the company and wrote a full-length book on NII. He has since taught workshops on the subject with varied audiences. He joined efforts with Interviewees 1 and 2 (both external consultants) to form a consultancy that is specifically aimed at helping organisations to use the principles of NII. Although this new organisation still exists, it has suffered from tensions amongst members and appears to be mostly inactive.

Interviewees were mostly cooperative and eager to share, with the exception of one interviewee who reluctantly contributed. Interviewees included current employees, former employees, and outside consultants who facilitated the NII activities. Although the NII team was interdisciplinary, it was dominated by business expertise and did not include expertise in biology. The project team included:

Interviewee 1: Entrepreneur, Social sciences

Interviewee 2: Engineer, Biomimicry

Interviewee 3: Business, Finance, Biomimicry

Interviewee 4: Marketing

Interviewee 5: Finance

Interviewee 6: Technical expertise

RQ1: NIIls Attempted and Achieved

Technological Innovations (None)

Organisational Innovations

Organisational Innovation 1 (Attempted)

O1 Synopsis: Broad application of nature's principles to a new service offering in partnership with prospective clients.

NII concepts were positioned as a component of a larger effort they branded “Firm of the Future”. The marketing concept promoted the “Firm of the Future” as exemplary of several characteristics of nature such as resilience, decentralisation, interdependence, multi-functionality, and self-organising. They used a myriad of terms related to natural systems to describe how a “Business Inspired by Nature” operates and relates to its “business ecosystem.” The marketing materials associated with this effort describe a transformation of the human-nature relationship in which businesses transition from “*taking from nature to learning from nature to being part of nature.*” They incorporated ideas related to business and nature into some aspects of their branding, produced white papers, and created a web presence that was still online at the time of the interviews, though the concept was largely discontinued when the Innovator resigned. At the time of the interviews, there had been no further client activities using this conceptual framework. Interviewee 6 described his disappointment: “There was no follow up with customers other than discussions and these kinds of things, but it didn't lead to concrete solutions or concrete business.”

Interviewee 2, an external consultant, described the overall project vision:

Our ultimate goal was to make organisations function in more sustainable way in the world, so not just what they made in terms of technologies but also how

they behaved. We wanted to focus on business as a big agent of change. The goal wasn't so much to change [ICT Inc.] as to work with them to help them serve their clients and [ICT Inc.]'s goal was to basically be more progressive.

The NII project that was attempted, but not achieved, was a visionary offering that aimed to reframe the way that ICT could influence sustainability in business and was presented to existing clients with an interest in sustainability. Part of the NII team saw this as a progressive approach to client engagement, but others viewed it as a marketing opportunity that did not provide clear business value. As part of this effort, they developed marketing materials related to NII as an approach to business that continue to remain on the website even though the thought leadership of this approach is no longer involved with the organisation.

Organisational Innovation 2 (Achieved)

O2 Synopsis: "Natural leadership" approach loosely related to a NII methodology and encouragement for employees to seek opportunities to interact outdoors.

Interviewee 4 developed a human resources program to encourage employees to go outside and in nature to "walk and talk". This management innovation was largely due to the motivation of Interviewee 4 who saw the value in NII and attempted to implement cultural changes to support this kind of thinking, despite the lack of progress with the visionary NII project that preceded it. She also used a blog to publicly develop concepts described as 'natural leadership' and utilised some of the ideas that were applied in O1 to articulate this approach.

While both of these innovations had metaphorical applications of NII, there was little discussion of connections with socioecological systems; rather, there was more focus on social and economic aspects of sustainability.

Systems Building Innovation (None)

RQ2: Factors Influencing Adoption

Factors: Characteristics of the Innovation Context

1. Norms Of The Social System: Perceptions Of Sustainability

The majority of interviewees described how sustainability was weak at ICT Inc., as sustainability initiatives were characterized by minimal spending, lack of understanding, and few dedicated resources. According to three of the six interviewees (who are no longer affiliated with the company), the company does not have a strong sustainability agenda. Interviewee 3 remarked that they were not trying to stay on par with their competition regarding their sustainability strategy (i.e., other ICT services firms), but rather they were being led by their clients to create sustainability solutions, and the company's sustainability spending was minimal compared to their closest competitors.

Interviewee 3 described how the NII activities took place in an era when sustainability in business was “essentially just measuring, monitoring, reporting... because without it, you can't go any further.” They were trying to “take it to the next level”. He continued, “A lot of the work in sustainability at that time was about cost reduction. So I put forward...going from cost reduction to compliance, from compliance to value enhancement to values...and I called that whole journey ‘Towards tomorrow's company.’ [...] We're talking about from 2007, 2008. Now at that time, [sustainability] was really always seen as a bolt-on, as a kind of a nice thing to do.” He went on to describe discontinuous sustainability norms internally: “They had different speakers talking about futuristic stuff. And Janine was a good example of that ... In coming along and saying, ‘This is what's happening in the future horizon and sustainability is one of them. And we need to think differently about these things.’ So on the one hand you had those sorts of stuff going on, those global initiatives. And on the other hand, at a local level, you had everybody focused just on P&L [Profit and Loss Statements]. And so therefore if sustainability doesn't have a P&L, what the f*** are we talking about it for?”

According to Interviewee 4, ICT Inc.'s sustainability efforts were documented in their annual reports, but she did not comment on specifics or on the general norms of sustainability at the company level. In regards to client demands, she said that it was difficult to engage with clients about sustainability because of the diversity of perspectives and definitions. Other interviewees supported this statement. Interviewee 6 emphasised, “In general, sustainability was not seen as a business opportunity.” Similarly, Interviewee 5 found that

In general, it's difficult for companies to understand how IT contributes to a sustainable world.... A few years ago, people were curious about sustainability and eager to learn about different ideas, but this changed at the economic downturn and now customers are more interested in what value sustainable solutions bring to them.

Instead, the sustainability directors found themselves needing to continually demonstrate the value of NII and seeking creative budgets to pursue SOI endeavors.

An outside consultant described how "we were and continue to be shocked by the level of ignorance around sustainability." Interviewee 6 joined the company as Global Director of Sustainability, but resigned when it became apparent to him that sustainability was not a significant aspect of the company strategy. He found NII to be incompatible with ICT Inc. because they lacked a culture of innovation and sustainability.

Interviewee 2 described why they pursued the NII project: "For us [the consultant team], [the NII project] was mostly about exposure, getting the idea out and getting exposure. And for [ICT Inc.], they wanted to look more progressive. I can remember one of the comments at the end of the day was 'Wow, I thought [the company] was a really conventional company but now I can see that you're progressive. You're progressive thinkers.' And that was one of the goals for [the company] and that was successful in that outcome."

2. External Knowledge Sourcing

Two external NII consultants facilitated the NII workshop with prospective clients. Of the two external consultants, only one of them had experience in NII before they attempted to use it with ICT Inc. Both external consultants described surprise at the lack of understanding of sustainability and how lowly it was prioritised. There was no design expertise on the team and it was not discussed in any interviews. No other outside consultants were utilised to implement the NII project. The NII project did not advance beyond the initial marketing activities enough to engage with any additional outside specialists.

3. Informal Social Network Collaboration

The innovator who initiated the NII activities had formed relationships with others in the NII field through training courses and consulting activities. After resigning from ICT Inc., he went on to engage with other NII professionals in his country in an effort to further promote NII and create a consulting career outside of the organisation.

4. Leadership

The external consultants and former employees described how the leadership was not interested in sustainability or NII unless it demonstrated clear financial returns. In reference to the NII workshop with clients, Interviewee 6 described: “There was very [little] recognition from the Board for sustainability in practice ... with real things. So they didn’t see this as a business opportunity. [...] It was more, in my opinion, seen as a customer relationship event than a strategic sustainability or sustainable solution development day.”

There seemed to be considerable siloing of sustainability because there was little comment regarding how sustainability was applied beyond a metric-driven approach to reporting. Furthermore, as stated above, three of the interviewees were members of the internal sustainability team and described a weak or non-existent sustainability culture. Interviewee 3 assessed his SOI marketing for ROIs and found that this work generated further contracts, thus enabling it to demonstrate the value of sustainability. However, his previous roles as a more general consultant generated multi-million Euro contracts compared with sustainability contracts in the €100,000 range, which were not considered to be substantially successful. He further described how he advanced the NII agenda internally: “It only worked because I probably had latitude within [ICT Inc.]. I was someone who had been there for a number of years and they trusted me.” He also described senior leadership as separate from other employees, although he would still approach them with new product development ideas related to sustainability. “I would just go up and mix in a room [with senior management]. They weren’t used to people doing that. They’re very funny in France, very elitist in a way.”

Perceptions of support from senior management varied amongst the interviewees, with some viewing them as very supportive and others viewing them as disconnected. Interviewee 1 explained, “There is no serious senior level commitment

[to sustainability]. Sustainability in the organisation, at a philosophical level, was just not there.” Interviewee 3, on the other hand, was more conflicted, describing how the senior leadership saw value in sustainability, but at the same time, he was forced to demonstrate the value of his activities in traditional profit and loss terms: “The CEO in the Netherlands at the time was aware of [the NII activities]. And he was up for it and he made sustainability – partly because of some of these initiatives – a priority for those organisations. He could see the value of sustainability for client relations beyond simply ‘we look good’ and it’s a brand issue, so that was the idea...but of course, there were these macro problems going on at the time...he was under pressure.” This pressure affected how Interviewee 3 perceived his own work as well.

Factors: Characteristics of the Decision-Making Unit

1. Attitudes Towards Innovativeness

The majority of interviewees described the innovation culture as ‘weak’ or ‘close to zero’. There was no mention of open innovation activities. Interviewee 4 specified that “They’re very technology driven, [...] but I wouldn’t say that they necessarily have a strong culture of innovation.” On the other hand, Interviewee 4 described how a company value of being ‘convivial’ or ‘playful’ contributed to the innovation culture, though other interviewees directly contradicted this assertion.

According to Interviewee 2, the NII project was unique:

I thought that [the internal supporter of the project] was really bold in taking this on and supporting it to the extent that she did. And I have to give [the innovator] a lot of credit for that...He was really willing to push and push and push. I think a lot of people wouldn’t have been in his role. I think he was kind of willing to lose it all too because he knew he wanted to quit at some point and do something really different. [...] He wasn’t willing to play the traditional corporate role anymore because he had done that for so many years and...So he was willing to push a lot and [internal supporter] was willing to take some risks [with him, using NII].

There was some indication that cultural issues were impeding creativity. As budgets became tight due to the economic downturn, individuals who were once supported to do expansive thinking on behalf of the company found the flexibility of their jobs reduced substantially, and they felt greater pressure to deliver billable hours.

According to Interviewee 3, “A lot of these people unfortunately went from being quite intelligent people who... had space to write papers and to really think and go

and have a conversations with clients and run workshops, to if they weren't chargeable, dump it."

There was a competitive culture related to client management that limited the ability of the innovator to further develop sustainability and NII offerings. Due to competition amongst staff for sales and commissions, existing account holders were reluctant to give co-workers access to their clients because of desired exclusivity in revenue-generating relationships. Sustainability-related services were a lower priority in these situations.

There was no mention of any previous or continuing NII activities. Interviewee 4 described: "I'm a little bit difficult on myself that we didn't do more within our organisation. But you know, it's still there in the background", suggesting that her thinking has continued on the subject despite a lack of innovation activities.

2. Formality of Organisational Structures

There were conflicting views regarding the formality of innovation activities, even within a single individual. Interviewee 3 described how a hurried series of mergers and acquisitions had created an environment where innovation was not managed by default. In his view, this gave him the flexibility to pursue projects without traditional innovation infrastructure. After he had demonstrated his value to the organisation within the confines of his position description, he was given the flexibility to work on other projects. He described how he 'created his own rain' by doing the minimum necessary assigned work to avoid being viewed as a problem. He could "earn [his] right to play, to be free...to make stuff happen." The culture of innovation "wasn't too bad, really" because of the rapidly changing business structures. Due to the frequent mergers and acquisitions, it was difficult to manage innovation. There was little comment on any innovation processes or departments within ICT Inc., suggesting that the NII activities were not related to any formal structures. Concurrently, however, Interviewee 3 also described a shift towards more rigid job obligations due to the pressures of the economic downturn. So while there were not formal innovation processes, there were other mechanisms in place that influenced the innovation culture.

3. Professional Training

Only the innovator and one external consultant had completed any training in NII. The innovator was “doing nature and business stuff” first, some time before he attended training in biomimicry. He viewed the training as an enhancement to his existing NII practices. He did not identify as a “biomimicry person” because he was not using the methodology for product design or applying anything he learned in the biomimicry course he attended. No one else inside the organisation had received any training on NII, nor did the team include design expertise or seek additional external consultants to implement NII.

4. Selective Exposure and Perception

No interviewees described any experiences with similar innovations, suggesting that SOI, in general, was not a common practice. It also suggests that the organisation is limited in the SOI tools and processes they have been exposed to, perhaps making it more difficult to implement NII.

There were several different perceptions of NII that varied greatly amongst participants, depending on their background and training. As Interviewee 3 described, “...[People thought we were talking about] trying to use nature and we had to be careful about it because [...] we need to keep saying, ‘Nature is a metaphor or nature is an inspiration.’ And people would get quite funny.” An external NII consultant described how she viewed NII, which was distinct from other interviewees: “Environmental sustainability would be an outcome of bringing nature’s principles, making nature’s principles their core [business] principles. And then the reverse is also true. If you don’t make nature’s principles your core principles, you just can’t achieve environmental sustainability”. In contrast is the perception of Interviewee 5: “I know the subject [NII], which I consider to be rather academic...” The disparity in these perceptions is likely due to the overall lack of alignment about perceptions of sustainability and the intended goals of the NII project.

Factors: Characteristics of the Innovation

1. Perceived Relative Advantage

Interviewees were not fully aligned about the creative potential of NII in practice, with some viewing it as a tool for sustainability and others valuing it as an approach for

“coming up with something new”. Interviewee 3 described how “[NII] unlocks a level of creativity. You actually go into nature and that brings another burst of creativity”.

Interviewee 1 demonstrated the value of NII as a tool to build relationships with existing clients: “Everybody who was there got very inspired by everything that happened there. [...] So from a real relationship point of view, it was a very good day.”

On the other hand, all internal company interviewees described how it did not produce any monetary returns with the clients who participated in the workshop, which is indicative of the high value placed on financial returns. That is to say, while they valued some intangible benefits, there were significant doubts. According to Interviewee 5: “[NII] led to a very nice workshop... with customers. It was nice to come. In my opinion nothing happened after that. [...] It doesn't add that much value. [...]. This doesn't help me to convince customers that they need IT solutions which are sustainability related.” Interviewee 6 described similar feelings: “I have no detailed recollection of the day although I can see it before me and I know there was a lot of positive energy. So I think it was very good that we did it, but my personal ambition for the day was higher. But it's difficult for people to be so innovative with this subject that is so questionable in the eyes of a lot of sceptics. So, yes, I'm glad we did it, and yes, I was also disappointed in the actual business that had come from it.”

2. Observability

For a few interviewees, there was very little emphasis on the biological principles at any scale, and instead, biological concepts were viewed as abstract metaphors to be used as marketing communication tools for sustainability offerings. Interviewee 6 stated: “The biological part wasn't, um, ... How should I say it? Our main focus. It was just a way to look at things...a way that inspired us. The examples that were given are very appealing, so it was merely a way to communicate about the topic of sustainability and corporate social responsibility than it was a concrete basis for a solution.”

A recurring theme was the inability of the NII activities to apply directly to every day operations and activities. Interviewee 4 said, “The concept of biomimicry and business inspired by nature, it’s a lot more engaging, visionary, best lead forward... really very disruptive. So it’s a lot more difficult than to explain to the business because it looks very far removed to the daily things they were working at.”

On the contrary, for other interviewees (both internal employees and external consultants), they viewed ecological principles as guiding principles for organisational sustainability in a socioecological context. Interviewee 3 stated, “Some of the stuff [the internal supporter] talks about is straight out of the [NII consultancy] play book, which I think is great that she obviously gets it. [...] She has made it her own.”

3. Complexity

Again, there were varied opinions on the intentions and complexity of the project. One interviewee reflected that the project goals were too broad and complex to be tangible in a business context. Interviewee 6 stated, “For me, it was more a way to communicate with clients [than it was] a clear vision on how this [NII program] would look like or how we could literally be inspired by nature [sic].”

Interviewee 4 reflected that they may have taken too broad of an approach early on: “We took it on too big because we wanted to look at the total business model.... maybe it was too big, too complex for them to actually get started.”

4. Trialability

As was suggested in several ways throughout the interviews, there were indications that NII was viewed as too large to implement. Interviewee 6 noted, “We wanted to inspire our customers with ideas of how to innovate their businesses from this [NII] perspective. [...] Nevertheless, the distance between the daily reality and this vision was very big and, for some people, unbridgeable.”

5. Compatibility

Broadly speaking, there was no mention of strategic sustainability goals in the organisation, but they were promoting the NII activities as a broad approach to

engage with clients in sustainability. Interviewee 2, an external consultant, articulated: “The idea was if you understood the principles of nature and then tie them to your business, your business will be more sustainable financially. The business itself will be able to last longer. You’re going to get more out of your people and they’ll be happier for it as well as being able to address the issues of conventional sustainability.” This presents a disconnection between what the company does and what it promotes as a part of its brand.

Interviewee 5 also discussed some issues when trying to develop business relationships with prospective clients using NII: “This is nice to discuss. This is nice to have material about that, but in the end this is not [a reason] for customers to do business with us. [...] If we could translate it somehow into IT, probably yes. But that’s not the case. [...] So the way I am treating sustainability as a whole is a non-academic approach, it’s a practical approach.”

On an individual level, NII was compatible for some interviewees, but not for others. The innovator described how NII had given him a new pathway for expressing and relating to sustainability as an individual, outside of the context of an organisation. He had always loved nature and the outdoors, but uncovered a deeper level of understanding through the NII project: “What I’d hoped for and what I continue to hope for ... is an innovation not just in terms of earning money or [being] more sustainable, but an innovation in terms of our whole relationship with ourselves, our own unconscious, our own self, each other, and life.” Since he began the NII project at ICT Inc., he has left the organisation, moved to a rural village to raise his family, started a NII consultancy, written two books related to the subject, and presented several NII workshops and presentations.

Case 3: Electronics Inc.

Case Description

Electronics Inc. is a publicly traded company with a 125-year history in B2B and B2C electronics. They are a global company with 115,000 employees in 60 different countries. In 2014, they announced \$21.38 billion in revenue across the organisation. It began as one of the first companies to offer electronics directly to

consumers and has a well-established legacy and culture of innovation. It is one of the few MNCs in their sector to maintain corporate research divisions that are complimented by a design unit focused on social research.

In recent decades, NII projects have applied a diversity of approaches, each framed with distinct terminology for each iteration. They have utilised biomimicry as a management and product innovation method, cradle-to-cradle as a product innovation method, and circular economy (a.k.a., performance economy) as a business model innovation platform. The NII activities began in the 1990s under the umbrella of servitisation, and today these activities are referred to as circular economy.

Interviewees included current and former employees involved in various aspects of sustainability and innovation. Most interviewees were eager to cooperate, with the exception of two key participants in the NII management innovation who avoided or declined being interviewed. Interviewees involved in the NII projects included a diversity of expertise:

Interviewee 1: Engineer, Biomimicry

Interviewee 2: Environmental science, Biomimicry

Interviewee 3: Physicist, Sustainability

Interviewee 4: Chemical/Environmental Engineer

Interviewee 5: Mechanical Engineer, MBA, Biomimicry

Interviewee 6: Product Designer, Biomimicry

Interviewee 7: Engineering, Marketing

RQ1: NIIs Attempted and Achieved

Technological Innovations

Technological Innovation 1 (Attempted)

T1 Synopsis: Device to assist in the disposal and repurposing of food waste to grow more food in the home.

Biomimicry was used to design new products for the home utilising NII principles, though the concepts were not fully developed. The intention of the new products was

to ease the cycling of food waste in the home with a unit designed for the kitchen to compost and reuse food waste. One interviewee (not a member of that specific project team) thought that biomimicry was not accurately portrayed in this concept.

T1 was a product innovation completed by an internal design unit, and no interviewees who had been connected with this project could be located. An outside consultant spoke of the project but was not directly involved, providing little information about the overall process. The other interviewees who were directly involved with the other NII processes also did not discuss this project, suggesting that it was an isolated project rather than part of a larger NII agenda.

Technological Innovation 2 (Achieved)

T2 Synopsis: Cradle-to-cradle design process applied to two household products.

One design team utilised cradle-to-cradle principles for the design of at least two products, but did not pursue certification by an outside agency. These products were discontinued due to higher production costs with no associated market return advantage. They have instead prioritised specific product features for sustainability without using a particular innovation method.

T2 was successful in developing a product and taking it market, however, it failed when it underperformed with consumers. It demonstrated the technological and commercial viability of cradle-to-cradle as an innovation process, but brings into question the market value of green certifications and labels. Additionally, the organisation decided to use the process without seeking actual certification, and it was not clear why they chose to do so aside from a lack of additional value.

Technological Innovation 3 (Achieved)

T3 Synopsis: Upcycling and recycling of discarded products recovered from the landfill.

Interviewee 3 described how a local waste management company had been collecting discarded product from this company, particularly their evergreen models, to be refurbished and resold. Waste management companies initiated this effort in

search of higher value recyclables in collected waste, and sustainability professionals at Electronics Inc. are in continual dialogue with waste management professionals in search of these types of opportunities.

External waste management companies who were seeking higher value for the waste already in landfills or arriving at landfills led this innovation project. According to one interviewee, this was a common practice in Europe due to limited space for trash disposal and highly regulated waste management infrastructure. Electronics Inc. was working in partnership with these companies to reincorporate used/discarded products back into their supply chain with as minimal requirements for repair and investment as possible. There was some indication in the interviews that this is part of an overall strategy to move more towards a service-based leasing model for the consumer-facing side of the company. (This business model is already very common in their B2B divisions.) While this may be seen as a waste management strategy, it has been included as a NII process because it demonstrates the principle 'waste=food' which is common amongst NII approaches.

Organisational Innovations

Organisational Innovation 1 (Attempted)

O1 Synopsis: Attempt to design the structure of new open innovation relationships by applying biological models to management.

A biomimicry management innovation project was intended to inform the relationships and innovation processes of a newly created open innovation unit. This project, spanning 6-9 months, was supported by an external NII consultant team providing support to Electronics Inc. as a project for a biomimicry course and on a voluntary basis. This project included several "awareness creation sessions", individual interviews, bi-weekly conference calls, and a report of biomimetic concepts. The NII consultant team provided preliminary application ideas of biological strategies and designed the project to be implemented by the internal team.

O1 arose after a senior sustainability director attended an in-depth workshop in NII and found the experience to be influential in her thinking related to sustainability. The

course facilitator then requested that one of her student teams be allowed to consult with Electronics Inc. on a voluntary basis in a project designed to influence the structure of a newly created business unit dedicated to open innovation. There were mixed responses as to why it did not progress, as discussed below, but in general it seemed to be a poorly designed engagement with little investment on the part of Electronics Inc.

Organisational Innovation 2 (Achieved)

O2 Synopsis: Product servitisation of several products; Primarily in B2B relationships and now expanding to B2C relationships.

Electronics Inc. has experimented periodically with servitisation of products, and recent circular economy efforts have further formalised this strategy. They are in the process of servitising several B2B offerings and experimenting with novel business models for B2C offerings. O2 is an ongoing approach to customer engagement that Electronics Inc. has experimented with for several years. The move toward servitisation rather than traditional producer/consumer relationships has been underway for some time. However, the rise of circular economy as a broad approach to NII, sustainable economies, and business has created a new framework to conceptualise this approach. Servitisation/circular economy was described as a distinct effort from other NII projects such as biomimicry and cradle-to-cradle.

Systems Building Innovations

Systems Building Innovation 1 (In progress)

SB1 Synopsis: Policy reform advocacy to enable the transition to circular economy models across multiple sectors.

According to Interviewee 7, the sustainability department is advocating for policy reforms within the European Union (EU) to enable a more fluid transition to circular economy models for their products. SB1 is an outward facing aspect of other circular economy efforts that Electronics Inc. is driving in the policy sphere to incentivise closed-loop business models. They are effectively in the role of lobbyists for circular economy in the EU. While they likely see business value in policy reforms, they also viewed this as part of their overall sustainability strategy.

RQ2: Factors Influencing Adoption

Factors: Characteristics of the Innovation Context

1. Norms Of The Social System: Perceptions Of Sustainability

The common theme amongst interviewees was that Electronics Inc. was dedicated to sustainability since the early days of the organisation, participating in various sustainability initiatives internationally, and defining their business purpose as bringing innovations that enhance well-being to millions of people. This is particularly accentuated in their healthcare business. They also have a substantial staff dedicated to sustainability accounting and reporting.

Interviewee 1 described the long history of sustainability efforts at the company and various aspects of their sustainability approach. Electronics Inc. was a founding member of the Club of Rome and active in social and ecological issues since its inception. Sustainability issues, influenced by stringent EU environmental standards, have increasingly been a part of the company reporting structure and made public via a balanced scorecard approach. They also address sustainability in various industries by innovating new products to support other sectors efforts (e.g., alternatives to existing products that reduce harm to biodiversity; products to support more efficient horticultural practices, etc.). Their sustainability approach is influenced by a balance between transparency of environmental disclosures and competitive advantage, viewing too much transparency as a vulnerability to competitive advantage.

Given the long history of engagement with sustainability, the biomimicry efforts had little influence on the organisational sustainability agenda. The cradle-to-cradle projects added an additional layer of analysis of product life cycle, however, the project was also discontinued. According to one strategy session, the circular economy effort would require four transitions in their business approach “from ownership to access; from transaction to relationship; from cost to value; and from product to service” (Interviewee 1). They consider a product to be “green” if it is “10% better” than a previous model and define six types of capital in their sustainability report (Interviewee 7).

More broadly speaking, Interviewee 4 described: “I found sustainability very important for [Electronics Inc.] at many different levels. Now that I have worked with other companies, [...] I see that sustainability has been very well implemented and embedded in the organisation. So people take sustainability seriously. And this doesn’t mean that people are completely happy about the objectives and how proactive the company is, but in that sense sustainability of [Electronics Inc.] is very conservative, doing small steps but very concrete steps. Which is good in a way. It’s not making a lot of greenwashing like other companies. It’s doing what it’s saying [sic].”

They have a highly institutionalised sustainability narrative that views “sustainability and innovation as the same thing.” Interviewee 3 stated, “[Electronics Inc.] has its vision and mission to make the world healthier and more sustainable through innovation. So innovation and sustainability is pretty much a one-on-one relationship. And, of course, that’s not automatic so you have to guard for that and work on it. And that’s why we develop those metrics that can measure how sustainable are innovation projects. But the intention here is to clearly link all innovation activities to some clear global trends that relate to sustainability.”

Interviewee 6 described how they link sustainability to profitability in the company by targeting innovations to improve well-being for impoverished people: “I think that they were having really good success with getting people to understand [the balance between wellbeing, economic, social, and environmental health] intellectually and then to translate it to product categories that were wins for the business. [...] Like how do we make a product that we can still make money that really improves the health of people in places that don’t have access to the resources.”

Interviewees also described corporate social responsibility as an important driver of their sustainability efforts. Interviewee 7 articulated, “As a large international global company, we’re responsible for what we do and we feel that we are creating waste with our products and we always feel very bad [...] when we see pictures of [...] all kinds of [Electronics, Inc.] products in a big pile somewhere, China or India...And we see that that cannot be resolved. We feel responsible for our products and we want

to make sure that at the end of life, at the end of use, our products are either recycled or dismantled and then re-used...and so we feel responsible for products.” He also described how products are currently designed for a linear production/consumption model at the lowest cost possible which is difficult to disassemble and repair, suggesting some inconsistencies in the overall sustainability strategy. They are currently transitioning to leasing models for several product categories, in which the most cost effective strategy is design for durability and longevity to reduce maintenance costs.

While most of the NII efforts were directed at product innovations, O1 was intended to have cultural influences. Interviewee 6 described, “[The NII management innovation] was specifically about culture. [...] And how to drive the [...] innovation within a culture of that business... They actually were very, very inspired at the workshop and they surprised me with their degree of creativity about triple bottom line [...] and how you might share [intellectual property].”

2. External Knowledge Sourcing

Several external consultants from various disciplines were involved in the NII activities, though only interviewees from O1 were identified. No other outside consultants were mentioned for NII activities.

O1 began after Interviewee 1 attended a one-week immersive training in NII and brought NII knowledge into Electronics Inc. An outside consultant then offered to provide a consultant team services as part of a training exercise for the consultants. The outside consultants were contributing in a voluntary arrangement, with minimal financial investment from Electronics Inc. aside from employee time and minimal meeting expenses. Interviewee 1 had some hesitations about this arrangement: “This also was something where I had a big debate with [the lead NII consultant], because she said to us that we would benefit from it because we would get people who worked for us for nothing and then I said, ‘No, this is completely the wrong way because we need to make an effort to bring information to [Electronics Inc. staff] and to support them and educate them and that takes some effort. And that it’s quite some time until they would seamlessly integrate in,’ you know? So it’s not that ‘you

are the giver and we are the takers but it's a win-win thing'. And this was something that was really hard for [consultant] to understand.”

They had mixed experiences working with outside consultants. Interviewee 2, an outside consultant for O1 described, “Another [issue] is just the challenge of working with the team of people and how we all kind of see the world in different ways. [...] It's wonderful to work with designers. Wow, they see the world differently. You learn what their process is and it was really challenging in our team.”

Interviewee 6 was “very hopeful” because the internal Nature-inspired management innovation team was cross-functional. However, when the external consultant team suggested that they add an internal designer to the team, “they did not understand and I think that's just a lot to do with the scientists probably a little bit more, uh, hierarchical, let's say.”

3. Informal Social Network Collaboration

Interviewee 4 described how they developed relationships related to NII outside of Electronics Inc.: “ I, myself, and other [people in the area] contacted [external NII consultant] to create the [national] organisation of biomimicry [...]. And we also started training the people from other companies and also from [Electronics Inc.] together about biomimicry. In fact, one of these girls who were trained, one of the first ones who were trained in biomimicry, now is working in [a local university] and has introduced biomimicry in the [university] and is quite successful. Because now the [university] is working with [Electronics Inc.] and they will start working in this field. So also the influence of [Electronics Inc.] is not only inside but is also from the outside world.”

4. Leadership

Several interviewees described a need to present tangible benefits of NII and sustainability to management. Interviewee 7 described, “When we talk to our business people, we try not to talk too much about sustainability or about environment or about waste but we say, '[...] how can we increase the valuation by changing these models [towards more circular business models]?’ And that works very well.” Interviewee 4 offered a similar perspective: “Unfortunately management

thinks in a more blind way. 'It's just like this. Other options are possible but I don't implement them'. So I see that [NII] is possible in small companies. In a big company, maybe it will take more time or it has to be sort of an upper guy who will say 'okay, my company will go in that direction.' It's really a leader and then 'we go for that'.

There was also indication that sustainability efforts were not supported consistently amongst managers and other employees. Interviewee 1 described that during the 2009 recession, there was a "visible split" between senior leadership who wanted to reduce SOI and those that wanted to persist. "Only very, very few who stayed believers and who tried to say 'Look, in these tricky times sustainability is the only good story that we have to tell.' But because everybody was in survival mode, these people were hardly heard. [Sustainability efforts] survived because of the profile and the will of the people in Research who enabled it... together with the Corporate Sustainability Office...that the topic survived." Interviewee 4 further specified, "At [Electronics Inc.], the research department, the researchers were really open for this but unfortunately management, not so much."

Interviewee 5, an external NII consultant, described his perspective on the engagement of the leadership: "The leadership, the people that were interested, really interested in the biomimicry piece, were the ones that were talking to us. But upper management was not that interested. And so the people that we were communicating with had to fight and struggle for time to communicate with us." Interviewee 4 had similar thoughts: "Management was a little bit more conservative, but in a sense they knew that biomimicry was there. And they cannot deny that it slowly became a very important tool to use. [...] So at the end, management is slowly understanding what it's about."

On the other hand, some interviewees (both current and former employees) saw the leadership as supportive of sustainability efforts, including NII. Interviewee 7 described his views: "I think [Electronics Inc.] is doing very well in all kinds of rankings and that is because our leadership team and especially our CEO is very convinced that sustainability is extremely important for a company. One is our image. If you have a good image, people want to work for you. I have seen a lot of young

people that are even more interested in sustainability than probably the old generation. And they don't want to work for a company [...] that does not take sustainability seriously." The global head of sustainability reports directly to the Board. They have approximately 200 people working in sustainability and they have done extensive eco-efficiency work in their factories, mostly driven by cost-saving measures. Interviewee 2 also described how a sustainability leader in management drove one NII project: "I think it just takes time, gauging the key decision makers. Obviously, [the innovator] was engaged because she'd gone to [a NII course]. She was obviously the lead making it happen."

Factors: Characteristics of the Decision-Making Unit

1. Attitudes Towards Innovativeness

Although several interviewees described how innovation and sustainability were an inherent part of their culture, there were inconsistencies amongst interviewees. Interviewee 4 saw this as an issue of being "conservative". "What I see is in [Electronics Inc.], it is very conservative to introduce new tools. Especially when it's about biomimicry." Interviewee 5 viewed this as a cultural issue related to workloads and capacity: "I understand they have, like, 1200 scientists and they've got an average of 1.4 pieces of intellectual property per scientist per year. [...] But really, we were dealing with people that were scrambling to try and make a business division work and operate. [...] They were all very hurried, very stressed out."

Interviewee 1 described how Electronics Inc. was positioning SOI as part of their brand: "Now they are moving back a bit but they have a new company vision and a new branding which has to do with meaningful innovation, and they deeply believe in innovation and I think they are [...] for a multinational corporation...they're quite innovative. But a lot has been eaten up of this innovative spirit and the innovative culture by the standard multinational or stock market knowledge cost driver." She went on to describe how difficult it was to implement NII as a management innovation, despite these organisational goals: "In the first place [the management innovation] was also intended to show how things could be done differently and to let people experience it, [...] to facilitate the mindset shift...because there was a lot of skepticism [...] and a lot of not knowing."

Interviewee 6 saw the internal NII team as being very open to innovation, but unable to act. “I was shocked by their complete change and their creativity, their willingness to think differently. I think that the work we did really inspired them. [...] To be honest, I think that the biomimicry just opened the door for them that they hadn’t noticed before. After they sort of opened this door, they had to keep this door open. They had to do that and I just don’t think they ever did anything.”

There were also several indications that incremental innovation dominates the SOI agenda. Interviewee 4 described how the various NII efforts were not viewed as a cohesive set of projects but rather “it was very isolated projects that the company took on at that time.” She went on to explain how they can be linked: “Circular economy is combining cradle-to-cradle with biomimicry as well. So it’s not making them two different methodologies. It’s just making one learn from each other, which is great because it is what we need now. A company cannot be married with only one and not see the others. You have to see the whole picture. [...] [NII] has to grow inside in order to cover the higher levels of the organisation. So to start from a product point of view, [...] it’s the best way. And then go for process and evolve with systems. I think it’s a logical step to take.”

2. Formality of Organisational Structures

Several interviewees described tensions between the desire to innovate and the formality of organisational structures related to innovation. Interviewee 6 articulated, “[The NII methodology] is this organic sort of iterative process and who knows where things can go. And if you’re totally open to discovery, you don’t know where you’re going to be at any time. But not many people have the chance to actually function in such an open way. Usually people have to follow a process and in [my company] our product development processes [...] are pretty strict.”

An internal manager of SOI, Interviewee 1 described the institutionalisation of innovation processes: “There were lots of processes...all the special tools that were around and that were emerging and brought into the corporation by consultants were tested. Like TRIZ or the Six Thinking Hats or biomimicry or cradle-to-cradle, or the Natural Step. They all came along and they all were tested. [...] In each set, it’s often used with different works but the processes are the same.” They utilise “very, very

sophisticated project management scales and tools that also worked across in the organisational units.”

Interviewee 4 (a former employee and external consultant) was the only interviewee to take a broad view on NII and include several projects in a larger NII agenda:

“Biomimicry is a very innovative tool. How can we learn from nature in the different levels like product development processes and even systems or ecosystems?

Biomimicry... I just checked out what was the work about and there were many activities related to biomimicry at [Electronics Inc.]”

3. Professional Training

One of the external consultants, Interviewee 4, described how they implemented NII trainings within Electronics Inc.: “We trained a lot of people, especially the researchers [who] are really open for new ideas and new techniques. [...] We really put seeds in the company.”

Interviewee 2 described how the Innovator was trained, but she was not aware of internal training efforts: “Obviously, [the innovator] was engaged because she’d gone to [a NII course]. [...] To what extent [the innovator] kind of trained people up in what biomimicry is, [...] I don’t know how much that went on.”

4. Selective Exposure and Perception

Several interviewees discussed how their experiences with NII compared and contrasted with other SOI approaches. According to Interviewee 4, there were several NII activities happening amongst various departments of the company. The management did not view biomimicry as an approach because it was broad and they preferred cradle-to-cradle, which was more tangible. The various efforts were not viewed as a cohesive set of experiments under the umbrella of NII, but rather... “It was very isolated projects that the company took on at that time.” On the other hand, she goes on to explain later “Now [...] circular economy is combining cradle-to-cradle with biomimicry as well, so it’s not making the two different methodologies. It’s just making one learning from each other, which is great because it is what we need now.”

Interviewee 3 compared their NII activities to other SOI activities as well: “I think the big difference [from other sustainability initiatives] has been that the objective at that moment with biomimicry in this specific activity was really to elevate it to an abstract level of comparison. I don’t remember having done that with any other sustainability approach and we have the Natural Step and cradle-to-cradle and now circular economy. And the closest is Natural Step where it stayed quite general, but even then the ambition is always to go quickly to something that is tangible. And in cradle-to-cradle, of course, it’s really it was always about product design so and now with circular economy, it has both the big picture and the policy levels, business cases and also product design. But never the inspiration on how to change your processes based on the way nature does things. I think that was quite a big objective.”

Interviewee 1 described a similar comparison across SOI approaches: “Biomimicry actually is the same like TRIZ. But the difference is that [...] you use as starting point the patent database. With biomimicry you use nature, so the database is from biologists. But the general process that you first have to define ‘what’s my problem’, ‘what’s the key functionality’? And then ask okay, how is this functionality fulfilled in different contexts. That’s exactly the same.” She further compared O1 to other SOI approaches: “It showed that [NII] is possible although it’s difficult. It also showed this method, like in most other innovation methods, really require time and thoroughness and if you don’t have the time and thoroughness then it doesn’t make sense to start. But that’s the same with lateral thinking or with TRIZ...lots of other stuff as well.”

Interviewee 3 similarly described how he saw the various approaches to NII as separate efforts: “Biomimicry has been mentioned quite continuously in the context of circular economy. But as a stand alone, I haven’t heard it mentioned in quite some time.”

Interviewee 4 described how other people perceived NII amongst the many SOI approaches and were saturated with SOI in general: “People [thought] ‘[NII], that’s another tool.’ Immediately, they get, like, de-motivated.”

When asked about his use of NII, Interviewee 7 said that he doesn’t apply “nature-inspired innovation for sustainability” in his work. However, he offered details about

the implementation of circular economy models and articulated “if you look at the way they explain circular economy, did they look at nature and say, ‘Well, it is no waste in nature. So why have we as humans developed an industrial system with waste?’ ...In that sense, to copy nature. There is a link, but it’s more just to explain how we think we have to change our industrial system [...] that there’s some inspiration from nature.” He later went on to say that he avoids discussing sustainability explicitly with the business specialists that he deals with inside Electronics Inc. because it is negatively perceived.

There were also various perceptions of NII that speak to the uniqueness of the individual’s experiences of the approach. Interviewee 1 described skepticism regarding the potential of biomimicry as promoted by an outside trainer and consultant. “The whole method has been put on such a [...] hero column [i.e., pedestal]. But I have a critical mind and you need to convince me and not persuade me.” Interviewee 3 described how “The owners on the [Electronics Inc.] side which is the Open Innovation people, they were not [...] impressed enough to give it very serious follow up. That was my impression.” (Note: The two NII project “owners” declined to be interviewed.) Interviewee 5, one of the external consultants on O1, also expressed concerns with the effectiveness of the approach. “By the time you [translate biology] back to business, it’s really cold and scientific. Which, in a lot ways is good, but we’re dealing with people, with a people system. And I felt it was very cold.”

Factors: Characteristics of the Innovation

1. Perceived Relative Advantage

In strictly monetary terms, Interviewee 3 discussed perceived relative advantage of two attempts to apply cradle-to-cradle to NPD, though they did not pursue certification because “customers are sick of all kinds of labels”. [...] “It didn’t get any better attention, didn’t sell any better, didn’t perform any better, but it had a higher cost to produce.” There was no indication of clear monetary advantages for the other applications of NII. They instead decided to focus on energy efficiency, recycled plastics, and other aspects that were similar, but without the guidelines. He also noted that they are able to purchase recycled plastics at a lower cost than virgin plastic. Additionally, he described how designers “loved” the cradle-to-cradle model

because it gave them clear direction to design products, however “marketing could not get anything out of it because it stayed with the same business model”, selling the product instead of leasing it, as promoted by a circular economy approach they are currently pursuing.

Interviewee 2 described the value related to expansive thinking she experienced in the overall approach: “[There is value] in just the opportunity to look at the other thirty million organisms from a strategy perspective and how they persisted on the planet for so long.” Interviewee 3 also articulated a similar view: “The premises are extraordinary, simple and powerful that you can better copy stuff that works well rather than re-invent the wheel. The difficulty is to find the right level of granularity and detail and how can you really make that translation.” Interviewee 4 described the purely innovative value of NII: “Biomimicry is a very innovative tool. How can we learn from nature in the different levels like product development, processes, and even systems or ecosystems?”

Also related to the value of NII, Interviewee 3 described how it was also enabling and enabled by partnerships with suppliers. The internal sustainability team frequently partnered with waste management companies to develop strategies to reincorporate discarded products and recycled materials into new products. The waste management companies are motivated to increase the profitability of their waste streams and approached Electronics Inc. with possible opportunities, such as the refurbishment of their evergreen models. Electronics Inc. has also recently adopted a policy of using a percentage of recycled plastics in many of their products.

Interviewee 6 described the value that she saw in NII, both in terms of building relationships and its value for expansive thinking: “At its core is what it does to people so they want to work together in a different way. [...] But I think the power of the inspiration, the power of the potential for knowledge, the power of the potential solutions [...] The chance for culture change using it is just ... to me, is fantastic.”

2. Observability

A few interviewees described less tangible advantages to the various NII approaches. Interviewee 4 described, “At that time, cradle-to-cradle became more

important in the sense that it was more concrete. Cradle-to-cradle is five different aspects to cover, while biomimicry is very broad. It's not a recipe. It can be taken from many different perspectives and that's why [it had a major] weakness part for management because [...] the framework is wide, it's not limited to few principles. But management likes better three steps and that's it, or four. So cradle-to-cradle came with more specific items to focus on."

There was also a general willingness to be open to what might emerge without specific intentions about project results, though this was not consistent amongst interviewees. Interviewee 3 saw NII as a broader approach. "This was quite open sky and no real fixed idea about the outcome. [...] It's something we call here, frequently 'co-creation. Let's work together and see where it goes' and so I don't think there was any very clear idea of what should be the outcome." He went on to describe how ambiguity about the anticipated results can be detrimental if expectations are set otherwise: "It has to be very clear that depending on which level you want to get at it, if it's about specific product related features, then I would highly recommend to engage [with] the tools that are developed by [NII consultants] and others. [...] If it stays on the abstract side, then I'm not clear if that has been proven beneficial anywhere else. [...] If you are in for experimenting and it's for the curiosity then, of course, by all means. But if you are in to say 'well, I expect some very detailed and tangible results after making project plan, this will be believable', then I'm not sure if it's the right approach."

Interviewee 4 described how it is difficult to clearly identify the results of NII: "It's not an easy concept because it's not touchable. [...] You need to invest in training people but also to give them the space to start creating. To give them the activities but also the possibility to just learn, applying the life principles, for instance, or try to identify new solutions. But it really takes time. It's not something that you can come away with a solution from one month to another." Interviewee 2, an external consultant, also described difficulty with the ambiguity of O1: "We were kind of figuring it out as we went. [...] On one level feeling okay 'Wow, this is biomimicry. It's a new thing.' and on another like 'what the f*** are we doing?' [...] Honestly I think that's what I struggled with personally throughout the whole process, is how ill defined the whole project was."

3. Complexity

Although interviewees were open to ambiguity, it was still viewed as complex. Interviewee 2 described, “We pulled something together in the end but, [...] I’m like, ‘wow, we actually did pull something together’ but the process was pretty darn messy and pretty all over the place.”

Interviewee 4 described some complexities more specifically: “Cradle-to-cradle comes with more a specific ‘okay, you have to do this and this and that’ and that’s it. Don’t think. Just follow this. While biomimicry is ‘okay, how can I developed a new way to attach to things?’ You have to search. You have to work with designers, biologist, with sociologist, anthropologist. It’s more complicated and you have to search the Internet or look for what is new, what university are doing in that aspect [sic]. So it takes much more time to come up with a solution.”

4. Trialability

Interviewee 4 saw difficulties due to economic pressures at the time of NII activities that limited the ability of the team to experiment: “[Management], at that time, there is trouble with...very short-term outcomes. They needed immediate resolutions. They needed to come with innovations, different innovations, and there was not attention enough to let them play with this new methodology.”

Interviewee 1 saw limitations of NII due to the timeframe for implementation: “I think for both approaches - cradle-to-cradle and biomimicry - we didn’t get that far. [...] And, I mean, what can you do in half a year?...to be very honest. [...] It showed the potential. I think it was opening up some excitement. It was helping to overcome prejudices and it showed the potential. But this was as far as we came.”

According to Interviewee 1, O1 did not come to fruition “because the whole business unit was closed. And that did not have anything to do with biomimicry. It was the consequence of the political situation and this really tough context right after the credit crisis. There was a big re-organisation under the notion of cost cutting. So in that sense, it was not really the best timing.”

5. Compatibility

Interviewee 1 described how they trialed NII and other SOI methods, tools, and processes in alignment with their larger sustainability vision “to enrich the existing innovation process...in such a way that it would automatically lead to innovation for sustainable development.”

And despite several challenges with implementation at the company level, several interviewees described how NII influenced them personally in their own lives, and their views on collaboration. For instance, Interviewee 1 stated how her perceptions of sustainability changed markedly during the same time period as the NII projects. She described her view that a “fragmentation” between personal sustainability beliefs in the workplace and those held in private is an impediment to sustainability because it limits an individual’s ability to develop “global consciousness” and “connect on a transpersonal level.” She further described how her experiences with NII had been personally transformative: “This is something that I also got from the biomimicry course [...] when we had this deep viewing experience where we should look on the first day for our favorite spot and then we were asked to go back there every day and sit there for like at least 15 minutes. And you get into that space deeper and deeper but just do nothing except for view...And then all of a sudden, I mean, I had the impression that I’m part of this, you know? And then I think that was my first sort of conscious experience of universal consciousness although I didn’t have the word to call it like that, at that moment of time but...this quieting down. I mean, who takes the time to be somewhere?” She has since left the organisation, written a book, and spoken publicly about this personal transformation.

Interviewee 4 also articulated her perceptions of NII on an individual level: “When you talk about learning from nature, it means you think and feel different. You have to be open for completely new ideas like cooperation, like sharing knowledge, like supporting each other or how to make a company more resilient based on breakthrough ideas that management need to implement in the company. [...] It’s a process that has to be developed. You have to see nature in a different way...be amazed about what is happening outside. This is the seed that has to come in everybody.”

Case 4: Cosmetics Inc.

Case Description

Cosmetics Inc. is a manufacturer of consumable products targeting mainly the market of their emerging economy and currently expanding into international markets. Founded in 1969, they have approximately 17,000 employees (through a series of recent mergers) and in 2016, claimed \$4 billion in revenue. They were privately held until recently, becoming 25% publicly traded in 2004. Their country has the 2nd largest market of the cosmetics market in the world and at the time of interview, they held approximately 33% of the market share in their home country.

The NII activities began in their scientific research group of about 200 associates, many of whom also specialise in sustainability. This group contains both secondary-research scientists and lab scientists, but is dominated by secondary research. The group is structured with various research programs and projects and NII is designated as a formal research program with an assigned scientific manager. Activities with NII began in 2009 with the formation of a research committee and have continued on until present day. Unlike most other cases, they have clearly tracked their investment in biomimicry (not including cradle-to-cradle or circular economy), and as of 2015, they had invested \$2-3million.

Interviewees included current and former employees of the research group. All interviewees were accommodating to the research process and seemed to openly communicate about their experiences. As a former consultant, I worked closely with this organisation on several of their NII activities and some of the detail is reflective of this engagement, though I have excluded any personal interpretive reflections from the data. The internal team was interdisciplinary, including the following:

Interviewee 1: Biology, Agriculture, Biomimicry

Interviewee 2: Food engineer, Environmental management, Biomimicry

Interviewee 3: Chemist, Innovation manager, Biomimicry

Interviewee 4: Biologist, Business, Biomimicry

Interviewee 5: Microbiology, Biomimicry

Interviewee 6: Product design, Biomimicry

Interviewee 7: Agricultural engineering, Biomimicry

Interviewee 8: Biochemistry pharmacist, Biomimicry

Interviewee 9: Biology, Forest Science, Biomimicry

Interviewee 10: Chemical Engineer, Innovation management

RQ1: NII Attempts and Achievements

Technological Innovations

Technological Innovation 1 (Attempted)

T1 Synopsis: Attempted packaging design using NII principles.

NII activities began when one of their external consultants, a packaging designer, began to apply NII on a project with them. The design consultant then recruited an external NII consultant. They formed a joint relationship with the company to use NII on packaging project. The NII consultancy created a report of biological strategies and the design consultancy produced a report of design solutions based on these strategies and others.

Technological Innovation 2 (In progress)

T2 Synopsis: New consumer product to replace a synthetic-based chemical process with a water-based chemistry.

A project was pursued with an outside green chemistry consultant and NII consultant together to innovate chemical formulation using NII and green chemistry for NPD. Interviewee 4 described an exploratory workshop to decide what to pursue with NII and green chemistry together and found that the green chemistry consultant allowed them to brainstorm in a way that was much closer to the consumers' interests. It resulted in several ideas and some were being pursued at the time of interview. However, there was a shift in the relationship dynamics of this project in which the green chemistry consultant provided more tangible, practical solutions than the NII consultant and consequently, the Research Director decided to remove the NII consultant from the project and continue with only the green chemistry consultant.

Technological Innovation 3 (Achieved)

T3 Synopsis: New product introduced into the marketplace applying a NII NPD process.

This NII application to product design included a compilation of a challenge-specific report regarding packaging again, this time followed by a new product development workshop with an interdisciplinary group of biologists and designers. At the time of interview, one new concept that was further developed in this workshop had advanced to the later stages of the new product development process and manufacturing equipment was being imported trans-Atlantic to the company's production facilities. There was, however, some disagreement amongst interviewees regarding if this was NII or not.

Organisational Innovations

Organisational Innovation 1 (Attempted)

O1 Synopsis: Attempt to elevate the position of NII from an NPD approach to the overall approach to corporate sustainability.

The Innovator attempted to push NII further up into the organisation to establish it as an organisational approach to sustainability. However, he felt that the senior leadership was reliant on a dated model of sustainability, too focused on economic returns, and unwilling to reconceive their CSR strategy. Interviewee 6 also described how they have created a core team with a team leader that has allowed the NII efforts to maintain a strong momentum. The team continued to train together, do projects together, and promote the NII efforts internally. However, they have found it difficult to maintain it as a priority.

Organisational Innovation 2 (Achieved)

O2 Synopsis: Application of swarm theory to management style in one business unit.

Interviewee 3 uses NII in his capacity as a manager as a framework for how he manages one unit of the organisation, albeit. He was inspired by the concept of swarm theory as a management tool and sees this as the most valuable use of NII, more than product innovation as he had originally learned about it.

Systems Building Innovations

Systems Building Innovation 1 (Attempted)

SB1 Synopsis: Development of a NII research center jointly funded by Cosmetics Inc., state government, and a university research body.

The research director (at the time) engaged with state government to create a research center jointly funded by the company and a university with the purpose of driving innovation and diffusion activities. NII was one of the two topics that they chose to be the foci of the research center. However, when they held an open event to try to develop partnerships with local universities, they found very few university researchers who were doing research in NII and had the capacity to offer joint funding.

Systems Building Innovation 2 (Attempted)

SB2 Synopsis: Intercontinental research in partnership with academic researchers to guide the development of a research agenda for a particular plant species that can inform their supply chain.

A partnership was formed with university researcher in their country and in Europe to guide the research of a particular plant species towards research questions that are relevant for the company's product development strategy. Interviewee 1 sited this as one the NII projects that she is working on as a biologist to help shape the research agenda of a research partner.

RQ2: Factors Influencing Adoption

Factors: Characteristics of the Innovation Context

1. Norms Of The Social System: Perceptions Of Sustainability

The founders started the company with a strong sustainability ethic and have a long history of tracking their environmental footprint and their relationships with their suppliers, specifically those local farmers and indigenous people who are impacted where raw materials are produced. An important part of their brand identity is the cultural and natural resource richness of their country. Incorporation of biodiversity into NPD and supply chain decision-making is a well-established priority. Their

intern-to-employee training program includes a sustainability component in addition to standard job responsibilities. While company-wide norms related to sustainability have existed since the company's inception, the connection between product design and sustainability performance has only recently been formalised through the eco-design program. Interviewee 2's comments exemplify these norms: "I think we have a great opportunity or chance at [Cosmetics Inc. to implement NII] because there is a real and a deep belief that sustainability is very important as a topic. It's part of the values of the company and it's something that people really understand." Interviewee 1 further articulates this position: "[The sustainability culture is] very strong, very, very strong. ... If you were not sustainable thinking, don't come here. We have a new researcher ...and he's a very traditional guy. He works with traditional agriculture...conventional. In his first project, he wants to work with machines doing conventional cultivation and everyone was, 'Oh God, what are you doing here.' (Laughs) Everyone was 'Whoa, whoa, whoa. You are in [Cosmetics Inc.]. It's not in this way. Come here. Let's talk.' And last week, he [said] to me, '[It] was a shock for me my first year... seeing that you were in another world.' And I told him, 'I think you came in another world because here everyone is looking for the sustainable way. And the best way to do things for the environment, for the economy, and people as well. Because we look for people all the time.'" Interviewee 1 went on to explain "We look now as an ecosystem for innovation. Our new sustainability directives and strategy are about how we can be more like an ecosystem, like nature."

However, the former Innovation Director described a contrasting position in which SOI was stagnating: "In [Cosmetics Inc.], we got kind of stuck into the old sustainability model. [...] It's very '90s now. Biomimicry was very new... but we have to do it behind the scenes. [...] We were stuck in a very successful brand that, in a way, did not help us much." He went on to describe a "deep cultural crisis" moving away from values being the main drivers of the company to a "very traditional competitive mode that all companies get into. And when you show them [i.e., the management/owners] biomimicry, its kind of a shock. You see that you're not going in the right direction and it's not a good message to give to senior executives with an ego bigger than their wallet. The limit was defined by success because we were really successful in one kind of sustainability that was developed close to 20 years ago. And we were the leaders of that. So we had to reinvent ourselves into a new

sustainability that is much more radical. It's not use of biodiversity but learning with nature and talking about social biodiversity. It's not using only vegetables from nature but talking about water. It's talking about relations in a much deeper way. It's going very deep into transparency. That is not a common thing in the corporate world, especially Brazil.”

2. External Knowledge Sourcing

The research division of Cosmetics Inc. contracted with outside NII consultants on at least four separate occasions for various projects, expending considerable funds. They also relied on further external design expertise to translate the biological strategies provided by the NII consultants. Interviewee 4 described, “When we got the first report how nature contain liquids, no one understood what it was.” It required translation from another outside design consultant to be useful. They relied on design expertise as part of the NII team, both internally and externally, and one internal product designer led the NII NPD project for T3.

3. Informal Social Network Collaboration

The NII project leaders attended conferences and met others working on similar projects. They also developed informal networks with local universities and individuals trained in NII in the surrounding city.

4. Leadership

There were various perceptions of how to value the intangible benefits of NII reflected in the different tiers of management that oversaw the NII activities. The Research Director who initially led the NII program was described as visionary and to the contrary, the research manager that is currently managing the program has more tangible, practical expectations.

Company growth was very intense for several years and slowed recently due to international competition and the global economic downturn. Consequently, they overpromised their shareholders and responded with company-wide reductions in expenditures and shortened innovation cycles. They reduced NII expenditures as part of the overall reductions. Interviewee 6 said that in his 20 years at the company, he perceived a stronger culture of innovation in previous eras than at present. Staff

was currently less willing to take risks and participate in projects at the periphery of their job assignments. He perceived that Cosmetics Inc. has transitioned from a smaller, nimble innovation culture to one more rigidly tied to shareholder performance.

Although sustainability is a major aspect of the company and brand identity, innovation related to sustainability seemed to be limited to the sustainability department and other departments responded to the sustainability mandates coming from this department. One interviewee mentioned that there had also been some changes in equipment and supply chain outside of the activities of the sustainability department, but there was no feedback structure to evaluate if these changes affected sustainability goals.

Leadership had variable responses to the NII program, ranging from highly receptive to reluctant. For instance, Interviewee 7 said that the previous leadership was more supportive of the NII efforts and the current financial climate and leadership would not have enabled the investment in the trainings, etc. to happen. On the other hand, Interviewee 9 described how the Innovator, who was a mid-level manager, embraced NII: “[The innovator] lived biomimicry. And he gave power for us to create a program specific to biomimicry.” Interviewee 4 furthered this sentiment: “[Innovator] would kind of hug everyone and say let’s go wild.”

When asked if they tried to apply NII to the larger approach to sustainability for the company, e.g., viewing the business as an ecosystem, Interviewee 10, the Innovator responded, “We tried that but we faced a big wall there. Biomimicry was really accepted by the innovation people as a new way to develop products and technologies, but when we started talking to different stakeholders, we got [a prominent NII consultant] talking to the owners and to the executive committee, they loved it but it was too much. They were trained and focused in the old school of ‘money, money, money and I don’t care about anything else’. It was a big war, a big war. [...] When we exposed biomimicry to that level inside the company, it was really not a good idea because it went back into something related to innovation and R&D.” For some cabinet-level leadership, NII was narrowly defined as a NPD tool rather than a broad approach to sustainability and this gap could not be overcome.

Factors: Characteristics of the Decision-Making Unit

1. Attitudes Towards Innovativeness

In general, they have cultural receptiveness to innovation, with two departments – Research and Development – dedicated to new products. Interviewee 10 described how they began with NII as an approach to SOI: “It started as curiosity and we did that a lot here. [...] I think all innovative companies should do that. They should be open to new things and they should bring them and see if there was a fit. And there was a tremendous fit with what [the NII consultant] said about biomimicry in general, the definition of it, and linking it to what we were doing. [...] It was an easy fit.”

On the other hand, there was some indication that this culture was shifting. The Innovator (Interviewee 10) described himself as a ‘fighter’ for innovation and has worked in this capacity in several companies. He ‘enjoys the fight’ and built structures to support innovation during his eight years at Cosmetics Inc. When they were affected by the economic downturn, he was instructed to re-focus the structure towards short-term innovation timelines, which he found difficult. He said “I was too radical for that. I had to go. Time to go.” An employee of 20 years, Interviewee 6 felt that economic impacts have been detrimental to investment decision-making at the company, particularly since they became publicly traded. Part of the strategy to produce investor returns is to reduce the number of products, instead adding more variety to fewer products. He saw this strategy - product personalisation - as detrimental to innovation.

Interviewee 9 described how the innovation efforts within the research group are targeted predominantly at incremental innovations that improve the marketability of their products in the short term in line with the 21-day cycles of new sales brochures. Due to the pressure to produce new sales brochures, they rely on incremental innovation in packaging, positioning, and similar small product changes averaging two product innovations per day. Longer-term innovation projects represent approximately 15%, while incremental innovations are 85%. After several frustrations with the NII program, Interviewee 4 suggested that NII could be successful but proposed a different model for implementation that relies on open innovation and leverages internal project management instead of relying on internal research and development.

2. Formality of Organisational Structures

Interviewee 4 described how incremental innovations are generated in the development department and four business units more frequently than from research. For radical innovations to develop, they are first pursued by the research department, then move through to the development department, and finally into the four business units. The two-stage innovation process spans two departments - research and development - with little continuity of project ownership between these departments. The NII product in late-stage development was an exception because the product designer transferred departments, taking the innovation with him through the process.

3. Professional Training

After approximately two years of engagement with NII in packaging design, the company hired the NII consultancy for a series of training sessions for scientists, marketing and design staff, and several mid-level managers. Approximately forty employees participated in one-week immersive trainings in biomimicry.

The NII research manager went through a one-year training program with a NII consultancy. The research manager also led internal trainings and presentations to align users of NII that are currently separated in different departments of research and product and packaging development.

4. Selective Exposure and Perception

Most interviewees were familiar with several NII approaches. Interviewee 2 stated that they have considered cradle-to-cradle certifications for their products and engaged with the principles of circular economy, and when discussed in the interview, he viewed these two frameworks as unique from biomimicry. He further described this broader approach: "What I've seen for biomimicry in [Cosmetics Inc.] is [...] strong inspiration for deeper research, for long-term innovation. And also for the moral inspiration or behavioral motivation. [...] But it's quite interesting to have [eco-design and biomimicry] together because you can use them on the simple and regular product development process. Eco-design principles are very, very simple and very objective. And also use [biomimicry for] strong inspiration for more long-

term research challenges and to look for new research and to find new solutions. For the future, we need that too because it's not sufficient to have the incremental improvements and innovations. For these more long term innovations, [we are looking for] a convergence of eco-design and biomimicry, for example. And cradle-to-cradle is somehow a mixture of that. The circular economy is very powerful...and we are going to explore that. There is a lot of space exploring these directions and biomimicry is one of the drivers for that [sic].”

Interviewee 6 also explained his perspective relating the various approaches: “Biomimicry is very big. Cradle-to-cradle is inside of biomimicry. But I think that sometimes we have some waves of sustainability. Now it's biodegradable - it's one wave. Now it's cradle-to-cradle – it's another wave. Biomimicry is a sea.”

Generally, interviewees described a variety of perspectives related to NII to their innovation processes. Interviewee 6 described, “I think the big value of biomimicry is make the people think. Make the people stopping and looking around [sic].” It helps people to identify “the real problem” leading to more appropriate solutions.

Interviewee 3 said that a major barrier is a lack of “deep understanding” of NII, instead with a focus on short-term, product-driven goals. He prefers to emphasise NII as an approach to problem solving, not necessarily as a way to achieve market-driven product and process innovations. Interviewee 4 reiterates this sentiment: “It's completely obvious that if we do things like nature does, we wouldn't be in this mess that we are today. We would be in equilibrium with the world.”

Factors: Characteristics of the Innovation

1. Perceived Relative Advantage

Interviewees described mixed perceptions and various values of NII. Interviewee 9 described feeling pressure from upper management to produce tangible product results with a financial return, indicating that monetary value was a significant consideration.

Furthermore, Interviewee 6 described the value of expansive thinking he sees in NII (also quoted above): “I think the big value of biomimicry is make the people think.

Make the people stopping and looking around [sic].” It helps people to identify “the real problem” leading to more appropriate solutions. Interviewee 8 described a different type of value: “ I think the most valuable thing that I see in biomimicry is a different way to think to create new things and new solutions. It’s a new model of thinking almost like design thinking. It’s a nature-side thinking.” On the other hand, Interviewee 7 viewed the biomimicry process as presented in the NII training too inhibitory to the application of NII because it frames the approach too narrowly. For her, the methodology instilled a consciousness about learning from nature but it limited the innovation process in other ways. She thought the highest value was its expansive approach. “[NII] broadens your universe. [...] I don’t think you could not profit from looking broader and considering more complex activity.” Other interviewees also articulated this value of expansive thinking.

There was little apparent value in engagement with suppliers to implement NII concepts. This was only evident in the new product coming to market, T3 that is controversially categorised as NII. While it did involve sourcing technologies new to their sector, this technology was not chosen for SOI factors.

2. Observability

There were mixed views on the need to clearly demonstrate tangible NII results. Interviewee 7 saw little need for clear outcomes: “We don’t search for a new project or a new technology using the biomimicry method, but [...] we’re sensitised to news that says, ‘Oh, this is a biomimicry inspired ingredient’ [...] If you detach from the process, then biomimicry works.”

To the contrary, some interviewees described a desire to see clear results. Interviewee 10, the Innovator, described his initial approach to bring NII into the company: “We know that when you go into some new technology or something new, it’s better to get a low hanging fruit. [...] And [packaging] was the most basic idea of biomimicry 20 years ago... start copying forms and function of nature. That’s why we started [with] packaging. [...] But it was thought it would evolve to everything... Packaging, formulas, and systems in general.”

The NII research manager, Interviewee 4, expressed pressures to produce tangible results that stemmed from the Innovator's leadership to pursue this low hanging fruit: "What we [don't have] is a clear understanding of to use biomimicry or nature's strategy to create a specific technology or product. This is [...] the challenge that we cannot tackle. We do have some products like [NII project from the new product development workshop] but it's still like more at the inspirational level. And not into the specific technicalities of how the natural strategy works applied to a technology for a cosmetic product." For her, the NII program is not successful unless it produced a substantial commercial success and the less tangible effects did not indicate success based on this criterion. However, as Interviewee 8 pointed out, "We don't have a protocol that we say 'Okay, the scientific community, the academy, considered this biomimicry or not'," making it difficult to determine what is NII and what is not. Adding to the confusion of observability, Interviewee 9 expressed concern regarding the NII product in late development. He was cautious of greenwashing and expressed difficulty linking the concept to specific biological strategies to enable a cohesive NII story appropriate for marketing purposes.

3. Complexity

The program manager in charge of the project, Interviewee 4, described various ways in which complexity was a factor of the NII projects. "I am kind of already exhausted of ideation sessions. [...] My feedback to [the NII consultancy] was... we are not going to be able [...] to just trust that the ideation session is going to come up with a perfect solution 'cause it never comes out to be the perfect solution. It's a good input but it's not going to generate the output. At the end what happened was, I couldn't ground the ideas with [the consultancy]. I closed the project [...] because they are not a group ready to develop a solution. They're ready to present a possible idea that could result in a solution. And if I don't have anyone to develop that solution with me, I'm not going to be able to create that by myself. At the end what I wanted from [a NII project] was to come up with a briefing for a project and what came out was a briefing for another report. And the report by itself is not going to be useful for us. We need to have a partner that is going to commit to creating the solution based on the report." She continued, "Just for inspiration, you don't need a scientist. You can just have a design agency look at nature and really be inspired and seeing the shapes. It's different than really applying the chemistry, the mathematical

approaches of nature.” She also expressed how a lack of consistent definition and clear project intentions resulted in ambiguous results: “It’s just so broad and has so many different meanings that if you don’t have that for yourself what it means for you, you get lost along the way.”

4. Trialability

Cosmetics Inc. chose to pursue a packaging project which they felt was a ‘low hanging fruit’, however this too proved to be difficult to implement. In the midst of the NII activity, there were significant managerial changes and the research director who initiated NII activities resigned. His replacement was more focused on short-term innovation returns and less focused on longer term, potentially higher impact results of the overall innovation strategy. This caused a shift in priorities for the scientific and research managers towards shorter-term projects and goals.

According to Interviewee 7, new managers and a new CEO recently began to shift organisational and research priorities towards a more customer-focused approach that might have negative consequences for the sustainability and research agendas. Before recent financial difficulties, she described a ‘culture of abundance’ but there were recent pressures to demonstrate more economic value. They did not ‘plant enough seeds’ during abundant economic times and they now lack innovations ready for market.

Interviewee 8 stated that NII was a difficult process to assimilate with everyday work schedules and estimated a necessary three-month development timeline dedicated exclusively to a NII effort to develop a new product. She noted that the typically longer innovation cycles in the research department frequently cause project management and administrative issues and NII would be subject to similar issues. Similarly, Interviewee 9 anticipated a three to four year NPD process for a NII product. He thought the necessary investments in staff, research, etc. make the “revolutionary potential” of NII difficult to realise in short time frames with diminishing budgets. Interviewee 2 furthered this sentiment: “I think...that biomimicry is quite difficult to apply when you have short timing, short deliverables, and so on.”

Interviewee 4 reiterated this concern and questioned whether they could demonstrate the value of NII in a time frame compatible with the expectations of the business. “I do think that there is a lot of value but I just don’t see it being ready. [...] I don’t see real value in just the inspiration. [...] It’s important as well. We need it. But it doesn’t have a specific value and that’s why I always chase the perfect project or the perfect case because as I say to have value, it needs to fulfill all of the metrics. It really needs to be sustainable.”

5. Compatibility

Interviewee 4 saw NII as highly compatible with Cosmetics Inc.: “It was a sort of a perfect match between the idea of bringing nature’s inspiration and knowledge and intelligence to [Cosmetics Inc.], which we usually have a close relationship with nature and how we relate to nature. [...] The idea of [Cosmetics Inc.] as a company has always been to have a sustainable relationship with the world, with nature and with yourself. This is something that was already embedded in [Cosmetics Inc.] belief since the beginning, so it’s easier for us to kind of just add some new ideas, new perspectives in. It’s just bringing more like a clear science behind how nature works to a company that already believed that we should work more like nature. We just didn’t have life principles.” Similarly, Interviewee 9 specified that NII could enable more sustainable solutions by altering supply chain management and life cycle assessments.

Interviewee 2 perceived NII as a logical extension of their existing conceptions of sustainability. “We have to look for the harmony with nature, [...] and somehow we have to translate these principles of harmony with sustainability with nature into more tangible criteria. [...] There are two dimensions: [...] the inspiration but also [...] the connections with nature at the end that you have to recognise. If you only use the inspiration, you can produce anything which is not harmonised with nature which would not guarantee the sustainability [sic].”

However, Interviewee 4 articulated some limitations to NII for NPD. NII hadn’t contributed to environmental aspects of sustainability because they were already using sophisticated tools to assess environmental impacts. She viewed NII as a qualitative tool. “It is more... some fresh eyes on a way to see things in a broader

way but [...] when we talk about product development, it's very difficult to set metrics in a qualitative approach. It's [...] more viable to have quantitative indicators where they can have a result and see clearly which is best. [...] It's difficult for us to set goals like biomimicry and eco-design to be included if [product developers] have two hundred things that they have in their checklist for each product. [...] They already have goals that are carbon, water, waste, recycled material, biodiversity. They already have so many rules that they need to follow to develop a new product." They do longer term, innovative work with sustainability tools, which are difficult to incorporate into other parts of the business that are developing incremental innovations very quickly.

From the perspective of the individual, several interviewees described profound shifts in their perceptions of sustainability that likely influence compatibility issues with the organisation. For instance, when asked what advice Interviewee 10 would give to others using NII: "Jump. My advice is don't try to close it or try to translate it into very conventional stuff, because it's not. It's revolutionary. So lead the revolution. Do not try to hold it. It's coming. Lead. Take the lead. [...] If you try, you lose lots of people and there will be lots of frustration really because you see reality. In reality, you understand much more. You see how unsustainable what you are doing really is, and you see that there is an interesting path way up there that you want to follow and you need to follow, so don't try to refrain from it. Jump. This can be crazy in personal terms and I can talk about personal experience. When you see those things, you cannot go back to the old way." Interviewee 6 described a similar transformation: "When you have contact with biomimicry, everything that you usually do in your life, you always look for how the things [are] happening outside the window...How are the things happen in the nature ...to solve that problem. It becomes a part of you."

Interviewee 7 described how her NII training created a bridge between several aspects of her education and training. She articulated how NII enabled her to view her work in a more holistic way. "I like the movement. What I like is the pleasure and the intelligence in the movement, of the interactions [between molecules]. [...] You can see the interactions and the movement in an atom, in chemical elements, in a chemical molecule. And you can grow it for a cell and you can grow it for a tissue or

a microbiome and you grow it for individuals and known biological players. I like the movement, the beauty of the movement, and the interactions and why 'A' doesn't interact with 'B' and but interacts with 'C'. And it's not because they don't like each other. It doesn't have this kind of concept in nature. It's not a case of likeliness; it's a case of fit. It's a case of belongingness. You belong here, you don't belong here. [...] And that's the beauty of the thing. Each day you can choose again. You can choose again. You're not stuck. You can make another chemical connection. You can do another molecule; you can destruct and recreate yourself as a molecule, as an organism, as a species, as an environment. And that's the beauty, the opportunity to choose each and everything and evolve gives the same type of pleasure.” (She had tears in her eyes at the end of this description.)

Case 5: Clean Inc.

Case Description

Clean Inc. is an international, European-based company founded in 1979 that produces personal care products and cleaning products for home and commercial use. They were privately owned by a single founding family until the mid-1990s when acquired by a private investment firm. With approximately 250 employees and the recent acquisition of a similar brand, their global reach is currently growing. Amount of annual revenue was not explicitly publicly available, though some third party websites listed \$200million in annual revenue in 2016. Their target customer is an ecologically minded consumer and the brand is designed for this “deep green” market. Given the recent merger with an established B-Corp, they have also become a B-Corp bringing in a stronger social aspect to their sustainability agenda. They have received several awards for the environmental performance of new product innovations. They are also well known for their operation of “ecological factories”, the first of which was built in 1992. Biological principles such as using wind and solar energy, recycling all materials, and using low energy processes were all considered in the design of the factory, though interviewees did not consider this to be NII. The NII activities discussed in the interviews are currently being led and funded by the long-term innovation manager's budget and many of the activities are being outsourced to design firms and consultants.

The NII activities began within the last ten years, though no specific dates were given in the interviews. Given that NII has been a major influence on the organisation's sustainability narrative, it may be difficult to discern specific timelines of engagement. However, NII activities have recently become a more explicit aspect of their sustainability strategy and are on the rise internally.

Interviewees included two current staff members and external consultants from three separate NII projects. All interviewees were willing to engage and open in their discussion of the NII projects. Interviewees involved in the NII activities included the following disciplines:

Interviewee 1: Product design

Interviewee 2: Product design, Biomimicry

Interviewee 3: Biology, Sustainable design

Interviewee 4: Psychology, Marketing, Biomimicry

Interviewee 5: Sustainable Business

Interviewee 6: Industrial Design, Management

Interviewee 7: Environmental Scientist

NIIs Attempted and Achieved

Technological Innovations

Technological Innovation 1 (Achieved)

T1 Synopsis: New packaging utilising all recycled materials that were designed with structural inspiration from a marine organism to optimise strength-to-material ratio.

This innovation involved the creation of a new packaging design that emulated several biological strategies in the design of the bottle itself and in the life cycle of the package. The design emulated the structure of a marine organism, which resulted in higher strength to material ratio than similar designs. In addition, the product used recycled ocean plastic as its primary source of material, emulating the principle of "waste=food." Other aspects of this innovation, are described below as Systems Building. Interviewee 1: "We applied biomimicry from beginning to end in the design of the bottle."

Technological Innovation 2 (Achieved)

T2 Synopsis: Fermentation chemistries used in product development.

They aim to use “life’s chemistry as much as possible” (Interviewee 1), referring to fermentation chemistries rather than traditional chemical methods to produce their products. Additionally, they are considering their product life cycle in relation to the biocycle after use.

Technological Innovation 3 (Achieved)

T3 Synopsis: Synthetic biology to produce algal oils that replace palm oil.

They take the position that synthetic biology can be considered NII in some instances and have been applying it to an aspect of their production processes, to create algal replacements for palm-based oils. (In recent years, increased demand for palm oil has resulted in destruction of tropical forests and many organisations are seeking replacements.) When they recently came under scrutiny from environmental groups for their use of synthetic biology, they sought the opinions of NII thought leaders to influence their decision-making in the use of these controversial techniques.

Organisational Innovations

Organisational Innovation 1 (In progress)

O1 Synopsis: Design of the business and its activities on the systemic principles of ecosystems.

Interviewee 1 described, “Our central question is how to design all our business more like an ecosystem. So we start from fundamental principles that are coming from how ecosystems work, really on a systemic level and translate that into products and services and business models and whatever as much as possible.” This broad reaching goal influences all other NII types, but is unique as a management innovation.

Organisational Innovation 2 (Achieved)

O2 Synopsis: Development of informational materials for products that demonstrate

inspiration from and integration with natural systems.

Clean Inc. partnered with an external NII consultant to develop product informational materials that emphasised NII for new products and the general approach to business. These materials included short stories of ecological and biological functions that relate to their products and water use. Their aim was to increase awareness of ecological function and the role that their products play in the hydrological cycle through the storytelling of biological strategies. Interviewee 4 described, “We started with cleaning stories and then it expanded a little bit on a packaging story. We looked at other parts in the value where they could maybe influence other people doing other stuff in logistics or that was related to their own business but not necessarily the ingredients of the products themselves. The goal was to have a larger public that would go “Wow, nature is really cool and [the company] is looking into it and this is something which is really different from any other biodegradable soap.”

Systems Building Innovations

Systems Building Innovation 1 (In progress)

SB1 Synopsis: Localised system of production and consumption for a new place-based product.

One NII activity was intended to create a localised production and consumption system utilising local raw materials and a new business model based on the concept of an ecosystem as a model for manufacturing processes. It was also an attempt to prototype a ‘glocal’ (i.e., globally local) approach to manufacturing and distribution. The concept was to form a consortium of manufacturing partners to create a new product which would be locally sourced with non-food agricultural sources and distributed only locally (i.e., on an island location). Interviewee 1 stated that they were looking for available feedstocks for raw materials that did not compete with food sources. Clean Inc. hired an external consultant to manage the effort and coordinate the consortium for the initial phases of the project. The external consultant then formed a team of sub-consultants with expertise related to the development of a new product. After several meetings with consortium members

individually and one large workshop-style meeting with all prospective consortium members, the innovator leading the project from Clean Inc. commented that stronger interest and leadership was needed from the local businesses and Clean Inc. could not continue to fund the development of the project, leaving it 'dormant'. At the time of interview, one external consultant was seeking grant funding to advance the research end of the new product development process. For the company, it was an experimental project to create a new business model but as it developed, it became apparent to the innovation manager and the outside consultants that a wider base of support was needed in financial support and entrepreneurial expertise. At the time of interview, it was unclear if the project would progress.

Systems Building Innovation 2 (Achieved)

SB2 Synopsis: Plastic for recycled product packaging were collected by local fishermen and school groups to remove polluting plastic from the oceans and beaches and reincorporate it back into their supply chain.

As described in TI1, NII was applied to packaging design. In addition to the technical applications, the project also had goals within the greater socioecological system. According to Interviewee 1, they aimed to create a 'restorative' package and claim that 'for every bottle you buy, there is less plastic in the ocean.' They partnered with fishermen and local groups to collect ocean plastic (specifically PET), during waterfront cleanups, They have since expanded this program in partnership with elementary schools and created an educational awareness package to engage students in the collection and recycling of plastic waste.

Factors Influencing Adoption

Factors: Characteristics of the Innovation Context

1. Norms Of The Social System: Perceptions of Sustainability

Clean Inc. was founded specifically to address the need for sustainability-oriented products in their sector and this has become progressively more integrated into the organisation. According to Interviewee 2, they were founded specifically to serve a market niche of environmentally friendly products in their sector and have maintained this mission throughout their history and changing leadership. An important aspect of

their sustainability messaging is the use of only plant- and mineral-based materials and manufacturing processes that allow the materials to be reabsorbed back into ecological processes after use. There is a component of bioutilisation as part of the NII story to support the ecological elements of sustainability. Interviewee 2 described, “[...Clean Inc.] is one of the few genuine companies in terms of sustainability. They really care. They really are doing their very best to be good.”

The innovation manager (Interviewee 1) is officially the employee responsible for corporate sustainability, but views his role as more of a coordinator because they position sustainability as the responsibility of every employee. Historically, they have taken their sustainability agenda for granted as an integral part of the culture. Recently however, they began to formally track environmental, social, and economic metrics as part of the overall corporate strategy discussed weekly by the management team. Previously this was an informal aspect of management discussions, but the company has recently grown and a formalisation of accounting became necessary to ensure company alignment. He described collaborations with stakeholders such as environmental NGOs to discuss various sustainability issues that have emerged in their business in an open roundtable format (e.g., the use of GMOs to replace palm oil).

Interviewee 7 further articulated how they are positioning their sustainability agenda: “[One] key element in this is learning from ecosystems...the fact that...ecosystems can be restorative. When they're being impacted by external forces, they have the ability to restore themselves. That's the idea then, being translated to our main sustainability philosophy...that we want to... be a business for good, to [create] those kind of restorative cycles. We could help ecosystems. [...] We mostly try to work within the biocycle and the biosphere. [...] Again at the systemic level, one of the principles that we use is that an ecosystem is able to provide a symbiotic environment for all its constituents - animals and microorganisms - whatever lives in that system are being taken care of in mutual understanding, almost. They depend on each other. [...] [We] do then more translation of social element that we, as a business, we need to provide that kind of ecosystem for our work as an immediate community to improve their wellbeing.” Interviewee 3 reiterated similar sentiments: “We're in a situation where we really need to do more than just 'do no harm'. We

need to restore but also reconcile the gap between humanity and nature and in a way, the combination of the two is what [being] regenerative is trying to achieve.”

Interviewee 7 described the progression of their sustainability focus through time from only “what’s in the bottle” until their current approaches to redesigning the bottle itself, how products are produced, and how they are engaging with local communities and universities, etc. Interviewee 1 further described how they are expanding to a more holistic view of their supply chain: “The third [sustainability focus] is shifting from linear systems to restorative loop systems, a circular economy idea, focused on this bio-based goal. [...] This [focus] is a very high ambition, something we aspire to do.”

An external product design consultant (Interviewee 2) described how he worked with Clean Inc.: “...The most important goal of the [Systems Building Innovation 2] was to alert society of the huge problem [of] the plastic contamination of the oceans.” He further articulated how he viewed NII as an approach to SOI: “It’s always extremely exciting to just go straight to the research phase and look for nature models and do the emulation and start doing brainstorming about...what you discover, but if you do not have constantly on your mind the importance ethical and reconnection part of biomimicry, you are missing the point of doing biomimicry.”

2. External Knowledge Sourcing

The NII projects involved at least six external consultants to implement NII initiatives and the innovation director sought consultation on other issues from NII specialists. At least three of the six consultants had specific training in NII. The various innovation teams included two outside consultants with design training and internal innovator is a designer by training. The NII activities also involved several other partners that focused on developing the supply chain to support NII activities rather than the innovation and design process.

3. Informal Social Network Collaboration

As an organisation, they are well connected with several individuals and organisations known for NII and have relied on these connections for advice on

various issues, ranging from product design to marketing to sustainability assessments of materials.

4. Leadership

The degree to which leadership valued intangible benefits was not obvious based on interview data, though it may be significant that the Innovator's job title is 'Long Term Innovation Manager'. Interviewee 3 described how this title is difficult to reconcile with current circumstances: "I think that's partially why we're currently in a bit of a limbo because I think that they charged [the innovation manager] with being daring and innovative and doing something out of the box and that's what he's done and now they're kind of going 'maybe not quite so out of the box'.

Interviewee 1 described how sustainability is a key aspect of the company agenda and an innovation manager coordinates these efforts. Leadership made a strategic decision to not create a sustainability department, per say, but rather position all employees as attentive and accountable to this agenda. Interviewee 2 described how this decision has been implemented: "[The innovator] wants to do his best to integrate biomimicry in every single aspect of [Clean Inc.] and he's trying to understand how he's able to do that effectively."

Interviewee 4 was an external consultant who was doing communications consulting with Clean Inc. to help their customers understand their NII strategy as an approach to SOI. She recounted some of her experience: "When I did the first presentation and their director was there, he said right away, 'we have this meeting in June and with the board and you should come in and tell them about this'. So, I think there's more people [in support of NII] and they all were very excited about this."

For other NII projects, support from senior leadership was less clear. The SB2 project reached a decision point in its development that required increased investment from the rest of the senior leadership team and support regarding the next strategic decisions for the project. At that time, it was decided that Clean Inc. would not continue to fund the project. It was unclear whether this decision came from the innovation manager or others of the management team.

There was no evidence of managerial insularity, likely due to the managerial role of the innovator.

Factors: Characteristics of the Decision-Making Unit

1. Attitudes Towards Innovativeness

Interviewee 7 described how they collaborate extensively with universities and outside research departments to develop new materials and molecules that are lower impact than current products. They have a long history of this type of engagement with open innovation. Interviewee 1 also described how they contracted with several outside consultants to implement NII. At least four outside consultants that they have engaged with about SOI activities have extensive training in NII.

Concurrently, however, Interviewee 7 (R&D manager) and Interviewee 1 (innovation manager) described how they frequently push innovation into a somewhat reluctant group of internal researchers and scientists. Interviewee 1, the manager responsible for NII internally, expressed frustration over this reluctance of the company scientists to consider novel approaches to new product development in the lab. Interviewee 1 summarised: “Whenever you talk to [the chemists] about, ‘yeah, let’s go out in nature and find some stuff,’ they think you are crazy.” The company does not develop new materials internally and given that they are a small, consumer-facing company, they are reliant on external research partners to drive much of their SOI activity.

2. Formality of Organisational Structures

There was no indication of formal innovation or organisational structures. They were in the midst of a merger throughout the interviews so several structural issues were pending.

3. Professional Training

There was no NII training within the company itself, though at least four outside consultants have completed intensive NII trainings.

4. Selective Exposure and Perception

There was little detail given of various NII approaches, though they did demonstrate awareness about cradle-to-cradle and circular economy as a design and innovation strategies in addition to biomimicry.

Two interviewees described how they maintained a critical view on the integrity of claims of NII amongst their own organisations and others. Interviewee 7, R&D manager, expressed his views: “Whenever I hear the word biomimicry, I’m a bit skeptical. Some biomimicry projects, for sure, came about taking inspiration from nature or actively taking this biomimicry approach. For some others, this biomimicry name came in after...just kind of a selling proposition. And I find that the two stories are kind of mixed up, or too intermingled, to really make it a pure thing.”

Interviewee 2, a product design consultant who applied NII to NPD for Clean Inc., also described how he perceives various NII projects with a critical eye: “I’ve seen many bionic projects that, [...] I look at them and ‘wow, this is an amazing project.’ But when I start looking at the ethos and the reconnection part with nature, the projects ethics are very, very questionable and the relation that they actually have with nature is kind of dominant relationship. [...] Even though they are being inspired by nature and trying to learn with some organism but they basically continue to think that the organism’s only purpose to exist [...] is to serve humans.”

Factors: Characteristics of the Innovation

1. Perceived Relative Advantage

Low/no ROI was problematic for SB2, but it was not explicitly articulated as such by the Innovator. It was more likely an issue of complexity and long-term ambiguity about the project. Low ROI was not an apparent issue for other NII projects. For instance, several interviewees commented on how NII enabled novel ways to innovate in their supply chains. Interviewee 1 described how Clean Inc. partnered with fisherman who then collaborated with local environmental groups who facilitate waterfront clean-ups to collect ocean plastic to return to the company as a raw material for packaging.

Interviewee 3 gave his perspective on the value of NII when applied to systems building in reference to SB1: “If you’re really working on biomimicry at the

ecosystems level then it is absolutely normal that you would find sort of keystone species in the ecosystem and they might be the ones that initiate the project, so to speak, but eventually as you understand the potential for synergies and the need for missing pieces in the puzzle, they become collaborators in a much wider system of collaboration. And also the economics of it probably only begins to start up if you don't look at just [the company's] economics but you need to look at a number of collaborations that fit together and find new economic models to actually share the benefits of the innovation. [The innovation manager] probably got a bit concerned when he realised how big of a project this really is and but if we got two or three other players that also have some bigger weight in it to join in, then they could finance it and [the company] will just be one of three or four major companies supporting this concept that we are creating as a test field for a regional bioeconomy.”

Other interviewees described other types of advantages of applying NII. For instance, Interviewee 4 described, “With the language of biomimicry, you can make it something bigger than the small project in itself and also give them some direction where to go in the future.” Interviewee 2 also valued the expansive thinking of the NII approach: “To approach a challenge using nature as ally to try to solve the problem basically opens extremely the possibilities of not only solving that challenge, but of doing true, true innovation. [...] It quickly makes you rethink all of the preconceived ideas that you have about a product or a challenge. It's always very, very refreshing when you start doing the research the biomimicry research and looking for natural models and you start discovering the organisms that actually already solved the problem that you are trying to solve. I'm always amazed with the strategies that I find because...most of the time I never thought of that.”

2. Observability

There was no clear evidence that lack of observability was a barrier to NII. To the contrary, interviewees saw it as an advantage. For instance, Interviewee 1 described how NII is a valuable SOI approach because of its scalability, going from the systems level to more specific technical challenges. As an example, he described how he translates ecological principles into SOI: “From a principle point of view, using fermentation technology is a lot more like it's happening in nature compared to

practical chemistry. [...] We also tried out the cleaning idea versus the cleaning with chemicals idea, and again as a main principle, it links a lot closer...to our ecosystems work and how [cleaning is] being dealt with in an ecosystem.”

Similarly, an external product designer (Interviewee 2) articulated how he applies biological principles to product design: “Life’s principles [is] much more important than if the packaging resembles a tree or a fish or a tiger or whatever. For me, it is an accessory in this process because Life’s Principles go much deeper in terms of being truly sustainable.” (Life’s Principles is a design tool created by a NII consultancy).

3. Complexity

There were a few instances of complexity being an inhibitor of implementation. Interviewee 1 explained, “It is used in some very concrete cases but it is more difficult to apply it on a very technical aspect some times, when we talk about the chemistry. And I think we have not yet many projects where we really started from chemistry that we found some where in nature and then applied it into our product.” They rely on collaborations with external innovators to develop new materials for their products including ingredient suppliers, universities, and other research institutions, creating some limitations on their NII activities.

Interviewee 5 described how one problematic issue with SB2 was the level of complexity and the ability to tell the story to large audiences with short messages. The marketing team involved with the project had difficulty distilling the key messages out of the project in such a way that they could distribute it via social media to generate interest and support for the project.

4. Trialability

Though Clean Inc. has invested substantially in open innovation for NII, Interviewee 1 described the cost prohibitive aspects of undergoing new product development with one specific outside NII consultant, suggesting that Trialability might be an issue.

5. Compatibility

NII as an approach seemed to be very compatible, if not the most important aspect of their SOI agenda. Interviewee 1 gave an overview of their sustainability agenda: “We’ve reviewed our complete sustainability philosophy...in several layers, going from ‘what are the principles we start from?’ all the way down to ‘when you have actual roadmap?’ So you know starting from the main principles, there are certain principles in nature that are so fundamental that they should be guidance for us a business tool to start from. Our central question is how to design all our business more like an ecosystem. So we start from fundamental principles that are coming from how ecosystems work, really on a systemic level, and translate that into products and services and business model and whatever as much as possible. So we're starting from that. [...] For our products, we have to embrace specifically the biological cycle of extracting renewable materials, making products which [have] certain functions to deliver a sustainable way by using life’s chemistry as much as possible...so fermentation as much as possible. And then making sure whenever they’re used, they’re integrated back into the same cycle. We're looking to cradle-to-cradle philosophy combined with biomimicry. That’s kind of the fundamental bio-cycle that we focus on.” Interviewee 7 also described how some NII work was serendipitous for them: “Biomimicry became a common word maybe seven or eight years ago and it wasn’t until that time that we realised that some of the work that we were doing was biomimicry... or looking for inspiration from nature.”

When discussing SB2, Interviewee 6 described some of the inherent tensions when promoting a NII strategy to innovation at the systems level. This project involved multiple stakeholders from one region and engaged them in new forms of economic activity compared to what they are doing now. The current economy of this region is based on tourism and SB2 would represent a transition to a closed-loop production model, shifting the economic drivers of the region substantially. Interviewee 6 described some of the tensions with this situation: “I think [SB 2] is a political question. Saying actually, we're criticising how the economy is working...And that takes a completely different turning there. We’re not talking about a closed-loop product. We're not talking about the bioreactor. We’re not talking about the satellite company. We’re talking about the economy. [...] Which is interesting because glocal - or models like these ones that fundamentally challenging how we commercialise

and enable different collaborations - that is exactly something like a political message in some way, which is not what we want. We don't want to go that route."

Interviewee 2, an external design consultant, also described how NII may or may not be compatible for an individual or an organisation: "[NII] is a design discipline, but it's also a branch of science, but it's also almost a philosophy. It's a movement. [...] I cannot separate my personal from my professional life in terms of biomimicry. [...] I cannot do biomimicry on Mondays and Wednesdays and do business as usual the rest of the week. For me, it does not work that way. [...] There is an ethical part of doing the biomimicry practice and there is also a process of analysis about how you related with nature. What is your sort of relation that you have with nature, that you need to analyse in order to put yourself in the right place before you do the emulate part? So for me that is really...It's mandatory."

Case 6: Textiles Inc.

Case Description

Founded in 1973, the company is a publicly traded manufacturer of durable consumer goods based in North America. Its operations include 4000 employees and in 2012, generated \$932 million in annual revenue. They have 33 manufacturing facilities located globally, a global distribution reach, with sales in the Americas, Europe, and Asia-Pacific, and sales offices in more than 110 countries.

Most interviewees referred to the company-wide story that the company's founder and long-time president had an 'epiphany' in the mid-1990s, realising that his life's work in resource-intensive manufacturing was causing such harm, he began on a visionary leadership path to transform the company to a more sustainable model. The Innovator assembled a team of sustainability practitioners that served as an advisory board including Janine Benyus, who is credited with coining the term biomimicry, William McDonough, co-author of Cradle-to-Cradle, Amory Lovins, co-author of Natural Capitalism and Karl Henrik, creator of The Natural Step Framework, among many others over the years. The company has undergone a long process to change the culture and operations of the organisation so that all employees are responsible for the transition to a more sustainable business. It has

become known as leader for corporate sustainability and a pioneer in NII, frequently cited as a case study for applied NII.

In the late 1990s, the first NII activities were initiated by an external design consultant who hosted sessions with internal staff and an external NII consultant. Since then, several product, process, organisational, and systems building innovations have been accomplished. With NII as a major component of the company sustainability ethic, it was difficult for some interviewees to refer to specific projects, but they have been using the approach broadly for approximately 22 years.

Interviewees included internal employees in sustainability, innovation, management, and human resources and external design consultants who have worked closely with the organisation for over 20 years. All interviewees were open and willing to contribute to the interview process. Interviewees involved with NII activities included:

Interviewee 1: Biology, Economics, Business, Biomimicry

Interviewee 2: Biology, Chemistry, Management

Interviewee 3: Product Design

Interviewee 4: Engineering, Textile design

Interviewee 5: Engineering, Marketing

Interviewee 6: Engineering

Interviewee 7: Textile engineering, Marketing

RQ1: NIIs Attempted and Achieved

Technological Innovations

Technological Innovation 1 (Achieved)

T1 Synopsis: Modular component design that reduces the need for total replacement throughout the product life cycle.

Their most referenced use of NII has been in the form of a new product that emulates several biological principles, resulting in a modular component design that reduces the need for total product replacement throughout the lifecycle of the product. This was created in partnership with an outside design consultant and an outside NII consultant. The NII product design emerged from an explicit process with

an external NII consultant in which the consultant took the design team into a natural environment to identify biological models related to the design challenge. Today, this product represents 40% of their total sales.

Technological Innovation 2 (Achieved)

T2 Synopsis: Adhesive product that reduced the need for >90% of total adhesive.

A second product innovation was developed as part of an analysis of their overall impacts. They developed attachment component that eliminated the previous need for adhesives altogether and substantially reduced the impact. The origins of this story are mixed, with the Chief Innovation Officer and the project team leader crediting NII with the solution from an internal design and engineering team, but one leading engineer viewed NII as peripheral to the innovation process.

Technological Innovation 3 (Achieved)

T3 Synopsis: Sophisticated used-product collection infrastructure built into their supply chain that closes material loops and enables product recycling from other manufacturers as well.

Interviewee 7 described, “The whole recycling program that we’re operating, so the [recycling] program which we have running in the Americas, in Europe, and we just started to build up in Asia Pacific and also in fact the [upcycling] program that we introduced a couple of years ago in the Philippines, both those programs were based on the principle that nature doesn’t do waste, and that waste from one kingdom of nature becomes food for another kingdom of nature.”

Technological Innovation 4 (Achieved)

T4 Synopsis: To enable the aforementioned recycling program, the company partnered with process engineers to design a new separation technology to recycle fibers that were not previously accessible.

As part of their overall strategy to reduce the amount of raw materials in their supply chain, they have developed several innovative ways to recycle their product and recycle the used materials. Part of this strategy was to engage with outside

engineers to develop a piece of equipment that could disassemble their product into its constituent parts so it can be re-manufactured into new product, effectively closing the loop on their material use for two of their primary needs.

Organisational Innovations

Organisational Innovation 1 (In progress)

O1 Synopsis: Ecological Performance Standards to guide the redesign and operational performance of factories.

According to Interviewee 9, they have been experimenting in recent years with outside consultants to develop *Ecological Performance Standards* for a new factory facility that was already built and another one that is currently in the design phases. The goal of Ecological Performance Standards (as described by several biomimicry practitioners) is that a building and its operations should provide the same functions as the native ecosystem would in terms of water filtration, carbon sequestration, temperature moderation, and other such services. This was in early phase development at the time of interview.

Organisational Innovation 2 (Achieved)

O2 Synopsis: Various managerial perspectives inspired by biological phenomena that are consequential for strategy, operations, new product development, etc.

According to Interviewee 3, the Innovator's vision of sustainability represented "where we're going" and NII was "how we can get there, what can we do." Interviewee 7 described how their NII agenda was developed in the early days of their activities: "It's using those tenets that [NII consultant] laid out about how nature would run the factories [...] that we've used in our organisation for some time. And what we've done over the last 20 years on this journey is, we've been far more, frankly speaking, far more focused on environmental sustainability and less focused on some of the other sustainability issues, like social. So we've used biomimicry as a tool to engage our factory, our shop for our workers, in thinking differently about process, in thinking differently about raw materials and wastage and that's helped with our programs like our local internal waste elimination program. And so we've run

workshops in the factories to teach the principles of biomimicry. We have some biomimicry professionals within the organisation now who are continuing to preach the principles of biomimicry into our business into different areas. We do it with marketing, as well on how does nature communicate, how would we use examples from nature on a communication strategy from the marketing teams. So those are the kinds of areas that we've used biomimicry for, apart from the obvious [product innovations].”

Interviewee 2 further described the company-wide application of NII: “We've looked at it in a lot of different ways. We looked at processes as in feedback loops within the company, [...] trying to understand closed and open loop, feedback loops. And trying to identify how we can effect change rapidly through an open feedback loop example.”

Interviewee 6 also applied NII as a broad managerial goal: “Biomimicry allowed us to find the next ‘Aha’. [...] It changed the way we thought about something. [...] I think everybody is always looking for the tangible [NII products], but the thinking that really changed inside the company was one of abundance versus scarcity. [...] It let us understand that the next ‘Aha’ was not really that scarce, that it was actually very abundant and that we could take an old innovation and essentially marry it to a new innovation and look at all the offspring and see how they played across our needs matrix.”

Interviewee 1 described how she had been incorporating the concept of resilience into their management strategy and drawing inspiration from resilience strategies in natural systems such as the adaptive cycle, seed banks, and DNA.

Systems Building Innovations

System Building Innovation 1 (Attempted)

SB1 Synopsis: New textiles made from waste plant materials in partnership with female artisans in an emerging economy.

This project aimed to partner with female artisans from an emerging economy to produce new textiles using waste plant material. This production method, while a

viable NII model with a social benefit, did not continue because the product did not meet customer expectations of a specific aesthetic and would have required creating new market channels.

Systems Building Innovation 2 (Achieved)

SB2 Synopsis: Nylon for 100% recycled products was collected by local fishermen and other community members in emerging economies to remove polluting nylon fishing net from the oceans and beaches and reincorporate it back into their supply chain.

Interviewee 7 described how they were utilising discarded fishing nets as a novel source of material as part of their strategy to make textiles from 100% recycled materials. “That’s where the [upcycling] program came in; we developed the [upcycling] program basically for two reasons. First, it was the idea of scavenging waste and second was the idea of bringing a social aspect to our product... So the opportunity for [upcycling] where we’re scavenging waste fishing nets and then selling them into our supply chain, becoming a supplier of our supplier, was too good an opportunity to pass and we developed the whole [upcycling] program. [...] We have set this up to be independent. [...] We’re not involved with the day to day running of them. [...] The villages run their own community banking scheme. We don’t have any skin in the game with those at all. We set them up [and] third party monitor them to make sure that they’re maintaining their transparency. And we do that through [NGO partner] and they’re on the ground support. But it’s a separate inclusive business model that we setup. [...] It’s not philanthropic. [...] If they are true to stand the test of time and true to be sustainable, you need to set these models up so that they’re self sustained.” The motivations and logic behind this project vary amongst interviewees. For some, this was not related to NII and was rather a way to incorporate the social aspects of sustainability into products. For others, it was viewed as a NII approach because it “views one organisms waste as food for another organism.”

Systems Building Innovation 3 (Achieved)

SB3 Synopsis: Development of regulations to ban their product from the landfill at the end of its use, driving SOI for the entire ubiquitous industry.

Interviewee 4 has been working intensively in one US state to create regulations banning this textile from the landfill. As part of the industry committee working on this issue, he is the only textile manufacturer who is actively supportive of these regulations. “The industry is really fighting this movement towards producer responsibility.” As their textile recycling program has grown, they are discussing the establishment of regional hubs where materials can be processed without being reliant on shipping back to headquarters for recycling before re-entering their supply chain.

Systems Building Innovation 4 (Achieved)

SB4 Synopsis: Development of a textile-recycling infrastructure across several countries via the sharing of their intellectual property, unique capabilities, capital resources, and technological know-how.

Interviewee 7 also described how they were working with suppliers to develop textile recycling infrastructure across several countries: “We went to some of [the textiles recyclers] and said, ‘Well, we know how to separate [textiles]. This is the intellectual property that you need, this is the know-how that you need, this is the type of equipment you need and if you set this up, we’ll buy the materials off you.’ So that was very successful in California so we’ve now set that up in three or four other hubs now in the Americas. And each of the models is slightly different because you’re effectively working with ... the waste management people. So some of these guys have got machinery and infrastructure but they just need a customer, some of these guys have no idea how to start so they need technological know-how and some of them need investment because they’ve no money. So we’ve done all of those different [things]: we’ve invested in some of these guys; we’ve given them machinery or know-how; we’ve provided them with a customer that is prepared to purchase the waste materials off them.”

RQ2: Factors Influencing Adoption

Factors: Characteristics of the Innovation Context

1. Norms Of The Social System: Perceptions Of Sustainability

The majority of interviewees provided rich descriptions of sustainability and how Textiles Inc. was connecting NII and sustainability. Interviewee 7 traced this connection back to the founder: “We’ve talked to our business many times about the principle of becoming restorative through the power of our influence. That was how [the Innovator] framed the question, and so become ‘restorative through the power of our influence’. And [the upcycling initiative] is a program that alludes to what restorative business might do. So we’re now starting to think about that in a much broader context.”

Interviewee 4 reiterated the idea of being restorative: “We put upon ourselves quite a lot of restrictions because we ... want to be restorative as a company. [...] Not just get to zero or no harm. We want to actually start doing more good.” Conflictingly, this interviewee also commented that NII was not a part of his daily activity and he denied that climate change is primarily human caused, suggesting a dissonance within his views on sustainability. In this way, he was unique amongst interviewees in this case.

Interviewee 6 was able to trace the NII activities back to the origins and articulate continuity of NII practice from the beginning until current activities. He gives a lengthy but thorough description of their process to incorporate NII at multiple levels: “I was in the earlier stages of biomimicry. We all read the book together and [...] there was a lot of internal work in the business to look at our systems in, what I would call, a biomimetic mirror, essentially comparing what we’ve built to the cycles in nature. And we looked at it from a management standpoint and a process standpoint, as it is really a way to get a comparative against a truly elegant solution. [...] So, we at [Textiles, Inc.] kind of have this point of view that the system is broken and that we have a choice everyday to be a part of the existing system that’s broken and perpetuate it or to choose to be part of the solution that can show the rest of the world that you can be relevant in a closed environmental system, called the world, right? Earth. And I think a lot of that has to do with not only how we fit in environmentally but also how we fit socially. We’ve developed this point of view over time but I know if you go back to the original definition of Darwin’s fit, we start to look at product design with a very different point of view. [...] I think we started out [...] saying ‘how can we design our [textile], a product with more relevance?’ And then

we started saying, 'how can we design a new process with more relevance?' And then the next part was, really, 'how do we design our system to fit?' I think that's probably where we are today in our thought. And when we start talking about our system we're talking about everything from management of raw materials to management of human assets to management of distribution to reverse supply chain to all of those, the way the product is being used, whether the product is accretive in its space or not, those kinds of things."

Interviewee 1 described how they strive to be leaders in corporate sustainability: "...What we can do [is] create the models of success so that when we are in a reorganisation as a society, we'll have these shining beacons. [...] For example, when petroleum becomes increasingly scarce and volatile and [...] when we finally come to terms with the overall climate change, there's going to be this shining beacon of the [Textiles, Inc.] model that says, "Look, we've been able to make an extremely resilient product without using any petroleum, new or virgin resources. So there is a path for it and here's a model. This is how you do it." She went on to discuss training mechanisms and presentations that she uses to integrate sustainability and NII into the company SOI narrative: "For us, facilitating reconnect [with nature] opportunities is a way to translate this very abstract notion of everything that we are doing in terms of sustainability. [Textiles, Inc.] is rooted in this recognition that anything we do to the web of life, we do to ourselves. [...] If we can facilitate reconnect opportunities, that's when people actually can have a visual connection to our mission and what we are doing. [...] The global biomimicry workshop, that was one of the very clear design intents, is having our hourly associates have an opportunity to be out in nature and do so with intention of thinking about connecting."

Interviewee 2 further described this integration: "Now, [sustainability] is so institutionalised, that's just part of who we are. When new people come on board, [...] they get indoctrinated immediately into it and it's just part of the basics. So it's changed over time because it had just become part of everyday business here. [...] It's not this whole revelation and new and wow-effect that it used to have back in the day, which is a good thing, I guess."

Interviewee 7 noted how individuals have a personal relationship with sustainability throughout the company: “If you walk around any of our factories and you ask our people working on the lines on the manufacturing lines, most of them will refer to sustainability. Most of them will talk about you know the higher purpose of our business. The reason for being.”

Several interviewees specifically connected their sustainability strategy to NII. Interviewee 1 described how NII principles are incorporated into their sustainability strategy. For her, sustainability is “creating conditions conducive to life”; “a mentality of abundance versus fear and scarcity that is often the mentality for sustainability.” She continued with various other biological principles that are integrated into sustainability messaging: “Imagine if creating conditions for other life is the goal for business.” “Sustainability is sort of like homeostasis. Homeostasis is never static. It’s this constant creation and destruction. It’s not static. And so sustainability in nature is really this illusion of resilience and regeneration. So because you have resilience and you have regeneration, then that’s what creates sustainability.”

Interviewee 8 posed a question as if the two concepts were nearly identical: “How is it that you can have a sustainable company that you don’t look at what’s already working? And that’s nature.” Interviewee 5 also articulated a similar sentiment: “They’re [NII and sustainability] all part of each other.” To further develop this strategy, Interviewee 7 described how they are redesigning their factories using ecological performance standards as design guidelines: “We’ve been really exploring how you could set up a factory that was indistinguishable from nature, that operated the same principles as nature did.”

2. External Knowledge Sourcing

As one of the earliest adopters of NII, they have worked extensively with outside NII consultants as described above. They have also relied on external design consultants and other partners in open innovation strategies, particular for systems building innovations. The first NII activities were initiated by an external design consultant who developed a NII product that has been very successful.

3. Informal Social Network Collaboration

Two specific interviewees shared their experiences of social network collaborations. Interviewee 2 shared her experiences of monthly 'get-together' where participants took turns giving presentations on NII topics (after the initial two-day workshop in NII in the very early days). Interviewee 1 described how they currently participate in a biomimicry community of practice between Textiles, Inc. and three other MNCs that are using NII who meet on the phone monthly to share experiences. As leaders in NII, they likely have engaged in several informal collaborations over the years beyond what was described in the interviews.

4. Leadership

Several members of the leadership team had personal experiences and long-term perspectives on the role that NII had played in their success as an organisation. Interviewee 6, a senior level manager and long-term employee, described his views on some intangible and tangible benefits of NII: "Clearly the acceleration of innovation at [Textiles Inc.] coincides with our provocative conversation around biomimicry. [...] From the time that we were not comparing ourselves to nature to the time that we were, we accelerated our innovations and marketable innovations, four to six fold [during that] ten or fifteen year period." He went on to describe how NII was a process that "governs your thought more than your actions" like other sustainability tools do. He described how it gave him "altitude" to look at the cycles of the business instead of focusing on only a "snap shot in time".

Interviewee 2 recounted her impressions when the founder/innovator gave his first speech announcing the transformation he wished to pursue to make the company more sustainable: "[The Innovator] gave that speech [about sustainability] to us and we were very much blown away. It was a very heartfelt, a lot of tears in the eyes of the audience and we were just amazed and excited that suddenly our job was opened up to be very different from what it had been before. It was great from the beginning to watch the transition to where it became the driving mission for everybody in the company."

A human resources manager, Interviewee 8, described how she views NII and sustainability as a part of the company culture: "If we say we believe in this sustainability, biomimicry, [our sustainability agenda], if we honestly say that that is

part of who we are, then we owe it to our people to share that information and then allow them to process it and be educated in it.” Interviewee 1 also articulated similar views: “If we don’t have our people engaged, we are definitely not going to achieve the goal of redesigning commerce itself.”

Interviewee 4 perceived a shift in the company culture. In the early days of the sustainability transition, there was a resistance to this kind of change and people thought that the founder/innovator would bankrupt the company with sustainability efforts. Interviewee 4 was an employee during the early days of this transition. He then left the organisation for eight years and came back to a different organisational culture where the sustainability agenda was well-integrated and the resisters had “self-selected themselves out.” Enough time had passed that they also started to see some financial benefit from their sustainability efforts, changing the way that employees viewed the initiatives.

Interviewee 7 described how leadership had driven the cultural transition: “We were perhaps fortunate that it was the owner and the leader of the business that drove the direction of the organisation and created that alignment. And then he became one of many voices in the business pushing the sustainability agenda into place.”

Interviewee 1 described how the legacy continues today with several senior members of the organisation very supportive of NII, and although there are clear roles, the culture is “pretty nonhierarchical”.

Factors: Characteristics of the Decision-Making Unit

Given that the decision to adopt NII happened over two decades ago, there is no specific decision-making unit that is responsible for this decision explicitly. Rather there are several individuals across the organisation that maintain the institutional memory of NII efforts.

1. Attitudes Towards Innovativeness

Most interviewees described how innovation was an important aspect of their culture. Interviewee 7 described, “Our business has - particularly in the last ten years - been able to attract and retain some wonderful talent that comes into our business not because we make [textiles]...but because we have this audacious sustainability

ambition. It brings together people who naturally want to be at the forefront of technology, at the leading edge of innovation.”

Interviewee 4, an engineer, described how he perceived the culture of innovation: “The culture here [...] is just kind of permission to proceed. There’s no fear of failure. [...] If you don’t try things, you are not going to achieve things that you know no one has really thought of or achieved before. [...] It starts at the top. It started with [the innovator] and the guys that run the company now, I think feel the same way. It’s okay. Failure is okay.”

Interviewee 6, chief innovation officer, reiterated this permission to fail: “When you restrict a person to always being successful, you take away their ability to play. You take away their ability to experiment. You take away their ability to fail. And you get the results that you get...safe.” He went on to describe how they integrate NII into their innovation processes: “I don’t know that the question should be ‘how do you compartmentalise biomimicry in your process?’ but ‘how do you let it bleed into every part of everything that you do?’”

2. Formality of Organisational Structures

The majority of descriptions of their organisational structures reflect values of flexible, non-hierarchical management. Interviewee 7 articulated this in more detail: “I think there is a need for open mindedness for all of us. [...] And I think that’s the spirit of what [Textiles Inc.] is about. It’s about people with an open mind to different cultures and different principles and different processes and different approaches.” Interviewee 4 described a similar view: “Technology and innovation happens and I can’t really schedule it. It just kind of happens. But you have to be sure that you’re there to grab it when it does happen.” Interviewee 6 described how they also prepare their employees to innovate so they can respond to challenges as they emerge: “It’s the prior work to innovation. You can’t manage innovation. You get crappy results whenever you do.”

3. Professional Training

Interviewee 7 noted that they have developed NII expertise in-house: “We’ve recruited biologists on to the team to help us be far more considerate in the way we

use biomimicry. We have trained biomimicry professionals in the business that deliver teachings on biomimicry to our engineers and our factory workers.” As an organisation, they have invested in one employee going through a two-year biomimicry program, one employee doing a one-year program and at least one employee doing a one-week immersion course. They are also doing internal training modules for 1000-2000 floor associates globally.

Interviewee 3, the external design consultant who first engaged with NII, reflected on the factors that made the effort successful early on: “I think that getting everyone involved [...] of different disciplines also was really important thing. If I would have worked with [the NII consultant] and just my [external design] team would have worked with her, the results that I would try to pass on to innovate would have never worked. [...] I invited all the different people [for the first workshop]: manufacturing, research, marketing, design...everybody around this table. Even some customers came in, architects and designers.”

4. Selective Exposure and Perception

There was limited discussion of interpretations of NII other than biomimicry and interviewees tended to cluster several types of innovations as NII (e.g., their expansive recycling program). Also, given that NII was an important component of the overall sustainability strategy, it was difficult to distinguish between the two.

Most interviewees described how NII enhanced their perceptions of sustainability. Interviewee 2 (human resources manager), for instance, saw it as a way to expand employee engagement: “One of the great values of biomimicry is the engagement, the employee engagement. And also we do customer engagement. There is a sense of wonder from it when you consider it and it opens people’s minds and it gets them interested and excited at a level that doesn’t happen with a lot of programs or approaches.”

Interviewee 1 described how her views of NII were influenced by a broader systems-based approach to sustainability: “The practice of biomimicry is a very intuitive way to understand systems design and systems thinking which is really complex. Most people aren’t thinking at the systems level. But if you are looking at nature and you

begin to understand that everything is a system, so nothing is in isolation. [...] So it helps shift us from a reductionist mindset to a systems mindset, which is critical for sustainability. And then finally in the culture piece: This is that intentional cultivation of our connection to and appreciation of nature, because that's what will allow our mission and our culture to flourish. So it's that collective paradigm from nature as a source of materials to nature as a source of wisdom."

Interviewee 3 expressed concern that as people are increasingly disconnected from nature and the understanding of our reliance on natural systems diminishes, we are increasingly vulnerable to extinction ourselves. However, "when we get it right, we will fit in just like all the other species." On the contrary, however, Interviewee 1 described how there are religious conservatives in the company who discount biomimicry after the concept of evolution is mentioned, limiting its overall effectiveness with that audience.

On the other hand, Interviewee 3 also described internal tensions amongst the company leadership and some of their sustainability advisory panel because of their decisions to continue to use a particular material in their supply chain. The company's product development story for this product qualifies it as a NII; however, it does not qualify as certifiably cradle-to-cradle because of the material.

Factors: Characteristics of the Innovation

1. Perceived Relative Advantage

As exemplified by previous statements, the company has received a substantial return on their investments in NII over the years and it has a demonstrated financial value. Interviewee 1 reflected, "I don't think we ever would have come up with that [innovation] if we hadn't looked into nature. Just in term of sheer business value, we can't argue against that. It's very clearly quantifiable and huge." Nevertheless, short-term economic pressures also influence decision-making. Interviewee 4 stated that because each local business unit is a separate profit centre, it can be difficult to justify buying equipment or implementing processes that have a ten-fifteen year payback.

Interviewee 4 described how they work with suppliers and closely track the development of new materials in their supply chain so they can trial them and perhaps incorporate them into products (waste = food). Interviewee 3 also said that although they are quite accustomed to making sustainability a priority in their supply chain, having a bad sales quarter can make it tempting to purchase materials that do not meet their high standards.

Interviewees also described less tangible values. Interviewee 1 exemplifies the value for expansive thinking of NII: “Biomimicry [...] opens up to this entire solution set that, in our recent history as a species, we’ve been ignoring.” Additionally, Interviewee 6 described how he valued NII as a comparative tool to gauge sustainability within the organisation: “You get a deeper perspective about how good you are. When you define good in our economic system, it only takes into consideration a few degrees of freedom, whereas defining good against natural systems, there are a lot more degrees of freedom in play and a lot more axes by which you should measure yourself. It’s much more complex and it allows you to define your solutions in a much more holistic way.”

2. Observability

Although they have utilised NII for innovations at multiple levels, Interviewee 1 described how NII is a platform to teach sustainability, making it more widely encompassing. “It’s really robust and its got something for everybody.” It is accessible for a variety of users because of the “ethos, emulate and reconnect” components. She continued, saying, “I can turn anything into a biomimicry project and I don’t even have to tell anybody.” For Interviewee 3, NII was an unclear process that they were willing to experiment with as a team. They “had no idea what to do with biomimicry”, but they knew “how bad” they were and were seeking solutions to SOI.

Interviewee 3 was skeptical about sustainability altogether but through the process of reading books and attending NII sessions, he came to incorporate NII as a primary design strategy. Throughout the course of the interview, he used biological examples to explain several sustainability strategies that they had implemented through the years, e.g., “When nature makes a product any level or shape, that shape is grown.

There are no cutouts. It makes any shape it wants. And now we have this system of three-dimensional printing that will make any shape you want and there is no waste.” E.g.: “[Consultant] and we were talking about waste and she says, “Why can’t you think of waste as more valuable than your product? And then the waste word would go away.” If we took our waste and we could make a product that would be more valuable than the [product] then...Wow. Because in nature there is no word for waste.”

On the other hand, other interviewees had difficulty seeing tangible results. Interviewee 2, who other interviewees claimed is the main innovator for one particularly successful NII project, had difficulties with observability: “I just wish that I could be more positive about the tangible outcomes so that it would encourage more people but in my experience, tangible outcomes as in ‘here’s a new product we developed based on that’...they are few and far between. Maybe we haven’t trained enough. I think if we ended up just being fascinated with nature and learning about all the different things...but that connection of applying it to problem solving is something that is still lacking...to get that tangible outcome.”

Interviewee 4 described a similar position: “ I’ve been trying to get my team more involved with biomimicry and to try to broaden their horizons and to think along those lines. But if you look at what we do, I’m not sure that you could say much that we do is really inspired by biomimicry.” Concurrently, however, he went on to explain that his team does align itself with the company sustainability strategy, which on the company website, this sustainability strategy specifically sites NII as part of their goal-setting process.

3. Complexity

When asked if NII was more complex than other sustainability approaches, Interviewee 1 thought that it was about the same as sustainability in general. They have an SOI narrative that does not require specific metrics to validate their sustainability and innovation choices.

4. Trialability

There was some conflicting input regarding the need for trialability. Since they have

already demonstrated success with NII, this influences their perspectives on it. Interviewee 5 said, “Because of the way that our culture is, we have permission to think longer term. In other words, not under pressure to necessarily make a decision that would be good in short term, bad in a long term... And we like to ask ourselves what would [the Innovator] do?”

However, as described above, Interviewee 4 also mentioned that the need for long-term innovation is frequently “overwhelmed” by short term needs.

5. Compatibility

Interviewee 7 spoke frankly about the limitations of their NII work: “I’ll be really honest. I think we’ve only just really scratched the surface on biomimicry. I think it’s probably so indicative that we’re talking, because [internal sustainability officer] and I have been talking about biomimicry now within our business as [...] the next big thing for us. [...] We’ve been really exploring how you could set up a factory that was indistinguishable from nature, that operated the same principle as nature did.” He continued to describe how they weigh decision-making for sustainability: “We have to go through the same rigor that any other business would when they’re making an investment criteria. The only thing I would say is that we look at investment criteria not just from the financial return, but also from the environmental and social return.”

Interviewee 1 described how NII was personally transformative: “For everybody that went through [the NII training course] [...] it’s truly transformative. And that’s not something I’ve encountered anywhere else, [...] the transformative potential for organisations but also for people. [...] Nobody was able to get through the program without being fundamentally changed. [...] It wasn’t just life changing, it was totally transformative for us.”

Conclusion

In summary, this chapter has presented the data from each of the six cases, organised by question and then thematically at two levels of analysis that emerged from the results in an iterative case study process. The following chapter discusses these findings, reflecting on the data and thematic patterns in a cross case analysis. The cross case analysis, followed by a detailed analysis of the results is presented to

advance existing theory, as well as inductively describe data patterns for further theoretical development.

Chapter 5: Cross-Case Analysis

Introduction

While interview data was unique to each case, a cross case analysis was used to identify patterns and anomalies across cases. These findings will later be used to identify emergent patterns that might lead to more widely testable propositions in future research. The patterns in this cross-case analysis are positioned as more consequential than the individual cases.

Commonalities Across All Cases

There were several commonalities that were evident in all or the majority of cases, including the following:

NII Consultants Involved - All cases engaged with outside NII consultants for various types of projects. For some this included a team of consultants, while for others it was only a single consultant. The level of training of the consultants varied across cases.

NII Training - In all but one case (i.e., Clean Inc.), at least one employee had experienced some level of intensive NII training, but this was not associated with the level of effectiveness of NII. Intensive trainings ranged from one-week to two-year programs.

Interdisciplinary Innovation Teams - All cases included teams of interdisciplinary professionals, most of whom were technically and scientifically oriented. The composition of these teams was not a major differentiator, nor was having a biologist on the team.

Experiences With Nature - The majority of participants described some connection to natural systems in their background and/or childhood experiences, though it was not a strong determining factor for how they viewed NII and did not seem to be a relevant factor for adoption.

Value of Expansive Thinking - In all cases, at least one interviewee expressed expansive thinking as a valuable aspect of NII and valued it as an innovation tool. This was described as a “broadening of the possible solution space” or considering possible solutions that were not otherwise evident before NII as part of the innovation process. This was in addition to other values that were articulated in further detail in each case description.

Impacts of the Economic Downturn of 2008 - All cases exemplified limitations due to the economic downturn that started in 2008, though the effects were felt at different times and to varying degrees.

RQ1: NIIs Attempted and Achieved

The following comparisons are used to demonstrate differences and similarities amongst cases, referring to specific data (i.e., quotations) distinguished in each individual case above. The cases are arranged in order from the least to greatest number of attempted and achieved NIIs. This arrangement is consistent in all following tables to enable comparisons of relative effectiveness across cases by innovation type and influential factors.

Table 6 is an overall summary of innovations attempted and achieved, arranged by case and category. The abbreviations (T1, O2, SB3, etc.) refer to the descriptions in the previous chapter and are arranged by case. For example, Attempted Technological Innovation for Resources Inc. (T1) refers to the adoption of a shelf-ready technology that mimics sharkskin as described in the aforementioned description of that case.

Table 6: Types of Innovations Attempted and Achieved

Type	Status	Case 1: Resources Inc.	Case 2: ICT Inc.	Case 3: Electronics Inc.	Case 4: Cosmetics Inc.	Case 5: Clean Inc.	Case 6: Textiles Inc.
Technological	Attempted	T1		T1	T1		
	Achieved			T2 T3	T2 (In Progress) T3	T1 T2 T3	T1 T2 T3 T4
Organisational	Attempted		O1	O1	O1		O1 (In progress)
	Achieved		O2	O2	O2	O1 O2	O2
Systems Building	Attempted	SB1		SB1 (In progress)	SB1 SB2	SB1 (In progress)	SB1
	Achieved					SB2	SB1 SB2 SB3 SB4

Technological Innovation

The most common applications of NII were at the level of technological innovations, in which three were attempted and eleven were achieved for a total of fourteen applications across all six cases. Other innovations could be considered NII (e.g., recycling programs), but were not included in this analysis unless they were explicitly described as NII by interviewees. Although all were considered Technological Innovations, product and process innovations were separated here for the further analysis later in the Discussion. Table 7 provides an overview of the variety of Technological Innovations across cases, ranging from purchasing products to process changes that transformed their ability to use new sources of raw materials.

Table 7: Technological Innovations

Case	Ref.	Product or Process	Description
Case 1: Resources Inc.	T1	Process	Purchasing of an 'off the shelf' product that could be used in their supply chain to prevent scaling in pipes.
Case 3: Electronics Inc.	T1	Product	Device to assist in the disposal and repurposing of food waste to grow food in-home.
	T2	Process	Cradle-to-cradle design process applied to two new unspecified household products.
	T3	Process	Upcycling and recycling of discarded products recovered from the landfill.
Case 4: Cosmetics Inc.	T1	Process	Attempted packaging design using NII principles.
	T2	Process	New consumer product to replace a synthetic-based chemical process with a water-based chemistry.
	T3	Product	New product introduced into the marketplace applying a NII NPD process.
Case 5: Clean Inc.	T1	Product	New packaging utilising all recycled materials designed with structural inspiration from a marine organism to optimise strength to material ratio.
	T2	Process	Fermentation chemistries in product development.
	T3	Process	Synthetic biology to produce algal oils that replace palm oil.
Case 6: Textiles Inc.	T1	Product	Modular component design that reduces the need for total replacement throughout the product life cycle.
	T2	Product	Adhesive product that reduced the need for >90% of total adhesive.
	T3	Process	Sophisticated used-product collection infrastructure built into their supply chain that closes material loops and enables product recycling from other manufacturers as well.
	T4	Process	To enable the aforementioned recycling program, the company partnered with process engineers to design a new separation technology to recycle fibers that were not previously accessible.

Organisational Innovation

NII at the level of Organisational Innovation was slightly less common than Technological Innovation with four innovations attempted and six achieved for a total of ten across all six cases. Note that one of Organisational Innovations was still in progress at the time of interview. Table 8 provides an overview of variability of organisational innovations across cases. Some were implemented by only one individual manager, while others shaped the trajectory of the entire organisation. There were also variations related to direction of applicability with some organisational innovations targeted at prospective clients and customers, some directed at management styles, and others designed to shape business models and operations.

Systems Building Innovation

Even less common were Systems Building Innovations with a total of ten innovations: six were attempted and four were achieved. Again, note that two were still in progress with NII results to be determined. Table 9 summarises these innovations to enable a comparison across cases and specifies what type of systems were influenced by each innovation.

A slight trend emerges here, with innovation types becoming progressively less common and progressively more difficult to achieve – from Technological to Organisational to Systems Building – when comparing across cases. Technological Innovations were not prerequisite for Organisational Innovations, though Technological and/or Organisational Innovations always preceded Systems Building Innovations. Table 10 summarises the number of innovations by type, demonstrating this pattern.

Table 8: Organisational Innovations

Case	Ref.	Application	Description
Case 2: ICT Inc.	O1	Business Model	Broad application of nature’s principles to a new service offering in partnership with prospective clients.
	O2	Management	“Natural leadership” approach loosely related to a NII methodology and encouraged employees to seek opportunities to interact outdoors.
Case 3: Electronics Inc.	O1	Management and Business Model	Attempt to design the structure of new open innovation relationships by applying biological models to management.
	O2	Business Model	Product servitisation of several products; Primarily in B2B relationships and now expanding to B2C relationships.
Case 4: Cosmetics Inc.	O1	Operational	Attempt to elevate the position of NII from an NPD approach to the overall approach to corporate sustainability.
	O2	Management	Application of swarm theory to management style in one business unit.
Case 5: Clean Inc.	O1	Operational	Design of the business and its activities on the systemic principles of ecosystems.
	O2	Operational	Development of informational materials for products that demonstrate inspiration from and integration with natural systems.
Case 6: Textiles Inc.	O1	Operational	Ecological Performance Standards to guide the redesign and operational performance of factories.
	O2	Management	Various managerial perspectives inspired by biological phenomena that are consequential for strategy, operations, new product development, etc.

Table 9: Systems Building Innovations

Case	Ref.	System Type	Description
Case 1: Resources Inc.	SB1	Socio-technical	"...Create something valuable from someone else's waste stream."
Case 3: Electronics Inc.	SB1	Socioecological and Techno-economic	Policy reform advocacy to enable the transition to circular economy models across multiple sectors.
Case 4: Cosmetics Inc.	SB1	Socio-economic	Development of a NII research center jointly funded by Cosmetics Inc., state government, and a university research body.
	SB2	Socio-economic	Intercontinental research in partnership with academic researchers to guide the development of a research agenda for a particular plant species that can inform their supply chain.
Case 5: Clean Inc.	SB1	Socioecological and economic	Localised system of production and consumption for a new place-based product.
	SB2	Socioecological and Socio-economic	Plastic for recycled product packaging were collected by local fishermen and school groups to remove polluting plastic from the oceans and beaches and reincorporate it back into their supply chain.
Case 6: Textiles Inc.	SB1	Socioecological and Socio-economic	New textiles made from waste plant materials in partnership with female artisans in an emerging economy.
	SB2	Socioecological and Socio-economic	Nylon for 100% recycled products collected by local fishermen and other community members (in emerging economies) to remove polluting nylon fishing nets from the oceans and beaches and reincorporate it back into their supply chain.
	SB3	Socioecological and Techno-economic	Development of regulations to ban their product from the landfill at the end of its use, driving SOI for the entire ubiquitous industry.
	SB4	Socioecological, Socio-techno-economic	Development of a textile-recycling infrastructure across several countries via the sharing of their intellectual property, unique capabilities, capital resources, and technological know-how.

Table 10: Summary Count of Innovations by Type

Status	Technological	Organisational	Systems Building
Attempted	3	4	6
Achieved	10	6	4
Total	13	10	9

RQ2: Factors Influencing Adoption

As distinguished in the previous chapters, the factors that influence the adoption of NII have been divided into three categories: Characteristics of the Innovation Context (Tables 11-13), Characteristics of the Decision-making Unit (Tables 14-17), and Characteristics of the Innovation (Tables 18-22). These characteristics have been distilled from the aforementioned quotations from each case and categorised here for cross-case comparison.

Characteristics of the Innovation Context

The factors influencing the innovation context were derived from Rogers (2003), and further analysis was derived from related SOI literature, as discussed in the literature review.

Norms of the Social System: Perceptions of Sustainability

Those organisations with the fewest applications of NII also described sustainability perspectives which were “weak”, difficult to define, and driven by cost reduction and technology. Resources Inc. interviewees described sustainability in terms of reduced resource use and the pursuit of new energy technologies. They also described how some NII users experienced “political” or values-based tensions related to the implementation of NII. At ICT Inc., the former sustainability director of the organisation described sustainability to be nil, while other interviewees described it as “having no business value”. ICT Inc. was largely reactive to client demands for SOI and did not have a strong internal agenda themselves. For example, NII O2 was largely a marketing effort that targeted Organisational Innovations in partnership with clients, but it did not produce significant results.

Electronics Inc. and Cosmetics Inc. were similar in that they both had attempted several NII projects with some degree of success, but they also candidly recognised the limitations of their respective approaches in tangible ways. Both have historically embedded sustainability norms that are highly institutionalised. They both have sustainability departments with allocated budgets and staff that perform sustainability monitoring for activities company-wide. They also closely track supply chains, new product development budgets, and the product performance in the marketplace and throughout their life cycles. There are several layers of management of sustainability and SOI. For them, NII represents one in a collection of SOI tools that they apply frequently and in a diversity of projects.

Clean Inc. and Textiles Inc. also shared similarities relating to sustainability and SOI narratives. They both described the desire to be “restorative” and have “net positive” contributions as a business. Neither company described a specific sustainability or R&D department with dedicated budgets and exclusively allocated staff, but nevertheless both companies demonstrated a high level of experimentation and willingness to fail at SOI. They both also sought partners from a diversity of stakeholders for SOI, including non-profits related to ecosystem health, sustainability strategists, and product designers with particular expertise in SOI. All interviewees shared the belief that they were in a position of leadership related to sustainability and saw it as their purpose to drive SOI in their sector.

These differences, divided into three categories, will be further articulated in the Discussion Chapter.

External Knowledge Sourcing

All cases utilised external NII consultants as part of the NII team with various levels of inclusion. There was substantial variability amongst those cases that did and did not incorporate design expertise into the NII process or utilise additional consultants to implement NII. As described in Table 11, types of external knowledge sourcing could be divided into three categories based on the literature: NII Specialist Support, Design Expertise, and Further External Specialists. Note that the organisations that had the least amount of success also utilised less external support from designers and discipline-specific specialists.

Informal Social Network Collaboration

Most cases demonstrated some level of informal collaboration outside of formal innovation channels, though this was not consistent across cases. There seems to be a community of practice revolving around a few key players and thought leaders in NII. It was evident in a few of the cases that collaborations frequently moved between sectors as individuals leveraged their positions within their organisations to build their own careers in NII and/or left case study organisations to develop entrepreneurial ventures with others in their communities. A summary of these results can be found in Table 12.

Leadership

Finally, there was a clear trend regarding the engagement with senior leadership and the effectiveness of NII. Several managerial characteristics were evident in the cases examined, including leadership that values the intangible benefits of NII and SOI and leadership that generally supports NII efforts without siloing sustainability.

Furthermore, it was evident that management cultures that created clear separation between senior leadership and other staff as well as those with leaders who demonstrated political motivations had a negative impact on NIIs. Table 13 summarises the influence of management on the adoptability of NII, highlighting four specific characteristics that were comparable across cases: 1) The level to which management values intangible benefits; 2) Any siloing of sustainability created by management decisions; 3) The level of support NII efforts receive from senior management; and 4) Indications that management may maintain a cultural separation from other staff, or a type of insularity amongst the ranks.

Table 11: External Knowledge Sourcing

Case	NII Specialist Support	Design Expertise	Further External Specialists
Resources Inc.	Yes, team of NII consultants for one time engagement.	Not included.	Not included.
ICT Inc.	Yes, two outside consultants facilitated 1-day session with prospective clients.	Not included.	Not included.
Electronics Inc.	Yes, outside NII team of student-consultants engaged for 6-8 month process; Not described for other NII projects.	Yes, designers preferred cradle-to-cradle. NII consultants suggested incorporating design expertise into biomimicry management innovation project, but this was not pursued.	Not included.
Cosmetics Inc.	Yes, external consultants were involved in all NII activities and staff were trained to be NII Specialists.	Yes, designers were part of the internal team from the beginning of the NII work.	Yes, engaged with further external designers, formulation specialists and academic researchers to advance the NII agenda.
Clean Inc.	Yes, relied heavily on external NII consultants from multiple organisations on multiple projects. Outsourced entire NII projects.	Yes, innovation manager leading NII activities is a designer by training.	Yes, external specialists led most NII activities.
Textiles Inc.	Yes, relied on external NII consultants from multiple organisations on multiple projects. Also outsourced entire NII projects.	Yes, the first NII project was led by an external design consultant in partnership with NII consultants, and he continues to apply NII independently.	Yes, partnered with various NGOs, industry partners and suppliers to enable NII.

Table 12: Informal Social Network Collaboration

Case	Informal Social Network Collaboration
Resources Inc.	None described.
ICT Inc.	Yes, Innovator attended a training course as an employee and developed informal partnerships with NII practitioners who later became business partners.
Electronics Inc.	Yes, a former employee and external consultant helped Electronics Inc. train staff and other interested participants in their area. This external consultant described how members of the loose external group went on to develop a national NII policy and one participant completed a PhD in related research after involvement.
Cosmetics Inc.	There was none described explicitly outside of contractual relationships, though NII project leaders attended conference related to NII to engage with practitioners beyond the NII consultants that they contracted.
Clean Inc.	The Innovator and other external consultants described how they sought advice and perspective from the NII community related to specific sustainability issues, but outside of the realm of consulting engagements.
Textiles Inc.	As leaders in NII, they likely have long-standing relationships that were not mentioned in the interviews, but most recently have created a small group of corporate NII practitioners who meet monthly to discuss NII projects and compare experiences.

Table 13: Leadership

Case	Management Values Intangible Benefits	Siloing of Sustainability by Managers	Senior Management Support	Insularity of Management
Resources Inc.	No evidence of intangible values.	NII team members had little knowledge of sustainability activities of the company.	Senior management did not fully participate in the NII activities, as was anticipated.	Some suggestion that the project was not advanced due to political motivations of project leadership.
ICT Inc.	A few interviewees valued the intangible benefits on the NII team, but interviewees peripheral to the leadership only valued monetary benefits.	The two interviewed members of the sustainability leadership described frustration with the lack of initiative by the organisation as a whole, despite their roles as dedicated sustainability leaders.	There was no apparent support from senior leadership.	Interviewees described how leadership was 'elitist' and unapproachable and how they had attempted to overcome these boundaries. When asked if the former CEO might be available for an interview, this was strongly discouraged and he was described as inaccessible.
Electronics Inc.	Given that sustainability was an integral and historically relevant aspect of the organisational identity, there were several indications that leadership valued intangible benefits. However, this was also jeopardised during the economic downturn and some SOI researchers "fought" for it.	There was a substantial amount of resources dedicated towards sustainability accounting and innovation. However, it might have inadvertently created a silo-effect.	Senior management support for SOI was evident historically, but given cost-saving measures viewed as necessary during the economic downturn, compromises were made that caused dissatisfaction with SOI champions.	There was no strong indication of insularity of management.

<p>Cosmetics Inc.</p>	<p>There is a long history of valuing the intangible benefits of sustainability and it is institutionalised within supply chain management. However, economic conditions of recent years have caused an increased emphasis on financial concerns.</p>	<p>Similar to Electronics, there was a substantial amount of dedicated resources towards sustainability accounting and innovation that may have inadvertently created a silo-effect.</p>	<p>The management was highly supportive of SOI in principal, but at the time of interview, they were undergoing substantial changes in leadership as the founders moved progressively away from daily operations and new leadership took over responsibilities.</p>	<p>One interviewee described how he perceived the leadership as being more driven by profit than they had been previously, creating a level of insularity from the rest of the organisation in which sustainability was a driving motivation.</p>
<p>Clean Inc.</p>	<p>Clean Inc. recently merged with a Certified B-Corp and was in the process of becoming a B-Corp themselves, giving legal mandate to value intangible benefits of sustainability.</p>	<p>The founders created the company to fill a niche in for SOI in their sector and this is currently expanding from “what’s inside the bottle” to a larger view on their entire operations.</p>	<p>NII activities received instant recognition and support from senior management and one external NII consultant was invited to present directly to the leadership board.</p>	<p>No evidence of insularity.</p>
<p>Textiles Inc.</p>	<p>An interviewee from human resources described how NII and sustainability were an important part of the culture and a “gift” that the founder left them with because they were part of a larger mission and not only making textiles.</p>	<p>One internal NII leader described how her role is assigned, though most associates on the manufacturing floor would also describe sustainability as a part of their job.</p>	<p>The NII activities were supported by the company founder and led by senior staff members. Support from senior leadership is deeply embedded.</p>	<p>No evidence of insularity and in contrast, staff described a “flat” organisation.</p>

Characteristics of the Decision-Making Unit

As is apparent in the data, there were fewer clear trends amongst the Characteristics of the Decision-Making Unit, with interviewees giving a wide array of responses. Results for each category of characteristic are summarised below.

Attitudes Towards Innovativeness

The six cases demonstrated a variety of attitudes towards innovativeness, with three clear patterns emerging. The first characteristic was a general openness towards radical innovation, which was evident in some cases but clearly more difficult for others. The second characteristic was a culture that impedes creativity through competitive or destructive team dynamics. The third characteristic was an organisational emphasis on episodic or incremental innovation that has negative consequences for radical innovations such as NII. The two companies that were least effective demonstrated characteristics of cultures that impede creativity. Electronics Inc. and Cosmetics Inc. both demonstrated a tendency towards incremental innovation whereas Textiles Inc. and Clean Inc. demonstrated a general openness towards radical innovations. Further detail regarding these characteristics for each case is available in Table 14.

Formality of Organisational Structures

Table 15 provides descriptions of the degree of organisational structures that influence the NII process in each case, categorised as Formal Organisational Structures or Flexible, Decentralised Structures. There was a trend indicating that formal innovation structures were an impediment to NII, though when viewed in isolation, it was not consistent as a clear differentiator influencing the adoption of NII.

Professional Training

As suggested in the literature, professional training has a substantial influence on the ability of an organisation to implement SOI and, particularly, NII. Three aspects of professional training, as summarised in Table 16, emerged as relevant for consideration: 1) NII training of staff; 2) Cross-functional expertise of staff; and 3) The inclusion of a biologist on the team. Nearly all NII teams (with one exception) had employees trained in NII; the company that did not relied heavily on consultants with extensive training in NII. All NII teams were cross-functional, and although not all of them included a biologist, this was not a significant factor.

Selective Perception and Exposure

Data related to Selective Perception and Exposure revealed three categorical patterns across cases. First, as mentioned in the Commonalities Across Cases at the beginning of the chapter, all cases included various levels of exposure to natural systems, suggesting that Selective Exposure was common, but not deterministic about the success of NII. Interviewees from all cases expressed varying degrees of connection with natural systems, and this did not seem to be influential in their perceptions of NII. A second pattern, related to Selective Perception, emerged based on how individuals perceived NII depending on their beliefs and values (this is further detailed in the Discussion Chapter). A third pattern, which is presented as an additional category of Selective Exposure, emerged in which individuals compared their experiences with NII to each other and to other SOI tools. Although all teams demonstrated awareness of various approaches to NII when asked, only Electronics Inc. and Cosmetics Inc. made clear distinctions amongst the various approaches (i.e., cradle-to-cradle, biomimicry, circular economy, etc.). The second and third patterns are further described below in Table 17.

Table 14: Attitudes Towards Innovativeness

Case	Openness Towards Radical Innovation	Culture Impedes Creativity	Episodic or Incremental Innovation
Resources Inc.	Yes, NII activities initiated by business unit designed to support radical innovations.	Yes, internal politics creates a competitive culture that significantly affected the NII project.	No indication.
ICT Inc.	No evidence of openness.	Yes, internal competition for the attention of clients limited NII activities.	No indication.
Electronics Inc.	Yes, as a general statement but not effectively for SOI.	No indication.	NII users describe being overwhelmed by too many SOI tools and approaches, having trialed several with varying degrees of success. They are also driven by incremental innovations for SOI that are steady and demonstrable.
Cosmetics Inc.	Yes, as a general statement but with only moderate effectiveness for SOI.	No indication.	NII users describe being overwhelmed by too many SOI tools and approaches, having trialed several with varying degrees of success. Their product release cycle of every 21 days forces incremental innovations in marketing, packaging, and presentation, directing resources away from longer-term innovations.
Clean Inc.	Yes, rely heavily on open innovation strategies for SOI. Demonstrate a high tolerance for trial and error.	No indication.	SOI has been an aspect of their culture since founding and they seem to be experiencing a period of radical SOI momentum.
Textiles Inc.	Yes, the acceptance of failure is an important aspect of their innovation culture.	No indication.	Incremental innovation is a significant aspect of their overall sustainability approach but they have also been successful with several radical innovations in their sector.

Table 15: Formality of Organisational Structures

Case	Formal Organisational Structures	Flexible, Decentralised Structures
Resources Inc.	Though the business unit that applied NII was intended to advance new technologies from proof of concept to late stage development, the process that guided this transition seemed to have a narrow focus on specific kinds results that limited how the Innovator viewed the applicability of NII.	N/A
ICT Inc.	N/A	One interviewee described how the constant changes associated with mergers and acquisitions created an environment where he could “make his own rain”, as long as he was being accountable to the expectations of his job as a minimum.
Electronics Inc.	Interviewees described “highly sophisticated project management systems” and specific feedback regarding the marketplace performance of SOIs.	N/A
Cosmetics Inc.	Designers are subjected to +200 sustainability criteria for NPD; Organisational hierarchies are prolific with several managers assigned to various SOI projects and programs.	N/A
Clean Inc.	N/A	Internal reluctance towards radical innovation is compensated for by with several outsourced SOI projects and partnerships within the supply chain. The long-term innovation manager has been given freedom to experiment with new business models and spin-off projects.
Textiles Inc.	N/A	Two innovation managers and long-term employees described how innovation should not be managed, but rather staff should be trained and equipped for innovation to happen spontaneously.

Table 16: Professional Training

Case	NII Training of Staff	Cross-Functional Expertise	Biologist Included
Resources Inc.	Yes, two employees attended 1-week training; Former employee finished 1-year certification program.	Interviewee 1: Mechanical Engineering Interviewee 2: Chemical Engineering, Biology Interviewee 3: Psychology, Communication, Business, Biomimicry (post-employment)	Yes, 4+
ICT Inc.	Yes, one employee attended a one-week training.	Interviewee 1: Entrepreneur, Social sciences Interviewee 2: Engineer, Biomimicry Interviewee 3: Business, Finance, Biomimicry Interviewee 4: Marketing Interviewee 5: Finance Interviewee 6: Technical expertise	No
Electronics Inc.	Yes, one employee attended a one-week training.	Interviewee 1: Engineer, Biomimicry Interviewee 2: Environmental science, Biomimicry Interviewee 3: Physicist, Sustainability Interviewee 4: Chemical/Environmental Engineer Interviewee 5: Mechanical Engineer, Business, Biomimicry Interviewee 6: Product Designer, Biomimicry Interviewee 7: Engineering, Marketing	Yes, 2+
Cosmetics Inc.	Yes, one employee completed a 1-year certification program and approx. 40 employees were trained in immersive 3-6 day courses.	Interviewee 1: Biology, Agriculture, Biomimicry Interviewee 2: Food engineer, Environmental mgmt., Biomimicry Interviewee 3: Chemist, Innovation manager, Biomimicry Interviewee 4: Biologist, MBA, Biomimicry Interviewee 5: Microbiology, Biomimicry	Yes, 10+

		<p>Interviewee 6: Product design, Biomimicry</p> <p>Interviewee 7: Agricultural engineering, Biomimicry</p> <p>Interviewee 8: Biochemistry, Pharmaceuticals, Biomimicry</p> <p>Interviewee 9: Biology, Forest Science, Biomimicry</p> <p>Interviewee 10: Chemical Engineer, Innovation mgmt.</p>	
Clean Inc.	None, but several external consultants were trained extensively.	<p>Interviewee 1: Product design</p> <p>Interviewee 2: Product design, Biomimicry</p> <p>Interviewee 3: Biology, Sustainable design</p> <p>Interviewee 4: Psychology, Marketing, Biomimicry</p> <p>Interviewee 5: Sustainable Business</p> <p>Interviewee 6: Industrial Design, Management</p> <p>Interviewee 7: Environmental Scientist</p>	Yes, 1+
Textiles Inc.	Yes, one employee completed a 1-year certification program, one employee completed a 2-year program, and they were developing trainings for approx. 2000 employees at the time of interview.	<p>Interviewee 1: Biology, Economics, Business, Biomimicry</p> <p>Interviewee 2: Biology, Chemistry, Management</p> <p>Interviewee 3: Product Design</p> <p>Interviewee 4: Engineering, Textile design</p> <p>Interviewee 5: Engineering, Marketing</p> <p>Interviewee 6: Engineering</p> <p>Interviewee 7: Textile engineering, Marketing</p>	Yes, 4+

Table 17: Selective Perception and Exposure

Case	Selective Perception: Perceptions of NII	Selective Exposure: Previous Experiences with Similar Innovations
Resources Inc.	Conflicting perspectives amongst participants in the NII process regarding connections to nature, political motivations, and common ethical debates related to science and technology. Additionally, one interviewee framed NII as being essentially indistinguishable from engineering in practice.	Did not explicitly comment on varied approaches to NII or SOI.
ICT Inc.	Some participants in the NII activities had difficulty moving away from a bioutilisation mentality and into a mentality of learning from nature, creating some difficulties for the innovator and facilitators. Two interviewees viewed NII as impractical and “rather academic”. This likely created tension with the innovators and supporters of the NII efforts who viewed the adherence to nature’s principles as the only valid path towards sustainable business.	No interviewees described any experiences with similar innovations, suggesting that SOI, in general, was not a common practice. It also suggests that they are limited in the SOI tools and processes they have been exposed to, perhaps making it more difficult to implement NII.
Electronics Inc.	Some NII participants, upon learning about biomimicry, demonstrated saturation with learning about another SOI tool and were not motivated to engage further. One external consultant expressed concern that biomimicry was a “cold” approach to management, questioning its acceptability. There was also skepticism from several participants regarding the value of a NII approach to management innovations. One interviewee went so far as to say that he did not apply “nature-inspired innovation for sustainability” in his work, but later went described how he promotes circular economy with his colleagues without mentioning sustainability to avoid resistance to SOI.	Yes, several similar innovation tools were tested and viewed as all basically the same. Cradle-to-cradle, biomimicry, the Natural Step, circular economy, TRIZ, and others were compared and contrasted by several interviewees.

Cosmetics Inc.	There were some conflicting opinions regarding NII as a SOI tool, with some interviewees viewing it as a process for NPD and others viewing it as an approach to problem-solving more broadly. Furthermore, some interviewees saw it as a broad sustainability ethic. This created disconnections in perceived value amongst participants.	Yes, several NII (biomimicry, cradle-to-cradle, circular economy) approaches and ecodesign were managed as separate projects within the sustainability and R&D departments, which were closely linked. Interviewees expressed fatigue regarding new innovation approaches.
Clean Inc.	Two interviewees described general scepticism when reviewing NII projects from other organisations because of what they saw as a misuse of the label NII, with some cases using the NII label after the fact rather than during the process or other NII projects that lack an environmental ethic.	They were generally familiar with cradle-to-cradle and similar approaches, but were not especially appreciative of the distinctions between various tools.
Textiles Inc.	Despite the company-wide sustainability and NII narrative, there were still discrepancies between personal perceptions of NII that influenced adoptability. For some interviewees, it was an “intuitive way” to understand complexity and connect to nature in an integrated way. However, one interviewee described how religious conservatives in the company discount the concept of biomimicry due to its inclusion of evolutionary theory.	Though there were some conversations related to the adoption of cradle-to-cradle, it was ultimately not used. A senior innovation leader described biomimicry as integrated into everything that they do rather than being plugged it into their innovation process.

Characteristics of the Innovation

Again, the Characteristics of the Innovation are divided into Perceived Relative Advantage, Observability, Complexity, Trialability, and Compatibility. These characteristics are further subdivided based on the data. Perceptions of the Characteristics of the Innovation were overall consistent despite a few subtle anomalies across cases. Nevertheless, in of each of the three categories – Characteristics of the Innovation Context, the Decision-making Unit, and the Innovation – the perceived Characteristics of the Innovation were the most consistent, suggesting that this aspect is generally the least influential upon adoption.

Perceived Relative Advantage

The perceived relative advantage of NII was mostly consistent across cases, with three main advantages or values emerging: 1) ROI in absolute financial terms; 2) Expansive thinking of a NII approach; and 3) The application of NII instigating novel forms of cooperation with suppliers. With the exceptions of Resources Inc. and Textiles Inc., low monetary return was of considerable concern. At least one interviewee from each company expressed expansive thinking as a value of NII. For most organisations, NII also enabled novel forms of cooperation with suppliers to develop new products and/or modify supply chains. These advantages are discussed in detail in Table 18.

Observability

There was little indication that observability was a significant influential factor, with nearly all companies describing biological models at some scale and translating them into innovative solutions. Additionally, a lack of clarity about intended results was a consistent factor that individuals described as having a negative impact on adoption for all cases aside from Electronics Inc. However, given that all cases described this as having a negative impact (even those cases which are very effective with NII), the relative importance of this factor is low. Table 19 summarises two issues related to observability identified in the data: 1) A lack of clarity and 2) The types of biological inspiration that was described by interviewees.

Complexity

Nearly all organisations described issues of complexity regarding the NII process with the exception of Textiles Inc., which described issues of complexity as equivalent to sustainability more broadly. Table 20 summarises how interviewees in each case perceived and described this complexity.

Trialability

With the exception of Resources Inc., all cases experienced issues with Trialability. The data demonstrated two major issues related to the Trialability of NII: 1) Conflicts between short-term investments and long-term results and 2) Cultural influences that limited trialability. Table 21 summarises the results related to these two themes.

Compatibility

The final factor, Compatibility, was a major influence on the adoption of NII. The data demonstrated two main types of Compatibility issues across cases as described in Table 22: 1) Incorporation into strategic goals and 2) Individual transformations that made NII more compatible for organisational adoption. Cases showed substantial differentiation related to the incorporation of NII into strategic sustainability goals, with those companies that did so being considerably more successful than those who did not. And finally, at least one individual in each case described a personal transformation related to their experiences with NII, and in three cases, three or more interviewees described personal transformations.

Table 18: Perceived Relative Advantage

Case	ROI Viewed as a Major Advantage	Value of Expansive Thinking of NII	Value of NII Instigating Cooperation with Suppliers
Resources Inc.	No, ROI was not an issue in this business unit.	Yes	No
ICT Inc.	Yes, no perceived business value.	Yes	No
Electronics Inc.	Yes, two products were discontinued due to low ROI despite greater cost to produce.	Yes	Yes, with waste management/recyclers. Likely others.
Cosmetics Inc.²	Yes, but this was pending the release of a new product developed during a NII process.	Yes	Yes, with new equipment providers and new materials. Possibly others.
Clean Inc.	No apparent conflict.	Yes	Yes, multiple new suppliers and potential suppliers in the form of business model innovation partners on at least two NII projects.
Textiles Inc.³	No conflict and to the contrary, ROI had been easily demonstrable in just one product.	Yes	Yes, co-evolution of supply chains in partnership with suppliers. Instigators of several policies and programs to incentivise supply chain innovations.

² Interviewee 6 described an additional value unique to Cosmetics Inc.: “I think the big value of biomimicry is make the people think. Make the people stopping and look around [sic].” It helps people to identify “the real problem” leading to more appropriate solutions.

³ Textiles Inc. was unique in the articulation of one perceived relative advantage in that most interviewees described how NII enhanced their perceptions of sustainability. Interviewee 2 (a human resources manager), for instance, saw it as a way to expand employee engagement: “One of the great values of biomimicry is the employee engagement. And [...] customer engagement. There is a sense of wonder from it [...]. It opens people’s minds and it gets them interested and excited at a level that doesn’t happen with a lot of programs or approaches.”

Table 19: Observability

Case	Lack of Clarity	Types of Biological Inspiration
Resources Inc.	Yes, however, this was not abnormal for this business unit.	None
ICT Inc.	Yes, perhaps due to the attempted scale of application.	Ecological Principles
Electronics Inc.	Yes, but this was an accepted part of their innovation culture.	Ecological Principles System-Level Principles
Cosmetics Inc.	Yes, and after multi-million dollar investment in training, research, and NPD efforts, it was a major issue for the internal program manager.	Shape Function Ecological Principles
Clean Inc.	Yes, but this was not a significant issue.	Shape Function Ecological Principles System-Level Principles
Textiles Inc.	Yes, but did not influence adoptability at the level of the organisation because of open innovation culture.	Shape Function Ecological Principles System-Level Principles

Table 20: Complexity

Case	Complexity
Resources Inc.	Biological information was difficult to understand. Analogical translation of biological strategies could not be advanced by the organisation.
ICT Inc.	NII was considered to be an “academic” subject without clear and tangible objectives.
Electronics Inc.	Innovation processes more complex due to biological search. Additional layers of complexity in cradle-to-cradle design.
Cosmetics Inc.	Difficulty applying the biology in tangible ways with objective sustainability criteria.
Clean Inc.	While NII was viewed as complex, they managed this complexity by outsourcing the NII projects almost entirely.
Textiles Inc.	No, it was considered to be no more complex than sustainability more broadly.

Table 21: Trialability

Case	Conflict Between Short Term Investments and Returns	Cultural Influences on Trialability
Resources Inc.	No conflict directly, though there were later budget cuts that significantly reduced the staff and innovation capacity.	Difficulty identifying innovations that could be advanced further given their expectations and established innovation processes.
ICT Inc.	According to an interviewee, the company made very little investment in sustainability compared to their competitors, so while ROI was an issue, there was very little investment in NII to start.	NII was “very big” and “unbridgeable”.
Electronics Inc.	Yes, the need for returns was within a relatively standardised product development life cycle.	Difficulty “to let them play with this new methodology”, largely due to time and financial pressures.
Cosmetics Inc.	Yes, the need for returns was within a relatively standardised product development life cycle, though there seemed to be some leniency with this as leadership changed throughout the NII activities.	Initially, there was no conflict because of perceptions of “an easy win”. However, as the projects progressed, pressure to produce tangible, viable results increased.
Clean Inc.	Yes, however they were accustomed to accounting for longer term success and intangible values of SOI. The job title of the innovator of the NII projects was “Long Term Innovation Manager”, indicative of the expectations of his projects.	They had completed several successful NII projects, despite some internal resistance to radical innovation.
Textiles Inc.	The founder (now deceased) gave broad encouragement and thought leadership to the organisation to consider and value the long-term implications of the company’s activities.	There was little indication of trialability issues due to the long-standing success with NII that began 20+ years ago.

Table 22: Compatibility

Case	Incorporation in Strategic Sustainability Goals	Individual Transformations
Resources Inc.	No	One former employee used her severance package money to support her through a NII certification program and she continues to dedicate her career to SOI and NII.
ICT Inc.	No	The Innovator used the NII work at ICT Inc. as a springboard to launch his own consulting career on NII, writing a book and forming a consultancy that applies NII to management.
Electronics Inc.	Not explicitly.	Two interviewees described how experiences with NII had changed their perceptions of nature. One learned how to have immersive experiences in nature, and the other learned a new appreciation and perspective to view nature as inspiration.
Cosmetics Inc.	Not explicitly. Described as an additional layer of analysis.	At least four employees described how NII had enabled them to remember something about nature that they had lost, viewing NII as a “sea” of SOI and having experiences that are “crazy in personal terms.”
Clean Inc.	Yes, organisational goal of using nature as a guide for sustainability.	Interviewee 1 was in the process of leading a change in their overall sustainability narrative guided largely by the principles of NII and the integration with natural systems.
Textiles Inc.	Yes, organisational goal of using nature as a guide for sustainability.	NII strongly influenced the perceptions of several employees and managers, including the founder, who led the company transformation with NII as a guiding principle.

Conclusion

This chapter has provided a cross-case analysis of the results to compare and contrast factors across cases. It divided each case into separate categories that could then be compared with similar data from other cases. For several variables, while they were not particularly influential in isolation, when viewed in light of other factors, they were considerably defining. The following Detailed Analysis of Results Chapter will tie these variables together and link them back to existing literature. Some variables were clear differentiators (e.g., mostly the Characteristics of the Innovation Context and Compatibility issues), while others were less influential (e.g., the perceived Characteristics of the Innovation). These differences will be further discussed in the following chapters.

Chapter 6: Detailed Analysis of Results

Introduction

The previous chapters provided data from each of the six case studies, highlighting the types of innovations pursued and the relevant factors that influenced adoption across each of the cases. This chapter, structured similarly to the literature review and results sections, addresses RQ1 and RQ2, but with greater detailed and nuanced analysis of differences and similarities across cases and in light of the literature.

NII's Attempted and Achieved

Technological Innovation

Technological Innovations were the most common applications of NII, though the difference was not substantial. This is somewhat in alignment with the OECD (2009) report addressing sustainable manufacturing and eco-innovation, which suggests that technological innovations are easier to achieve than other categories of innovation. Each of Tempelman, et al.'s (2015) named benefits (i.e., product quality; closing of technical and biological resource loops; improved recyclability of products; and additional beneficial product functions, such as improving indoor air quality, capturing CO₂, or filtering water) were demonstrated in at least one case of Technological Innovation. Furthermore, the benefits described by Hellstrom (2007) were also demonstrated in at least one of the Technological Innovation projects, and include the following:

aspects of the manufacturing process (e.g. reduction of material in the product, number of parts in the product, and number of different materials in the product), product usage (e.g. reduction in usage of water, energy, and detergents), end-of-life (e.g. design for longer life, re-use of components, and design for upgradability, recyclability/ease of separation) and function redesign (e.g. redesigning of an activity). (p.151)

Benefits identified in each Technological Innovation can be found in Table 23.

Table 23: Benefits of Applying NII to Technological Innovations

Case	Ref.	Description	Benefits and Related Literature
Resources Inc.	T1	Purchasing of an 'off the shelf' product that could be used in their supply chain to prevent scaling in pipes.	Beneficial product functions (Tempelman et al., 2015); Product usage (Hellström, 2007).
Electronics Inc.	T1	Device to assist in the disposal and repurposing of food waste to grow food in-home.	Closing of biological resource loops, Beneficial product functions (Tempelman et al., 2015); Product usage, Function redesign (Hellström, 2007).
	T2	Cradle-to-cradle design process applied to two new unspecified household products.	Closing of technical resource loops, Improved recyclability (Tempelman et al., 2015); End of life benefits (Hellström, 2007).
	T3	Upcycling and recycling of discarded products recovered from the landfill.	Closing of technical resource loops, Improved recyclability (Tempelman et al., 2015); End of life benefits (Hellström, 2007).
Cosmetics Inc.	T1	Attempted packaging design using NII principles.	Not developed enough to identify clear benefits at the time of interview.
	T2	New consumer product likely replacing a synthetic-based chemical process with a water-based chemistry.	End of life benefits (Hellström, 2007); Reduction in ecological/biodiversity impacts in supply chain.
	T3	New product introduced into the marketplace applying a NII NPD process.	Function redesign (Hellström, 2007).
Clean Inc.	T1	New packaging utilising all recycled materials designed with structural inspiration from a marine organism to optimise strength to material ratio.	Closing of technical resource loops, Improved recyclability (Tempelman et al., 2015); Beyond shape (Reap, 2009).
	T2	Fermentation chemistries used in product development.	Reduction in ecological/biodiversity impacts in supply chain.

	T3	Synthetic biology to produce algal oils that replace palm oil.	Reduction in ecological/biodiversity impacts in supply chain.
Textiles Inc.	T1	Modular component design that reduces the need for total replacement throughout the product life cycle.	Higher product quality, Closing of technical resource loops, Improved recyclability (Tempelman et al., 2015); Aspects of the manufacturing process, End of life benefits (Hellström, 2007).
	T2	Adhesive product that reduced the need for >90% of total adhesive.	Improved recyclability (Tempelman et al., 2015); Product usage, End of life benefits, Function redesign (Hellström, 2007).
	T3	Sophisticated used-product collection infrastructure built into their supply chain that closes material loops and enables product recycling from other manufacturers as well.	Closing of technical resource loops, Improved recyclability (Tempelman et al., 2015); End of life benefits (Hellström, 2007).
	T4	To enable the aforementioned recycling program, the company partnered with process engineers to design a new separation technology to recycle fibers that were not previously accessible.	Closing of technical resource loops, improved recyclability (Tempelman et al., 2015); End of life benefits (Hellström, 2007).

While proponents of NII frequently cite visually enticing examples of new nature inspired products, in the majority of Technological Innovations identified herein, process innovations were substantially more common than product innovations. This finding highlights the difficulty in identifying NII in practical settings, due to the diversity of possible results and variability in the perception of results. An example of possible tensions that this can create was evident in Cosmetics Inc., where interviewees viewed the same nature inspired product differently: Some interviewees reported that the product was NII, and other interviewees said that it was not, despite its development in a NII workshop. This raises compelling questions about the marketing and brand value of NII. First, who decides what is NII without the oversight of some standards or certification body? Second, if consumers are not aware that the product is the result of NII, does the NII process have value in the marketplace and for the organisation? While these questions are beyond the scope of this research, this complexity with NII is applicable to the production and consumption of SOIs more broadly.

Similarly, challenges with development timelines for Technological Innovations were also influential in Cosmetics Inc. and Clean Inc. Interviewees at Cosmetics Inc. discussed how they could face longer NPD timelines (estimated to be two years longer) due to the need to comply with national laws regulating the use of biodiversity and other factors. Clean Inc. also described a limited capacity and willingness by staff scientists to develop new materials in-house, making Technological Innovations difficult within the organisation. (This will be discussed further in the next section related to RQ2.)

One final notable issue related to the development of Technological NIIs is the relationship with Organisational and Systems Building Innovations. In the cases of Cosmetics Inc., Electronics Inc., and Textiles Inc., there was some indication that Technological Innovations were limited by a lack of organisational change. For Cosmetics Inc., senior management was unwilling or unable to see NII as a tool for larger SOI changes in the organisation; this likely limited their ability to implement NII for Technological Innovations as these two types of innovations are closely linked. In the case of Electronics Inc., they discussed how their few attempts at cradle-to-cradle design were not effective in the marketplace, particularly because the

approach did not change the business model and perpetuated the selling of the product to consumers that created issues at the end of the product life cycle. One interviewee described the promise he saw in the circular economy approach because it changed from an ownership to leasing model, which increased the product life span and likelihood of recycling. At Textiles Inc., they had also tried to use leasing models for their product, but found it to be a difficult sales proposition in commercial settings. Because the ownership of their product is tied to the ownership of a building, the details of property transfer in a leasing model were difficult to negotiate for the buyers and sellers of buildings. Nevertheless, they have continued to pursue Technological Innovations and other types of Organisational and Systems Building Innovations that have enabled further Technological Innovations.

In summary, while Technological Innovations were the most common innovation type across cases and are often described as the most readily achievable type of SOI in the literature, this was not a consistent finding regarding NIIs in MNCs. While Technological Innovations may have the advantage of being heavily influenced within a single business unit or innovation team, the advancement of a NII NPD process is often closely tied to existing innovation infrastructure, innovation and/or sustainability trajectories, or company cultures that need to shift to accompany radical Technological Innovation. This is due to several factors, as described in the next sections related to RQ2.

Organisational Innovation

Though not as common as Technological Innovations, Organisational Innovations (attempted and/or achieved) were identified in all cases with the exception of Resources Inc. Although some research has suggested that successful innovation is the result of the interaction between process and management changes (Hollen, Van Den Bosch, & Volberda, 2013; Klewitz & Hansen, 2014), the distinction between process and management changes in a case study setting was difficult to identify. For example, in the case of Clean Inc. O1 (design of the business and its activities on the systemic principles of ecosystems), the distinction between the processes implemented and the changes in management are indistinguishable in application.

Additionally, although several authors have asserted that management innovations can shape a firm's environmental impact (D'Amato & Roome, 2009; Hollen, Van Den Bosch, Volberda, et al., 2013; Martin et al., 2012; Theyel, 2000), this was applicable to some, but not all NII projects. In some cases, the application of NII to Organisational Innovations influenced management practices but did not relate to socioecological systems in a tangible, intentional way (i.e., ICT Inc. O2; Electronics Inc. O1; Cosmetics Inc. O2). This disconnection between the results of Organisational Innovations and environmental impacts is likely related to the aforementioned distinction between metaphorical and analogous applications of biological strategies. While there are several examples of this situation scattered throughout the cases, two will be offered here for comparison and demonstration.

When Electronics Inc. attempted to apply biological models to the operations of a business unit focused on open innovation (O1), the biological strategies provided were mostly focused on the qualitative characteristics of the interactions between the organisations involved. The metaphorical application of biological models did not attempt to make connections to the larger socioecological context. Moreover, although this business unit was likely discontinued due to the economic downturn regardless of the NII activities, there was no indication within the project documents or interviews that there were any intended effects that would have had a positive impact for SESs. The metaphorical NII activities were directed at the organisation itself with no apparent consideration of socioecological impacts. Nonetheless, Electronics Inc. also implemented NII as an Organisational Innovation in the form of business model innovation (O2) in an analogical application of biological strategy (i.e., circular economy mimics principles of nutrient cycling in an ecosystem). In this application, the concept of nutrient cycling is applied to the 'technical nutrients' of the product life cycle and the relationships amongst producers (i.e., Electronics Inc.) and the consumers (i.e., customers), who in turn enable these relationships. The result of the latter example has tangible benefits for socioecological and economic systems, whereas the former is limited to socioeconomic systems.

As a second example, a similar situation arose in Cosmetics Inc. in which numerous individuals were trained in NII and began applying it in various ways throughout the company. Interviewee 3 discussed his successful, yet informal, attempts at applying

swarm theory in his business unit (O2), but he did not attempt to incorporate any biophysical aspects of operations into this metaphorical application of a biological strategy. Conversely, Interviewee 10 attempted to engage upper level management in using NII to guide the overall sustainability strategy of the organisation (O1), but he had little success in doing so. His vision was the incorporation of NII into every level of decision-making within the organisation, but he saw management as too entrenched in a dated model of sustainability and too driven by profit motives to engage more fully in this perspective. Thus, while the metaphorical application (O2) was relatively successful, it had limited influence because it was only conceptual and involved the actions of just one manager with a small team. Consequently, the opportunity to apply NII in a much broader analogical context in the company was surpassed and NII was narrowly viewed as a project of the sustainability and research departments by senior management, limiting its effectiveness in this larger context.

As a counter to these experiences, management innovations can reduce the codification of organisational routines, which may increase the likelihood that technological innovations can be adopted (Khanagha et al., 2013). This was the case for Electronics Inc. O2, Clean Inc. O1 and O2, and Textiles Inc. O1 and O2. It may be notable that these organisations, particularly Clean Inc. and Textiles Inc., were amongst the most prolific with NII, suggesting that managerial applications of NII enable the application of technological changes in at least some contexts. This is likely the most significant finding related to Organisational Innovations. While Organisational Innovations are not consistently effective across cases, in those cases in which NII is adopted at the organisational level and/or in operations (rather than only business model innovation or management innovations), it enables other types of NIIs.

As suggested by both Tempelman, et al. (2015) and Mohr, et al. (2015), NII does influence organisations “beyond the traditional scope of sustainable product design” (Tempelman, et al., 2015, p.327) and influences corporate missions by introducing ecological principles such as permeability, complex adaptive systems thinking, resilience, lexicons reflecting the natural world, and other principles (Mohr, et al., 2015). This was evident in all Organisational Innovations. While the categorical

nuances of NII at the organisational level are not of particular concern for the RQs of this thesis, the distinction between management, business model, and operational applications of biological strategy again point to the diversity of possible innovation types that are frequently overlooked by practitioners. Further recognition and leveraging of these differences would likely engage with NII participants with more targeted strategies and result in greater success with the application of NII. These varying applications are particularly relevant when considering the results of SOI processes. An overview of Organisational Innovations described in the cases can be found in Table 24 below.

In summary, NIIs at the organisational level can be influential when applied analogically to operations and NPD decisions within MNCs. However, they are limited or difficult to account for when they are applied in isolation from other types of SOIs. Additionally, many organisational applications of NII require commitment from all levels of the organisation, from senior management to middle management to employees (discussed further regarding RQ2); and, while metaphorical applications of NII may help to guide the dialogue about NII, these types of applications result in little tangible change. Analogical applications, however, demonstrate significant advantages for SOI and are recommended as a more refined approach to organisational NII in MNCs.

Systems Building Innovation

As might be expected, Systems Building Innovations were the least common application of NII. While there were ten total Systems Building Innovations discussed by interviewees, only four of these innovations have been implemented with demonstrable effects for socioecological systems. As suggested by Adams et al. (2016) and Jay & Gerard (2015), these types of system innovations – socioeconomic systems, systems of production, consumption and waste, eco-socio-techno systems (Adams et al., 2016; Jay & Gerard, 2015) and socio-technical systems (Gaziulusoy & Brezet, 2015) – represent a philosophical shift in the overall purpose of the business towards net positive goals for society and the environment. Moreover, although there were multiple descriptions of Systems Building Innovations in the literature, these definitions fall short of describing the quality of the changes in these systems to such

an extent that categorisation is difficult to apply in practical settings. This was apparent in several examples throughout the cases, described in more detail below.

Motion towards a net positive goal was apparent in all cases that discussed Systems Building Innovations, including Resources Inc., Electronics Inc., Cosmetics Inc., Clean Inc., and Textiles Inc., though their cultures, norms, approaches, and intentionality towards corporate social responsibility vary substantially. While five of the six cases demonstrated some attempt at Systems Building Innovations, the systems impacted varied greatly, with only some of them creating distinctly different approaches to historically established socioeconomic systems. An overview of Systems Building innovations by case, their categories, approaches and references to existing literature can be found in Table 25.

One challenge in applying the Systems Building category was revealed when comparing the origins of each of the organisations. Resources Inc., for instance, is known for high levels of ecological and social liability globally, and yet they concurrently contribute to social causes via a philanthropic strategy and the alternative energy sector, making it difficult to discern authenticity and intentionality in the global sustainability dialogue. Textiles Inc. is also a highly extractive industry, and yet it is frequently cited for its sustainability transformation that began in the 1990s with its founder's change of heart, exemplifying a shifting intentionality within an organisation towards net positive goals. And finally, as another variation, Clean Inc. was established to fulfill a specific market niche targeting sustainability-minded consumers with a net positive goal as part of its early charter, yet the organisation faced scrutiny for using GMOs. A comparison of these three cases provides an example of the challenges inherent in identifying, promoting, and enabling Systems Building Innovations in MNCs when they are identified in companies with public records of normative multiplicity.

While most definitions of Systems Building Innovations emphasise the business as a whole, several examples of Systems Building Innovations were evident amongst NII interviewees at the level of a particular project, demonstrating another ambiguity in applying the definitions in practical case study settings. Furthermore, the existing definitions that include systems of production, consumption, and waste may be a

system on a material level, but they do not fundamentally change the operational relationships in existing systems. For instance, Resources Inc. is in an extractive industry that many would argue is inherently unsustainable. Concurrently, however, they are engaging supply chain innovations to use waste from another industry as a raw material. In other industries, this would likely be considered a transition towards a more sustainable supply chain, but in this instance, sustainability is questionable due to the high levels of impact across the entire industry. Ultimately, these issues are beyond the scope of this thesis, but they demonstrate some of the difficulties in defining and applying systemic SOIs. When using a systems approach, it is difficult to distinguish what should be considered part of a particular system and what should not for the purposes of accounting for Systems Building Innovations.

And finally, the most interesting finding related to the categorical prescription of Systems Building Innovation was the difficulty in determining specifically what qualifies as a 'system' for the purposes of describing innovation results within multinationals. While existing literature provides broadly descriptive terms used herein such as 'socio-technical', 'socioecological', 'socioeconomic', etc., it became clear when applying these categories to activities described by interviewees that existing definitions were sufficiently vague to include any number of more complex innovations. This is not to say that these descriptive terms are not relevant or useful, but only that existing attempts to develop theory to describe these types of innovations rely heavily on the normative assumptions of the reader to determine what sustainability means in any given context – a particularly delicate task in the context of a MNCs. For instance, one interviewee from Clean Inc. described how SB1, though intended to be a systems-level innovation of a private sector client, was actually forcing questions about the appropriate economic strategy for an island community which currently relies on tourism as its primary economic activity. SB1 was proposing a new model of collaborative, localised production and consumption that challenged the political status quo, and this was not an issue that they were intending to pursue as SOI consultants. This type of cross-sectoral dialogue was common amongst Systems Building Innovation stories, in which those pursuing some sort of sourcing or supply chain innovations inadvertently found themselves in the role of advocate, lobbyist, or non-profit founder in order to realise their NII ambitions. The provocation of NII at the systems level entails an accompanying

normative position regarding the 'right' kind of economy, and this is rarely unpacked in the innovation management literature. It raises ethical considerations regarding the normative stance of various systemic approaches and provokes dialogue related to a diversity of sustainable development narratives in corporate settings.

Generally speaking, Systems Building Innovations are the most difficult to achieve due to the inclusion of diverse actors from multiple sectors working in partnership in novel ways. Those companies that were successful with Systems Building Innovations emphasised the need for these ventures to be profitable, although they were driven by socioecological factors on many levels. These types of innovations occupy a liminal space between the realms of corporate philanthropy and commercial endeavors, often blurring the lines in the relationships with external consultants from NGOs and private organisations. For instance, Clean Inc.'s SB1 and SB2 and Textile Inc.'s SB1 and SB2 have had mixed levels of success even within the same organisation. At Clean Inc., SB1, which involved the coordination of multiple commercial players and the development of new production techniques, was seemingly too complex to be financially self-sustaining and was consequently nearly discontinued at the time of interview. That project involved a team of NGO consultants, private sustainability and engineering consultants, and an academic research consultant for some technical aspects of the project. By contrast, SB2 also involves local NGOs, volunteer coordination, integration with schools, private design consultants and others, and remains financially viable. Textiles Inc. had similar variability across its four Systems Building Innovations, which have strong social and ecological components but require business viability. Only three of Textile Inc.'s four Systems Building Innovations are still being utilised (SB2), whereas the other (SB1) lost traction due to underperformance with customers. SB2 has been very successful and is currently undergoing expansion, demonstrating further viability.

In the cases of Electronics Inc. SB1 and Textiles Inc. SB3, both organisations have recognised that current waste disposal policies disincentivise innovations that utilise cradle-to-cradle, circular economy, and industrial ecology principles. Consequently, they have found themselves acting as lobbyists for policy reform initiatives that enable the realisation of the circular business models. For Textiles Inc., this put them in direct conflict with other companies in their industry who were resistant to

regulations mandating life cycle ownership and producer responsibility initiatives. Concurrently, however, in an effort to enable closed-loop manufacturing and reintroduce used materials into their supply chain, they have assisted several other companies and entrepreneurs in developing technologies and infrastructure that would further enable nylon recycling, extending their influence far beyond the political realm.

The primary challenge of applying systems level categorisation and analysis to NII relates to the difficulty entailed in establishing what qualifies as systems building in the present socioeconomic and socioecological conditions. The criteria for evaluating the implementation of Systems Building Innovations as applied in the context of an MNC are substantially under-developed when compared, for instance, to the criteria for Technological Innovations. Furthermore, criteria used to address the social aspects of sustainability are highly controversial, with competing interests preferring quantitative or qualitative measures of social sustainability such as gross domestic product, average income, educational metrics, life expectancy, inclusive governance, autonomy of cultural and ecological heritage, equitable distribution of wealth, and other measures. As Gaziulusoy, et al. (2015) assert, the application of NII as an approach does not result in ecological and social benefit per se, and instead needs to be contextualised within a broader system approach. This is especially relevant when applying NII to systems-level innovations. These innovations need to be considered within the broader social, economic, and ecological contexts. Given that recent literature suggests the necessity of these types of transition-based innovations for sustainable development, it is timely to begin to develop criteria that are relevant for the public and private sectors.

RQ1 Summary

Generally speaking, the three types of NIIs, once defined, were easily distinguished from one another and provided a useful analysis framework to describe the diversity of approaches utilised in MNCs. While the theory related to Technological and Organisational Innovations is well-developed and informative in the analysis process, theory related to Systems Building proved to be difficult to apply in case study settings.

Table 24: Benefits of Applying NII to Organisational Innovations

Case	Ref.	Description	Benefits and Related Literature
ICT Inc.	O1	Broad application of nature's principles to a new service offering in partnership with prospective clients.	Shaping firm's environmental impact (D'Amato & Roome, 2009; Hollen, Van Den Bosch, Volberda, et al., 2013; Martin et al., 2012; Theyel, 2000); Reduce codification of organisational routines (Khanagha et al., 2013); Influencing corporate missions (Tempelman, de Pauw, van der Grinten, Ernst-Jan, & Grevers, 2015); New ecological logic for innovation (Mohr et al., 2015).
	O2	"Natural leadership" approach loosely related to a NII methodology and encouraged employees to seek opportunities to interact outdoors.	Reduce codification of organisational routines (Khanagha et al., 2013); New ecological logic for innovation (Mohr et al., 2015).
Electronics Inc.	O1	Attempt to design the structure of new open innovation relationships by applying biological models to management.	Reduce codification of organisational routines (Khanagha et al., 2013); New ecological logic for innovation (Mohr et al., 2015).
	O2	Product servitisation of several products; Primarily in B2B relationships and now expanding to B2C relationships.	Shaping firm's environmental impact (D'Amato & Roome, 2009; Hollen, Van Den Bosch, Volberda, et al., 2013; Martin et al., 2012; Theyel, 2000).
Cosmetics Inc.	O1	Attempt to elevate the position of NII from an NPD approach to the overall approach to corporate sustainability.	Shaping firm's environmental impact (D'Amato & Roome, 2009; Hollen, Van Den Bosch, Volberda, et al., 2013; Martin et al., 2012; Theyel, 2000); Reduce codification of organisational routines (Khanagha et al., 2013); Influencing corporate missions (Tempelman, de Pauw, van der Grinten, Ernst-Jan, & Grevers, 2015); New ecological logic for innovation (Mohr et al., 2015).
	O2	Application of swarm theory to	New ecological logic for innovation (Mohr et al., 2015).

		management style in one business unit.	
Clean Inc.	O1	Design of the business and its activities on the systemic principles of ecosystems.	Shaping firm's environmental impact (D'Amato & Roome, 2009; Hollen, Van Den Bosch, Volberda, et al., 2013; Martin et al., 2012; Theyel, 2000); Reduce codification of organisational routines (Khanagha et al., 2013); Influencing corporate missions (Tempelman, de Pauw, van der Grinten, Ernst-Jan, & Grevers, 2015); New ecological logic for innovation (Mohr et al., 2015).
	O2	Development of informational materials for products that demonstrate inspiration from and integration with natural systems.	New ecological logic for innovation (Mohr et al., 2015).
Textiles Inc.	O1	Ecological Performance Standards to guide the redesign and operational performance of factories.	Shaping firm's environmental impact (D'Amato & Roome, 2009; Hollen, Van Den Bosch, Volberda, et al., 2013; Martin et al., 2012; Theyel, 2000); Reduce codification of organisational routines (Khanagha et al., 2013); New ecological logic for innovation (Mohr et al., 2015).
	O2	Various managerial perspectives inspired by biological phenomena that are consequential for strategy, operations, new product development, etc.	Reduce codification of organisational routines (Khanagha et al., 2013); Influencing corporate missions (Tempelman, de Pauw, van der Grinten, Ernst-Jan, & Grevers, 2015); New ecological logic for innovation (Mohr et al., 2015).

Table 25: Categories Of Systems Building Innovations

Case	Ref.	Description	Categories, Approaches and Related Literature
Resources Inc.	SB1	“...Create something valuable from someone else’s waste stream.”	Systems of production, consumption and waste; Closed loop production (Adams et al., 2015; Jay & Gerard, 2015)
Electronics Inc.	SB1	Policy reform advocacy to enable the transition to circular economy models across multiple sectors.	Systems of production, consumption and waste, Eco-socio-techno-systems; Circular economy (Adams et al., 2016; Jay & Gerard, 2015); Socio-technical systems (Gaziulusoy & Brezet, 2015)
Cosmetics Inc.	SB1	Development of a NII research center jointly funded by Cosmetics Inc., state government, and a university research body.	Socio-economic systems that span sectors (Adams et al., 2016; Jay & Gerard, 2015); Socio-technical systems (Gaziulusoy & Brezet, 2015)
	SB2	Intercontinental research in partnership with academic researchers to guide the development of a research agenda for a particular plant species that can inform their supply chain.	Socio-technical systems (Gaziulusoy & Brezet, 2015)
Clean Inc.	SB1	Localised system of production and consumption for a new place-based product.	Socio-economic systems that span sectors, Systems of production, consumption and waste, Eco-socio-techno-systems; Closed-loop production (Adams et al., 2016; Jay & Gerard, 2015); Socio-technical systems (Gaziulusoy & Brezet, 2015)
	SB2	Plastic for recycled product packaging were collected by local fishermen and school groups to remove polluting plastic from the oceans and beaches and reincorporate it back into their supply chain.	Eco-socio-techno-systems; Closed-loop production, Net positive (Adams et al., 2016; Jay & Gerard, 2015); Socio-technical systems (Gaziulusoy & Brezet, 2015); Systemic Global Waste = Supply Chain
Textiles	SB1	New textiles made from waste plant materials in	Socio-economic systems that span sectors, Eco-socio-techno-

Inc.		partnership with female artisans in an emerging economy.	systems; Closed-loop production, Net positive (Adams et al., 2016; Jay & Gerard, 2015)
	SB2	Nylon for 100% recycled products collected by local fishermen and other community members (in emerging economies) to remove polluting nylon fishing nets from the oceans and beaches and reincorporate it into their supply chain.	Socio-economic systems that span sectors, Eco-socio-techno-systems, Closed-loop production, Net positive (Adams et al., 2016; Jay & Gerard, 2015); Socio-technical systems (Gaziulusoy & Brezet, 2015); Recovery of waste in the global commons as raw material for supply chain.
	SB3	Development of regulations to ban their product from the landfill at the end of its use, driving SOI for the entire ubiquitous industry.	Eco-socio-techno-systems, Closed-loop production (Adams et al., 2016; Jay & Gerard, 2015); Socio-technical systems (Gaziulusoy & Brezet, 2015).
	SB4	Development of a textile-recycling infrastructure across several countries via the sharing of their intellectual property, unique capabilities, capital resources and technological know-how.	Socio-economic systems that span sectors, Systems of production, consumption and waste; Eco-socio-techno-systems; Closed-loop production, Circular economy, Net positive (Adams et al., 2016; Jay & Gerard, 2015); Socio-technical systems (Gaziulusoy & Brezet, 2015); Recovery of waste in the global commons as raw material for supply chain.

While SOI may be difficult to qualify via isolated variables, this innovation typology may contribute to the SOI process in which managers, NII practitioners, and consultants must communicate the level of change that they wish to enact. If an NPD process is directed only at Technological (product or process) Innovations and/or inward looking Organisational Innovations, the effectiveness of NII is limited in scope. To reach the full potential of NII, contextual relevance in socioecological systems is a key consideration and is demonstrated by few of the case studies.

While Benyus and following scholars describe the levels of emulation of biological strategies as “form, process and ecosystem” (E. B. Kennedy, Fecheyr-Lippens, Hsuing, Niewiarowski, & Kolodzieg, 2015), the reality of implementation of NII is far more nuanced with types and sub-types of innovations that are evident in the innovation management literature, but have yet to be fully recognised amongst NII educators, academic programs, and consultants. The recognition of the nuanced types of applications, as proposed herein, has the potential to shape the effectiveness of NII strategies by carefully targeting the potential levels of impact for NII projects.

Factors Influencing Adoption

Characteristics of the Innovation Context

1. Norms of the Social System: Perceptions of Sustainability

Interviewees were asked about sustainability norms at their organisations in several different ways throughout the interviews and were given the opportunity to discuss these norms as they related to metrics, culture, definitions, and innovation.

Perceptions of sustainability were markedly different across the six organisations, driving three general SOI narratives when viewed in conjunction with other factors. The three narratives are described herein as *Ambiguous*, *Accountable*, and *Aspirational* due to a combination of organisational factors and personal perceptions of sustainability. These SOI narratives are the result of several characteristics that were comparable across cases, as summarised in Table 26. While not derived verbatim from the interview data, the three categorical names are descriptive of how the interviewees articulated their organisational relationship with sustainability. These descriptions of sustainability are further differentiated by organisational characteristics related to innovation infrastructure and culture and the role of

leadership in the NII processes (as described in the following sections). The Ambiguous organisations included Resources Inc. and ICT Inc.; Accountable organisations were Electronics Inc. and Cosmetics Inc.; and Aspirational organisations were Clean Inc. and Textiles Inc.

Table 26: SOI Norms Related to NII Implementation

Ambiguous	Accountable	Aspirational
Resources Inc. and ICT Inc.	Electronics Inc. and Cosmetics Inc.	Clean Inc. and Textiles Inc.
Unclear or inexact definitions of sustainability due to lack of clear interpretation across the organisation.	Incorporation of sustainability is expected and required to justify everyday decision-making within the organisation for incremental improvements.	Demonstrate hopeful and ambitious objectives for organisational sustainability goals without clear accountability to incremental improvements.
Aim to <i>learn from nature</i> with NII.	Aim to <i>do like nature</i> with NII.	Aim to <i>be like nature</i> with NII.
Limited sustainability leadership; No common sustainability narrative.	Visionary sustainability leaders with a consistent narrative through time.	Visionary sustainability leaders, but a reinvented narrative.
Sustainability is political.	Sustainability is practice.	Sustainability is purpose.
Economically motivated.	Ethically motivated.	Intrinsically motivated.
Sustainability activities are mentioned in annual reports.	Sustainability activities must be measured for everything.	Sustainability activities must be modeled for others.
"[Sustainability] is hard to implement because it's such a broad word."	"As a large international company, we're responsible for what we do..."	We strive to "become restorative through the power of our influence."
"In general, sustainability was not seen as a business opportunity."	"How do we make a product that we can still make money that really improves the health of people in places that don't have access to the resources?"	"We've been able to make an extremely resilient product without using any petroleum, new or virgin resources. So there is a path for [sustainable business] and [we've created] a model."
External consultants were "shocked by the level of ignorance around sustainability."	We view "sustainability and innovation as the same thing."	"[Biomimicry and sustainability] are a part of each other."
"Weak"	"Very strong"	"Same principles as nature"

The Ambiguous organisations demonstrated a few similar characteristics in the way that they discussed sustainability, in that the organisational definitions were unclear or inexact due to a lack of clear interpretation across the organisation. There was little common narrative amongst interviewees, if any at all. Former employees described the sustainability cultures as weak or non-existent, and current employees made broad statements about carbon and water, frequently referring to evidence in their sustainability reporting. For them, NII was perceived as an innovation approach extending beyond the boundaries of their typical innovation infrastructure. *Learning from nature* for innovation was the primary objective of the NII processes without specific considerations for sustainability outcomes. They described how different internal political influences effected the adoption of NII. Additionally, there was little apparent accumulation of resources and capabilities necessary for SOI processes (Varadarajan, 2015), and to the contrary, several interviewed employees associated with sustainability and NII have left the organisation (*a sustainability brain-drain*). They also tend to rely heavily on business and financial justifications for SOI endeavors.

The Accountable and Aspirational organisations identified in this study share several characteristics of organisations that engage in SOI as described in the literature. Both categories demonstrate strong sustainability narratives, with all interviewees well equipped to discuss their strategies and give ample examples of how NII has been successful. They also described visionary leadership that guided a company-wide SOI agenda and the application of multiple, varied attempts at SOI and NII.

A few notable differences are also worth mentioning that significantly influenced the adoptability of NII. While the limitations of the Ambiguous category attempting SOI are somewhat obvious, the differences between the Accountable and Aspirational categories were elusive at first glance and mostly relate to the motivations and practices of SOI. For the Accountable organisations, sustainability is an institutionalised, practical aspect of their operations motivated by a sense of ethics and responsibility developed early in the history of the organisation. The incorporation of sustainability is expected and required to justify everyday decision-making within the organisation for incremental improvements. They strive to *do like nature* does and use NII as a tool for SOI. Aspirational organisations, by contrast,

discuss sustainability as an intrinsically motivated and purpose-driven aspect of their business that is being continually redefined. They describe hopeful and ambitious objectives for their organisational sustainability goals without being clearly accountable to specific incremental improvements while striving for those goals. They aim to *be like nature* in their applications of NII for SOI. For the Accountable organisations, sustainability and innovation are equivocal, while sustainability and NII are synonymous in Aspirational organisations.

2. External Knowledge Sourcing

While external knowledge sourcing has been seen as an important factor influencing the adoption of innovations and particularly SOI (Horbach et al., 2012; Jakobsen & Clausen, 2016), the influences on the adoptability of NII are inconsistent across cases. Although it is generally viewed as a positive factor influencing adoption, variations in the expertise of outside knowledge result in differing levels of influence. As this was inadvertently one of the selection criteria for the cases, all cases utilised external NII specialist support (particularly in the form of KIBS as suggested by Cainelli et al., 2015; De Marchi, 2012; De Marchi & Grandinetti, 2013), and as such, this was not a differentiator for adoption when comparing the six cases. Contrary to what might be expected, greater contact with NII specialists did not necessarily lead to more effective implementation of NII. For instance, Cosmetics Inc. invested substantially in external NII expertise, but at the time of interview, some interviewees expressed dissatisfaction with their relationship with their external consultants despite several years of work together. On the other hand, Textiles Inc. and Clean Inc. have worked repeatedly with external consultants with NII expertise and have had success outsourcing much of their NII activity. While the inclusion of NII specialist support may have an overall positive effect across all cases of attempted NII, in the six cases examined in this study, it was not a major differentiator influencing the success of results. This is contrary to findings of a previous case studies which suggest that the inclusion of a biomimicry specialist into the front-end of innovation processes had a positive effect on innovation outcomes (Kennedy & Marting, 2016; Tempelman et al., 2015). Similarly, all but one case had biological expertise, and this was also not a major differentiator.

At the same time, however, forms of external knowledge sourcing other than NII were more influential on the adoption process. In alignment with existing literature (i.e., Tempelman et al., 2015), those teams which utilised further external specialists to implement NII in partnership with NII specialists were more likely to have positive results. All cases relied on outside consultants, but it was the integration with other types of organisations that enabled NII rather than particular consultant interactions. For instance, at Textiles Inc., while NII specialist support was common, the integration with design teams, suppliers, equipment providers, lawmakers, and other stakeholders enabled the level of depth in applying NII that they have been able to achieve.

One additional variable that was influential amongst the cases studied herein that has not been previously addressed in the literature is the role of design expertise on the NII team. The inclusion of design expertise in NII activities, either internally or externally contracted, was a differentiating factor that positively contributed to the adoption of NII. Of the six cases, the four that have achieved more NIIs have relied extensively on design expertise as an integral part of the NII team.

3. Informal Social Network Collaboration

While partnerships with outside specialists such as manufacturers, NGOs, and other stakeholders did enable the adoption of NII from an organisational perspective, informal social networks related to NII were relatively inconsequential and had little influence on adoptability within MNCs in the longer term. Contrary to suggestions in the literature that “an organisation is more likely to adopt an innovation if those people who have significant social ties both inside and outside the organisation are able and willing to link the organisation to the outside world in relation to this particular innovation” (Greenhalgh, Robert, MacFarlane, Bate, and Kyriakidou 2004), this was not the case with NII in MNCs. For Electronics Inc., their informal network went on to develop national policies to promote biomimicry specifically, however, this did little to further the progress of NII projects internally. Similarly, Textiles Inc. had created a working group of MNCs using NII to exchange practical experiences and best practices. However, this was a result of their extensive success with NII rather than the cause of it. So although four of the six cases included informal social networks as part of their overall NII activities, this was not a clear differentiator

across cases leading to more successful results, but rather a result of engagement with NII.

However, a related phenomenon was apparent for those organisations that experienced *sustainability brain drain*, in which those responsible for and trained in NII leave the organisation to practice NII in other sectors. Several individuals who were leading or participating in NII activities within MNCs have left their organisations and gone on to pursue NII activities ranging from consulting to advising government officials to creating novel economic incentive policies promoting NII. Although the initial intention of NII may not be met, other results emerged in the months and years that followed the corporate investment in NII activities that contribute positively to socioecological and socioeconomic systems beyond the reach of the MNC.

4. Leadership

While leadership was not a specific focus of the initial interviews, several interviewees commented on various characteristics of the leadership, bringing it into question as an influential factor related to adoption. As discussed above, four characteristics emerged as relevant to the adoption of NII that will be discussed in greater detail here (As listed in Chapter 4): 1) The degree to which management values intangible benefits; 2) Any siloing of sustainability created by management decisions; 3) The level of support NII efforts receive from senior management; and 4) Indications that management may maintain a cultural separation from other staff – a type of insularity amongst the ranks.) In regards to the first two characteristics, findings were aligned with Haanaes, et al. (2011), who differentiated between the “Cautious Adopters” and “Sustainability Embracers”. In the four cases most successful with NII and aligned with the criteria of “Sustainability Embracers”, there was evidence that intangible benefits of NII and SOI were valued and sustainability was integrated throughout the organisation without being excessively siloed (though some siloing was evident in the “Accountable” organisations.) Based on these two characteristics, Resources Inc. and ICT Inc. would conversely be classified as “Cautious Adopters”.

Regarding the third characteristic, only the senior leadership of Clean Inc. and Textiles Inc. demonstrated significant support for the NII activities, exemplifying the importance of support at this level of the organisation. Tempelman et al. (2015) explicitly noted that NII projects that lacked the support of senior management “suffered more difficulties” than those cases in which senior management were supportive and this was aligned with the company “vision or ambition” (p.340). This was also apparent in the six cases analysed herein. The two cases in which nature was perceived as the standard for sustainability benefited from the greatest level of managerial support and success with NII projects. To the contrary, those organisations which expressed some level of insularity of management who have a vested interest in maintaining the status quo (i.e., Resources Inc., ICT Inc., and Cosmetics Inc.) experienced more difficulty implementing NII projects (in alignment with Francis et al., 2003). For example, as the Innovator at ICT Inc. described his experience, “I would just go up and mix in a room [with senior management]. They weren’t used to people doing that. They’re funny in France, very elitist in a way.”

And finally, in the Ambiguous organisations (Resources Inc. and ITC Inc.), there was indication of cultural separation of management from other employees. Furthermore, a managerial focus on competitive strategies (Biondi et al., 2002) amongst Resources Inc. and ICT Inc. may have negatively influenced adoption.

Summary: Characteristics of the Innovation Context

Table 27, arranged from left (least successful) to right (most successful), shows a clear trend related to the characteristics of the innovation context, with the more successful organisations demonstrating more factors in alignment with existing literature related to SOI and innovation adoption theory. Those organisations more to the left side of the diagram had difficulty with NII and likely also have difficulty with innovation and SOI in other contexts due to these characteristics.

Characteristics of the Decision-Making Unit

While there is considerable overlap with the previous section related to the Innovation Context, specific factors related to the Decision-Making Unit were identified and analysed in each case.

1. Attitudes Towards Innovativeness

Somewhat obviously, it is widely accepted that receptivity to new ideas influences an organisation's propensity to adopt new products (Frambach & Schillewaert, 2002).

When asked to address this issue, interviewees from each company had distinct responses that also corresponded well with their relationship to sustainability as addressed above. The Ambiguous, Accountable, and Aspirational organisations exemplified different values related to innovation as well as sustainability.

Interviewees from the Ambiguous category described a desire to pursue radical innovation in their projects, but this did not necessarily align with larger corporate innovation strategies. Both Resources Inc. and ICT Inc. were applying NII in experimental innovation channels. The Accountable organisations demonstrated a high-level commitment to innovation with significant budgets allocated to formal research and development departments. Concurrently, however, the innovation budgets at both Electronics Inc. and Cosmetics Inc. were "eaten up...by the standard multinational or stock market knowledge cost drivers." The Aspirational organisations, Clean Inc. and Textiles Inc., frequently engaged in open innovation and demonstrated greater willingness to share elaborate details of their SOI endeavors with the broader public. Furthermore, several interviewees described a "freedom to fail" as part of the company innovation culture.

Conversely, Resources Inc. and ICT Inc. demonstrated internal political problems and destructive internal competition, both described by Kimberly and Evanisko (1981) as characteristics of an organisational culture that impedes creativity. This was not evident in any of the other four cases, even amongst former employees who may be more likely to harbour negative feelings towards a former employer than current employees.

Table 27: Characteristics of the Innovation Context

Analysis Category	Factors	Resources Inc.	ICT Inc.	Electronics Inc.	Cosmetics Inc.	Clean Inc.	Textiles Inc.
Norms of the Social System	Perceptions of Sustainability	Ambiguous	Ambiguous	Accountable	Accountable	Aspirational	Aspirational
External Knowledge Sourcing	NII Specialist Support						
	NII Team Included Design Expertise			4 of 6 Innovation Attempts	3 of 7 Innovation Attempts	7 of 7 Innovation Attempts	4 of 10 Innovation Attempts
	Utilised Further External Specialists				3 of 7 Innovation Attempts	2 of 7 Innovation Attempts	1 of 10 Innovation Attempts
Social Network	Informal Collaboration						
Leadership	Values Intangible Benefits						
	No Siloing Of Sustainability						
	Senior Management Support						
	No Insularity Of Management						

Two final characteristics related to innovation culture are the tendencies towards episodic innovation or an emphasis on incremental innovation (Francis et al., 2003). While seemingly subtle, this was a main differentiating factor that separated the Accountable organisations from the other cases. Episodic innovation was evident at both Electronics Inc. and Cosmetics Inc. in their descriptions of how they used various NII and SOI tools. They had different departments and/or teams trialling biomimicry, cradle-to-cradle, and circular economy as separate initiatives with distinct budgets and project management processes. As exemplified in Electronics Inc., the various NII projects were “very isolated” at that time. Interviewees suggested that the best way to progress was to start with a technological application – an ‘easy win’ – to gain broader support for NII. To contrast, an innovation manager from Textiles Inc. said, “I don’t know that the question should be ‘how do you compartmentalise biomimicry in your process?’ but ‘how do you let it bleed into every part of everything that you do?’ And one way to do that is through language.”

The emphasis on incremental innovation was evident when Electronics Inc. interviewees described small cautious steps towards sustainability and incremental gains in product and material efficiencies as part of the SOI strategy. Similarly, Cosmetics Inc. described how their NPD cycle of producing a new catalogue every three weeks systematically drives incremental product innovations rather than supporting the long-term innovation culture of the research department. However, despite this strategic position to produce product innovations using NII, these organisations expressed frustration with the effectiveness of the NII approach and the lack of benefit evident in the innovation results.

In summary of attitudes towards innovativeness, while openness towards radical innovations might seem to be a precursor for the implementation, it did not necessarily influence the implementation of NII strategies. Several organisations described a general willingness to move towards radical innovation and/or gave previous examples of how innovative they had been in the past, but this was not indicative of their ability to successfully adopt NII. Similarly, internal competition or politicking with the NII process (or otherwise) was detrimental to overall success, creating a culture in which innovators were positioning themselves for individual

gains rather than company-wide success with NII. And finally, when individuals felt constant pressure to be innovative and use new tools and approaches for SOI, it also had an overall negative effect. However, when managers support risk taking and do not maintain regular accountability for innovative behaviors and incentives, the aspirational aspects of NII are given space to flourish.

2. Formality of Organisational Structures

Similarly, the formality of organisational structures seemed to differentiate the Accountable organisations from the Aspirational organisations, but this was less defining in the Ambiguous organisations. The Accountable organisations (Electronics Inc. and Cosmetics Inc.) had specifically allocated innovation budgets, project managers, and “very, very sophisticated project management scales and tools that also worked across the organisational units.” An SOI manager at Electronics Inc. described how “all the special tools...were brought into the corporation by consultants and were tested.... It’s often used with different works, but the processes are all the same.” In light of the other cases, this statement is more likely a reflection of the organisation than of the innovation approaches, as the interviewee suggests. This contradiction is in alignment with several authors who suggest that while firms with more abundant resources for innovation are better able to adopt innovations, the formalised and centralised structures common in these organisations are concurrently limiting (Damanpour, 1992; Hojnik & Ruzzier, 2016; Kim, 1980; Zaltman et al., 1973). One interviewee from Cosmetics Inc. described how she had grown tired of ideation sessions on various topics and was craving tangible results. In short, there seems to be a saturation point for innovation processes when they are viewed as investments that need to demonstrate a return. Similarly, these two organisations described sustainability criteria integrated into the design process at the outset, which, at the surface, seems as though it might enable the advancement of SOI, but in actuality such criteria may have the opposite effect of over-burdening creative capacities. This type of performance pressure does little to advance NII at any level of application.

The Aspirational organisations (Clean Inc. and Textiles Inc.), on the other hand, do very little or actively discourage the internal management of innovation, viewing it as counter productive. For instance, as an innovation manager at Textiles Inc.

commented, “Technology and innovation just happens and I can’t really schedule it.” Another senior leader said, “It’s the work prior to innovation. You can’t manage innovation. You get crappy results whenever you do.” Innovation managers and employees alike describe how they avoid managing innovation and instead offer employees permission to fail, preferring to create a culture of innovation that enables employees to embrace innovation when it happens rather than planning for it.

Interestingly, while there is some resistance to innovativeness internally at Clean Inc., they seem to address this gap by relying heavily on open innovation channels for NPD and business model innovation. They have compensated for difficulties with internal innovation by altogether outsourcing some of their more radical pursuits. This is perhaps to bypass a stagnating innovation culture that two internal employees commented on in the interviews. Clean Inc.’s pursuit of radical innovations is led by a long-term innovation manager in partnership with external teams, in a similar style to that described by managers at Textiles Inc.

While there were differences in how Clean Inc. and Textiles Inc. managed innovation, their lack of structure is a common asset. In the literature, these cultures are described as “decentralised and informal organisational structures [that] facilitate innovativeness” (Subramanian & Nilakanta, 1996, p.634). Amongst the six case studies, this style of organisational structures seems to be most supportive of NII activities compared to non-standard innovation channels (Ambiguous narratives) and heavily managed and structured innovation channels (Accountable narratives).

3. Professional Training

One of the most common aspects of all cases was the type of professional training represented on the NII innovation teams. All cases, with the exception of Clean Inc., had invested in staff training of NII. The amount of training varied greatly. Electronics Inc., for instance, only sent one senior manager to an immersive NII training, while Cosmetics Inc. trained more than forty associates and executives in NII principles and methodologies. Although studies have suggested that professional training (Hage, 2016; Kim, 1980; Kimberly & Evanisko, 1981), specifically training related to ecological systems and environmental problems (Purser et al., 1995) and NII (Tempelman et al., 2015), is necessary for the implementation of SOI and NII

respectively, this was not a consistent factor across all cases. Evidence from interviewees suggests that training in ecological systems and environmental issues was common at Electronics Inc., Cosmetics Inc., and Textiles Inc., though this was not specifically addressed in the interviews. While the level of training in environmental and ecological issues may have been a relevant variable that affects the overall norms of the organisation, training in NII was not a significant differentiator for the effectiveness of NII in these six cases. To summarise, there was no clear indication that internal training in NII was positively influential on implementation.

Although Genç & Di Benedetto (2015) suggest that cross-functional integration of expertise also has a positive impact on innovation outcomes, this was also not an influential differentiator for these six cases. All cases *demonstrated* high levels of interdisciplinarity that included research scientists, engineers, business expertise, and, in all but one case (ICT Inc.), biologists. As described briefly above, the only expertise that was of consequence was the inclusion of a designer on the team. The two cases that did not include design expertise internally (Resources Inc. and ICT Inc.) seemed to have mostly abandoned any NII activities, and the other four cases demonstrated some level of self-sustaining activity regardless of the involvement of external consultants.

4. Selective Exposure and Perception

As described in the Commonalities section above, the majority of interviewees described some connection to natural systems in their childhood experiences, though this was not a prerequisite to be supportive of NII projects. Additionally, several interviewees described how personal beliefs and perspectives may have influenced adoption, both positively and negatively, in all cases.

In short, although individual beliefs and values shape how NII is perceived across all cases, this was not a strongly influential factor for adoption. Selective perception was common with all cases having some interviewees and/or participants who were supportive or sceptical of NII for various reasons (personal ethics, religious considerations, personal views related to innovation, professional training, etc.). And while these personal perspectives may have interfered with the individual's ability or

willingness to apply NII, this did not necessarily impede adoption at the organisational level. Considering the other factors that demonstrated consistently stronger influences across cases, selective perception of NII at the individual level was not a significant factor.

Selective exposure, on the other hand, was likely more influential in adoption decisions. For Resources Inc. and ICT Inc. (i.e., Ambiguous organisations), none of the interviewees discussed familiarity with other SOI tools and approaches. This suggests that NII was their first application of SOI and demonstrates that NII is an unlikely entry point for SOI.

Rogers (2003) suggests that users are likely to be influenced by their experiences with similar innovations, and this was most evident amongst Electronics Inc. and Cosmetics Inc. (i.e., the Accountable organisations). For these organisations, exposure to similar innovations and the ability to compare different SOI tools and approaches seemed to be detrimental to the NII activities. Both organisations drew on experiences with biomimicry, cradle-to-cradle, and circular economy projects and found it easy to compare and contrast them as distinct endeavors. At Electronics Inc., this had cultural consequences. Interviewee 4 described reactions as follows: “People [thought] ‘[Biomimicry], that’s another tool. Immediately, they get like demotivated.” Similarly, at Cosmetics Inc., Interviewee 4 described feeling “exhausted of ideation sessions, not just for biomimicry” but in general. Although a few interviewees in both Electronics Inc. and Cosmetics Inc. described NII as an overarching narrative for SOI, the majority of interviewees described biomimicry, cradle-to-cradle, circular economy, eco-design, etc. as distinct endeavors. This is likely due to the tendency to seek categorical differences that define success with various SOI tools. At Cosmetics Inc., for instance, there were separate program managers dedicated to ecodesign and biomimicry, creating a subtly competitive environment for other users in which they had to choose which approach they were going to pursue. This put excessive emphasis on adherence to a particular process rather than other aspects of NPD, such as product features, marketing, positioning, or branding. The drive to ‘do biomimicry’ became a stronger motivating force than consideration for the relevance of the final product. In the cases of Clean Inc. and Textiles Inc., neither was particularly influenced by the various NII and SOI

approaches; instead, they blended NII, SOI, CSR, and company-wide sustainability agendas together in their description of activities. The distinctions across the six organisations were likely consequential for NIIs. Similarly to the aforementioned results for Norms of the Social System, three categories emerged that can inform future adopters. For organisations that have not been exposed to other SOI approaches (i.e., Ambiguous organisations), NII is not likely to provide an easy win to build SOI momentum. Those organisations that are accustomed to adopting new SOI approaches and tools (i.e., the Accountable organisations) must remain vigilant to avoid SOI fatigue amongst staff members who may grow “tired of ideation sessions.” And for companies that view nature as the model for a sustainable system in principle (i.e., Aspirational organisations), more detailed, process-oriented approaches and certifications related to NII may not add value compared to the creation of an overarching culture of NII. And finally, Clean Inc. and Textiles Inc. (i.e., Aspirational organisations) were aware of these different tools and had been exposed to their methodologies, but they did not describe explicitly comparing and contrasting perspectives, suggesting that they were viewed on more of a continuum as opposed to discrete tools.

The following Table 28 summarises the findings related to the Characteristics of the Decision-Making Unit that influence the adoption of NII. This visual representation demonstrates the high degree of variability related to Characteristics of the Decision-Making Unit across cases, particularly when compared to the previous Table 27 that demonstrated clear trends related to the Characteristics of the Innovation Context. This visual representation suggests that the Decision-Making Unit – despite their unique cultures, intentions, and momentum – may have less influence over the adoption of NII than the larger organisational influence.

Characteristics of the Innovation

1. Perceived Relative Advantage

When asked, “What is the value of NII?”, interviewees provided a diversity of perspectives with a few thematic consistencies. Common themes included ROI, expansive thinking, communicative value, and the enabling of novel forms of

cooperation with suppliers, as reflected in the literature. A few other values were also mentioned, described below, and highlighted in Table 29.

For half of the cases, low or unknown ROI on NII products was a significant factor that influenced continued adoption. Three of the cases described pressures to demonstrate a clear return on the investment in NII consultants, which had been unclear to date. ICT Inc., Electronics Inc., and Cosmetics Inc. described issues related to the demonstration of business value and definitions of project success that included a well-received consumer product with a clear return. In the case of Electronics Inc., a NII product that had been fully developed and entered the marketplace had later been discontinued due to lack of clear return. Interviewee 3 explained, “It didn’t get any better attention, didn’t sell any better, didn’t perform any better, but it had a higher cost to produce.” ICT Inc. was hoping to engage with clients in new ways using NII but failed to see clear returns, and consequently, a few interviewees described their overall disappointment with the project. Cosmetics Inc. described pressures from senior leadership to demonstrate returns, and at the time of interview a new NII product was in the late stages of development that some interviewees saw as a clear demonstration of value, though this was controversial amongst interviewees.

Two who did not feel pressures for ROI gave different reasons for not experiencing pressure for monetary returns. For Resources Inc., interviewees described expansive budgets to advance existing energy technologies and did not describe any expected return on their investments in NII. Clean Inc. did not specifically address this issue, likely due to the long-term perspective of their NII projects and the relatively recent move towards sustainability accounting. Textiles Inc. described how their investments in NII have been exceptionally lucrative: “I don’t think we ever would have come up with that if we hadn’t looked into nature... Just in terms of sheer business value. We can’t argue against that. It’s very clearly quantifiable and huge.” Furthermore, Interviewee 6 explained, “Clearly the acceleration of innovation at [Textiles Inc.] coincides with our provocative conversation around biomimicry. [...] From the time that we were not comparing ourselves to nature to the time that we were, we accelerated our innovations and marketable innovations four to six fold [during that] 10 or 15 year period.”

Table 28: Characteristics of the Decision-Making Unit

Analysis Category	Factors	Resources Inc.	ICT Inc.	Electronics Inc.	Cosmetics Inc.	Clean Inc.	Textiles Inc.
Attitudes Towards Innovativeness	Openness Towards Radical Innovation						
	Culture Impedes Creativity						
	Episodic Innovation Or Emphasis On Incremental Innovation						
Formality Of Organisational Structures	Formal Structures						
	Flexible, Decentralised Structures						
Professional Training	NII Training Of Staff						
	Cross-Functional Expertise In NII Team						
Selective Exposure And Perception	Influenced by Existing Perceptions of Nature						
	Influenced By Previous Experiences With Similar Innovations						

In alignment with Tempelman, et al. (2015), another value frequently expressed was expansive creative thinking. At least one interviewee from each case expressed this as a benefit of a NII process. Several interviewees described how nature was “innovative” and enabled “innovative solutions.” For instance, from ICT Inc.: “It unlocks a level of creativity.”; From Electronics Inc.: “Biomimicry is a very innovative tool.”; And from Textiles Inc.: “Biomimicry [...] opens up to this entire solution set that, in our recent history as a species, we’ve been ignoring.” These findings are consistent with Tempelman et al.’s (2015) suggestion that “The designers from the larger companies also valued NID for providing inspiration and out-of-the box thinking” (p.341).

Also concurring with Tempelman et al. (2015) was the communicative value of NII. Interviewees from ICT Inc. and Clean Inc. discussed how they used it to communicate with customers, prospective clients, and potential business partners, though it also posed additional challenges of complexity. There were paradoxical statements related to this because while some interviewees viewed NII as adding additional complexity to the communication of the project, others saw it as a simplified way to communicate about complexity. Interviewees mentioned the value of NII for a “systems” perspective in various ways, as evident throughout several interviews. For instance, Interviewee 7 at Cosmetics Inc. explained, “[NII] broadens your universe. It broadens your horizons. [...] I don’t think you could not profit from looking broader and considering more complex activity.” So while several interviewees described communicative values of NII, these values were of mixed origin.

An additional value that was communicated in several ways was the value of NII in framing sustainability narratives. This aspect was revealed more in the ‘norms of the social system’, though it was also apparent in this context. Interviewee 2 of Electronics Inc. exemplifies this view: “[There is value] in just the opportunity to look at the other thirty million organisms from a strategy perspective and how they persisted on the planet for so long.”

And finally, findings related to the value of cooperative relationships were also consistent with Tempelman et al. (2015) in that there was value related to the

development of cooperative relationships with suppliers. However, this was not explicitly articulated as a value by interviewees; rather, it was evident in data related to other issues. Those cases that demonstrated a high level of implementation of NII also engaged in more extensive cooperation with suppliers.

Overall, the perceived relative advantage of NII was largely inconsequential for adoptability with interviewees in all cases, demonstrating similar views and variability within the cases. All but two cases considered the need for advantageous ROI in a financial sense, and the two organisations that did not discuss this need had very little else in common otherwise, demonstrating no significant pattern. For all organisations, NII was valued as an approach for expansive thinking or to “widen the solution space”, with many variations on this theme throughout the interviews. Similarly, several organisations described how it enabled their communication regarding sustainability with various stakeholders and customers. The only described value that may cause variation is the value of instigating new relationships and forms of cooperation with suppliers. In the four more successful cases, there was some evidence that NII was instigating novel partnerships or use of novel materials beyond just the purchase of off-the-shelf products. While no interviewees described this as an intended advantage, it seemed to have opened other SOI possibilities.

2. Observability

Although literature suggests that straightforward, observable goals and a clear project vision improve adoptability by aligning expectations (Ceschin, 2013; Rogers, 2003; Tempelman et al., 2015), a lack of clarity about the intended goals of NII was a common factor amongst all organisations and was not an issue that significantly effected adoption because most interviewees (with a few important exceptions) were comfortable with the ambiguity of innovation processes in general and did not view lack of observability as an impediment overall. There were various degrees of acceptance of ambiguity regarding goals and expectations embedded into the innovation culture. For instance, although a few interviewees from Textiles Inc. described ambiguity with regard to which SOIs were NII and which were not, this did not seem to influence adoptability at the level of the organisation because of the overall open innovation culture created by management. In Electronics Inc., a few interviewees conveyed a sense of ease with unknown innovation goals, as this was

a part of their culture and a common practice to trial a SOI tool without having specific intended results. However, for the interviewees who were challenged in accepting ambiguity, it was due to the difficulty in identifying the value of late stage results in the NPD process and clear return on prospective investments in further development.

There was a high amount of variability in the types of biological inspiration applied to various SOIs, with some organisations attempting to mimic ecological principles while others emulated shape, function, ecological principles, and system-level principles in alignment with Tempelman et al. (2015). Resources Inc. was not interested in developing NIIIs internally, and consequently, the innovation process there did not explicitly reflect any inspiration from nature, but rather the adoption of existing technologies. At the same time, as companies pursued greater numbers of NIIIs, the reliance on various types of biological inspiration became more diverse. For instance, ICT Inc. only attempted one organisational innovation that would have relied on systems-level design principles. This is in comparison with Clean Inc. and Textiles Inc., which attempted seven and ten NIIIs respectively and applied inspiration for shape, function, ecological principles and system-level design principles. Generally speaking and somewhat unsurprisingly, the more NIIIs attempted and achieved, the more diversity of types of inspiration from nature were incorporated. The main significance of this finding is that the imitation of shape, while sometimes assumed to be the most straightforward application of NII, is not necessarily the most common, nor is it necessarily a precursor to other types of emulation. As noted in response to RQ1, innovations applied at the organisational level may be precursors to other types of innovations, contrary to some popular opinions that technological applications of NII are “low hanging fruit”.

3. Complexity

As defined above by Rogers (2003), “Complexity is the degree to which an innovation is perceived as difficult to understand and use” (p.15). All cases described varying degrees of complexity in the implementation of NII. For Resources Inc. and Electronics Inc., the biological information itself was complicated to understand, and the analogical translation of the biology was beyond the scope of the business unit’s expertise. An interviewee from Electronics Inc. noted that it was a more complex

NPD process because of its expansiveness and the requirement of an additional layer of search for biological organisms. For ICT Inc. and Cosmetics Inc., the difficulty was in the process of applying the biology in a tangible, practical way. ICT Inc. was not aiming for a literal translation, but nevertheless, one external consultant reflected that they might have taken on too much at once, creating too much complexity for prospective clients to understand. Other interviewees saw NII as a communication tool and not a clear vision for “how we could literally be inspired by nature [sic].” At Cosmetics Inc., Interviewee 4 closed the NII project with an external NII consultant, because she felt that their service offering was not consistent with the level of complexity that was necessary for the development of a NII as they were intending. Clean Inc. was somewhat unique in that they recognised that the NPD process is frequently too complex for them to manage internally and they rely on open innovation to make NPD advances. Additionally, one of the issues with Clean Inc.’s SB1 was the complexity of the project and the difficulty communicating the potential of the project to prospective stakeholders and other employees. Finally, for Textiles Inc., Interviewee 1 described how NII was complex but perceived it as equivocally complex to sustainability in general.

The details of these perceptions of complexity reveal little clear pattern except that all cases demonstrated some perceptions of complexity of the NII process, and the influences of this complexity were not consistent. For instance, at Resources Inc. and ITC Inc. there were clear indications that NII was viewed as complex to the extent that it limited adoptability altogether. In the cases of Electronics Inc. and Cosmetics Inc., NII was viewed as yet another layer of complexity in an already complex innovation environment. Interviewees in both of those cases described a sense of layering of SOI criteria and project management tools that made implementation difficult. However, while Clean Inc. and Textiles Inc. also viewed it as complex, they did not view the complexity as a major obstacle that made adoption impossible; instead, complexity was viewed as a part of the innovation process that had to be dealt with, just like other types of problems inherent to business operations. In summary, it is not the complexity of the innovation itself that influenced adoptability, but rather the organisational culture related to the tolerance for management of complexity. These findings are in alignment with existing literature (Cainelli et al., 2015) which suggests that SOIs are characterised by high levels of

novelty, uncertainty, and variety, though determinations as to whether this was higher than “traditional” innovations remain inconclusive.

4. Trialability

There was no clear trend in the data related to trialability, though two related themes were evident. First, some interviewees expressed a conflict between short-term investment decisions and the need for returns, which limited implementation (in alignment with Biondi et al. (2002)). The second theme was evident in cultural influences on trialability. For Resources Inc. and ICT Inc., there was no evidence of a major investment in NII that required significant return, but concurrently, NII was also seen as “very big” with no clear next steps towards implementation. For ICT Inc., the need for financial returns was nearly immediate. Electronics Inc. and Cosmetics Inc. were similar in that they needed to identify clear returns on the NPD process within a normal product development life cycle. This was difficult due to time restrictions and the inability “to play” with the methodology without the need for clear returns. For Clean Inc. and Textiles Inc., the leadership clearly demonstrated the value of long-term innovation timelines and cultures that supported radical SOI with a variety of metrics. These last two cases demonstrate characteristics described by Gaziulusoy (2015), in which innovation planning periods are not tied to business planning periods, thereby enabling more systems-level changes. This was not the case for ICT Inc., Electronics Inc., or Clean Inc., which focused on NPD cycles and budgets to delimit the NII process. Only Resources Inc. described a situation of seemingly limitless resources that could have been dedicated to the advancement of NIIs, and this did little to enable implementation.

An additional circumstance that affected several cases, directly or indirectly, was the economic downturn of 2008. It has been felt at different times in different continents, but it occurred in alignment with Adams & Bessant's (2008) suggestion that organisations resist adoption due to economic constraints. Although Resources Inc. did not describe NII being limited due to the costs, they also went through a period of downsizing due to the economic downturn, and the business unit using NII was cut from 112 to 12 employees globally. At ICT Inc., budget cuts had negative effects on the innovative culture of the organisation, limiting employees’ “ability to think and produce white papers on subjects that interested them.” Electronics Inc. cut one

entire business unit that was attempting to use biomimicry as a management innovation as part of the downsizing during the economic crisis. Cosmetics Inc., located in an emerging economy, felt the downturn substantially later than the other cases but experienced substantial cuts in their R&D budgets due to the crisis. Clean Inc. and Textiles Inc. (the Aspirational organisations) did not specifically discuss how the economic downturn had affected their innovation processes more broadly. This last point supports the assertion that investment in R&D is the most important factor to support technological capabilities (Horbach et al., 2012; Jakobsen & Clausen, 2016).

For other organisations, trialability was not linked to financial metrics but rather to the conceptual space required to develop NII. ICT Inc. described NIIs value for inspiration, but it was perceived as being “very big and for some people, unbridgeable.” At Electronics Inc. there was not enough leniency within the organisation “to let them play with this new methodology”, largely due to time constraints and economic pressures. While O1 showed the potential of NII, the entire business unit was closed due to the economic downturn. At Cosmetics Inc., there seemed to be internal conflict regarding the need for trialability amongst interviewees. Trialability was not an issue in the early stages of the NII projects because they identified what they perceived to be “an easy win”. However, as the projects progressed, it became increasingly difficult to demonstrate clear value, and they eventually ended some aspects of the NII activities because of this difficulty in demonstrating clear returns. Although the innovation manager who initiated the NII projects foresaw a 3-4 year NPD process and attempted to scale up the NII activities to the level of the corporate sustainability mission, he left the organisation when he felt an inability to advance these goals. While most interviewees at Cosmetics Inc. saw the transformative potential of NII, they did not agree on a path forward, thereby limiting their ability to implement. For Clean Inc., they had trialed NII on several different projects rather successfully. However, they also described the cost-prohibitive aspects of embarking on a more research-intensive NII project with one particular external NII consultant. And finally, at Textiles Inc., there were some conflicting opinions regarding trialability. Some interviewees felt a clear culture of a “permission to fail” without strong drivers to demonstrate clear results, while others described how long term innovation strategies can sometimes be ‘overwhelmed’ by

short term financial circumstances. However, given the multiple successes that they have had with NII through the previous 20 years of implementation, trialability issues have likely been surpassed.

In summary, across all cases challenges related to trialability appeared consistently, though different issues caused those challenges. Contrary to the literature, which suggests that trialability is a mostly financial issue (Adams & Bessant, 2008), other issues related to capabilities, scalability, cultural impediments, and implementation timelines emerged as themes related to NII specifically. Unlimited budgets, while comfortable, do little to improve trialability of NII. Rather, the cultural support of SOI and the intellectual freedom to develop NII and other radical approaches is much more consequential for success.

5. Compatibility

Compatibility of NII in an innovation context is perhaps the most defining influential Characteristic of the Innovation. This aspect is also closely aligned with the Norms of the Social System as defined above. To reiterate the norms, compatibility varied considerably depending on how the organisation described sustainability and its relationship with SOI more broadly. The incorporation of innovation objectives into strategic sustainability goals (as previously described by Eccles et al., 2012; Hallstedt et al., 2013; Jakobsen & Clausen, 2016; Wagner & Llerena, 2011), and specifically the incorporation of NII into strategic sustainability goals (Tempelman et al., 2015), was a significant factor that influenced adoption.

Those organisations with an Ambiguous perspective on sustainability – Resources Inc. and ICT Inc. – did not describe strategic sustainability goals whatsoever. The Accountable organisations – Electronics Inc. and Cosmetics Inc. – had strategic sustainability goals, but NIIs were not explicitly incorporated into them. At Electronics Inc., although NII was not explicitly integrated in strategic sustainability goals, there were several indications that it was compatible with the SOI narrative of the organisation, which was accustomed to trialing new approaches and sustainability tools. Similarly, at Cosmetics Inc., although NII was highly compatible with their existing narrative of sustainability, they saw it as an additional tool to complement their sustainability strategy rather than being especially influential on the strategy

itself. NII was not explicitly incorporated into their strategic sustainability goals, and consequently, it formed an additional layer of complexity in the NPD process. Interviewee 4 commented that the designers already had more than two hundred sustainability criteria to consider and NII added even more criteria to this list, making it difficult to promote amongst designers internally. This was amongst a few indications contrary to existing literature that the deliberate and systematic inclusion of environmental criteria improves SOI outcomes (i.e., Wagner & Llerena, 2011). In the case of NII, systematic and accountable inclusion of environmental criteria might actually be a limiting factor for implementation because it limits the expansive creative potential of NII for SOI. And finally, for the Aspirational organisations – Clean Inc. and Textiles Inc. – NII had become a major component of their corporate sustainability agendas. From Clean Inc., Interviewee 1 gave a point-by-point description of how it was incorporated into their goals and the current development of a corresponding “roadmap”. As suggested in other sections, NII was perceived as equivalent to sustainability in many ways within Textiles Inc. and was a major aspect of the strategic sustainability agenda. As Wagner and Llerena (2011) suggest, SOI – or more specifically NII in these cases – were the result of a corporate focus on global megatrends. One novel megatrend that has yet to be considered in the SOI literature but is gaining recognition is the reintegration of polluting ocean plastics into supply chains (Brink, Schweitzer, Watkins, & Howe, 2016). Both Clean Inc. and Textiles Inc. are pioneering innovators in this area.

Although the unit of analysis was at the level of the case, in the prominent issue of innovators leaving organisations that had attempted to use NII (Resources, Inc., ICT Inc., Electronics Inc., and ICT Inc.), the role of individual transformations and transitions became a relevant factor. On an individual level, Rogers (2003) pointed out that “The adoption of an incompatible innovation often requires the prior adoption of a new value system, which is a relatively slow process” (p.15). This was likely the case in those organisations that struggled to implement NII. The necessary precursory cultural shifts to re-invent their corporate sustainability narratives had not yet been sufficiently accomplished to enable NII more widely.

Furthermore, on the individual level, in alignment with Seligman’s (2006) description, an individual might alter his or her own personal identification to justify the adoption

of an innovation. A transformational shift in sustainability narratives was common amongst individuals who experienced NII training. Many individuals involved in NII activities describe a change in their personal relationship to nature – both in their work and in their personal lives – through the process of learning about and practicing NII. At Resources Inc., Interviewee 3 had a transformative experience with NII education after leaving Resources Inc. with a severance package. She went on to create a national organisation dedicated to the promotion of NII and developed a program in partnership with her national government to incentivise NII at the national level. For two interviewees at ICT Inc., NII training was transformative, and they articulated this in their interviews. At Electronics Inc., two interviewees described how it was transformative for them personally, shifting their personal views on their connections to and perceptions of nature. Although it was difficult to implement for the organisation at Cosmetics Inc., it was transformative for several individuals and resulted in the departure of the innovation manager, who said, “This can be crazy in personal terms and I can talk about personal experience. When you see those things, you cannot go back to the old way”. Interviewee 7 gave a tearful revelation in the interview process, and several other interviewees described how it had changed their views on natural systems. Interviewee 6 explained, “When you have contact with biomimicry, everything that you usually do in your life, you always look for how the things [are] happening outside the window...How are the things happening in the nature...to solve that problem. It becomes a part of you [sic].” While Interviewee 1 of Clean Inc. did not describe his experiences as transformative, it was clear in the interview and in the context of SB1 that the corporate sustainability narrative of Clean Inc. was in the midst of a shift due to his leadership and his perceptions of NII. For several external NII consultants who had been involved with Clean Inc., their experiences with NII were transformative enough to become outspoken proponents of a NII approach. And finally, at Textiles Inc. several employees described how NII had been transformative for them, as well as for the late founder of the company who initiated their existing corporate sustainability narrative. NII was an important aspect of his personal sustainability transformation, and it continues on in his legacy in the organisation.

In summary, Compatibility was indeed a significant factor that influenced the adoption of NII, as those organisations that incorporated NII into their strategic

sustainability goals had a markedly higher level of success than those who did not. While ITC Inc. and Resources Inc. did not mention strategic sustainability goals, Electronics Inc. and Cosmetics Inc. had strategic sustainability goals, but viewed them as parallel to NII rather than integrated with NII goals. At Clean Inc. and Textiles Inc., the emulation of natural systems in all aspects of the business was viewed as the basic strategic sustainability goal, though the practical implications of this goal create significant challenges.

In all cases, there was at least one interviewee who described a transformative change within themselves due to their experiences with NII, though this personal transformation was not necessarily consequential for the organisation as a whole. In four of the six cases, this personal transformation occurred around the same time as the individual's departure from the organisation, indicating that the *sustainability brain drain* may be occurring amongst SOI innovators related to this transformation. While causal mechanisms could not be determined, this phenomenon may be indicative of the inability of organisations to push radical SOI boundaries, and the concurrent desire of individuals involved to more effectually seek SOI results elsewhere.

Table 29 summarises the findings related to the Characteristics of the Innovation. As is evident by the shaded grid, the Characteristics of the Innovation were relatively consistent across cases with a few exceptions. Those organisations that viewed NII as a systems approach and incorporated NII activities into strategic sustainability goals were more effective overall, and this may be consequential for future NII users looking for easy wins. The easiest win may be to apply it at a larger scale to begin with or situate NII projects as part of company-wide sustainability goals as opposed to seeking NIIs in the form of a product.

Table 29: Characteristics of the Innovation

Analysis Category	Factors	Resources Inc.	ICT Inc.	Electronics Inc.	Cosmetics Inc.	Clean Inc.	Textiles Inc.
Perceived Relative Advantage	Low Monetary ROI Value						
	Expansive Thinking						
	Cooperation With Suppliers (Material Search)			Waste=Food		Waste=Food	Waste=Food
	Communicative Value						
	Systems Approach						
	Sustainability of Nature						
Observability	Inspiration For Shape, Function, Ecological Principles And/Or Systems-level Design Principles		Ecological	Ecological, Systems-level	Shape, Function, Ecological	Shape, Function, Ecological, Systems-level	Shape, Function, Ecological, Systems-level
	Lack Of Clarity About Results						
Complexity	Descriptions Of Complexity						
Trialability	Conflict Between Short Investments And Long Term Results						
Compatibility	Incorporation Into Strategic Sustainability Goals						
	Individual Transformations						

RQ2 Summary

Broadly speaking, the Characteristics of the Decision-Making Unit demonstrated little pattern, and perceived characteristics of NII itself were relatively consistent across cases. The Characteristics of the Innovation Context – the larger organisation; the social, economic, and ecological influences surrounding the organisation; and the way the organisation responds to that context – were of the greatest consequence for NII project results.

Conclusion

This chapter provides a more detailed analysis across cases and specified emergent patterns in the data not clearly perceptible at other levels of analysis. It further articulated the various findings related to RQ1 and RQ2 with some reflection against existing literature. The following Discussion Chapter will interpret the practical and theoretical implications of these results.

Chapter 7: Discussion

Introduction

As demonstrated in the literature review, NII has generated substantial interest as a tool for corporate sustainability and SOI more broadly in multiple sectors. Its broad vision of learning from nature for sustainable human design and innovation has captured the imaginations of innovators, sustainability professionals, scientists, and designers around the globe. However, there has been little research differentiating NII as an approach to SOI in MNCs. Additionally, aside from a few recent studies, there are few empirical indications addressing why it is successful in some adopting organisations and unsuccessful in others. There has been little interpretation of this phenomenon in the context of innovation management and, more specifically, SOI management. Furthermore, there is a gap in understanding why some organisations integrate biological thinking into a single product compared to those organisations that view biological systems as their standard for sustainability, integrating it into their overall SOI approach and narrative.

To address these gaps, this exploratory research applied SOI and innovation adoption theories to describe the types of innovations found in MNCs (RQ1) and identify the factors that influence the adoption of NII (RQ2), specifically in the context of MNCs. The literature review explored the scholarly landscape of the NII, SOI, and innovation adoption literatures, and the methodology applied was a phenomenological case study approach drawing on these bodies of theory to create an insightful analysis framework used for each of the six cases. Following this research approach, several patterns and themes emerged. This chapter begins with a discussion of the Commonalities Across Cases and is then followed by four themes: 1) NII Typology In The Innovation Management Literature; 2) Sustainability Narratives; 3) Senior Leadership Support and Engagement To Operationalise “Being Like Nature”; and 4) Innovation Cultures and Infrastructure. The chapter closes with the integrating section entitled *SOI Cultural Types: A Unifying Concept*.

Commonalities Across Cases

Although the sample size was small, potentially causing some limitations in the wider applicability of the findings, the commonalities identified across all cases may be considered as prerequisite considerations for any application of NII.

NII Consultants Involved

While this was not included by design, most of the cases were identified through an informal network of NII consultants, and as such, the involvement of NII consultants in each case says little about the need for these consultants to be successful with NII. Anecdotally speaking, there are numerous cases of companies and inventors who pursue NII successfully without the inputs from outside experts. Given the high variability of success amongst cases herein, it is questionable whether the inclusion of NII specialists or consultants is a precursor for success with NII, which is in contrast to previous case studies (Kennedy & Marting, 2016; Tempelman et al., 2015).

NII Training

All cases but one (a successful case, at that) had internal staff trained in NII for a minimum of a one-week immersive workshop, making the level of staff training an unlikely marker for the most indicative factor related to success (this is in contrast to suggestions by Tempelman et al., 2015). To exemplify this finding, Cosmetics Inc. had trained approximately forty staff members in immersive workshop settings and experienced considerable difficulty, while Clean Inc. did not have any internal staff trained in NII and experienced substantial success with NII. To compensate, Clean Inc. relied heavily on external consultants with extensive training to outsource several NII projects. In the absence of trained internal staff, this outsourcing with trained NII professionals likely enabled their success. This represents a strategic decision for companies hoping to apply NII, as to whether they should: a) Train and support qualified staff in a novel innovation approach, or b) Utilise external consultants with the capacity to fully develop new innovations in partnership with the company.

Interdisciplinary Innovation Teams

Since all cases had interdisciplinary professionals, this too had a limited influence on the adoptability of NII for SOI (contrary to Genç & Di Benedetto, 2015). While this may be a minimum for NII teams, what may be more indicative of success is the inclusion of at least one designer on the internal team. Other than the designer, other variability in disciplinary backgrounds was not influential with a variety of technical, natural, and social sciences represented across cases.

Furthermore, while the inclusion of biologists may seem to be a necessary precursor, there is little evidence amongst these six cases that a biologist team member is particularly influential for innovation results, and this finding is also contrary to existing literature (i.e., Purser et al., 1995). For example, Cosmetics Inc. trained several internal biologists in NII explicitly and their achieved innovations were comparable with Electronics Inc., which had no internal biologists. In fact, one interviewee from Resources Inc. commented that a biologist colleague specifically rejects NII as presented by an external NII consultant due to the alleged incompatibility with GMO technologies, demonstrating the diversity of opinions amongst natural scientists that may interfere with the implementation of NII.

Experiences with Nature

One surprising finding from the interview data was the relative indifference regarding strong personal connections to nature. Interviewees were asked about their personal experiences as an exploratory question to identify emergent patterns, and most interviewees had some personal experiences with nature in their childhood or other life experiences. However, the most vocal and effective innovators were not necessarily the individuals most connected to nature, nor had they spent considerably more time in nature than other interviewees, according to their own descriptions. In fact, some of them were rather nonchalant about their experiences in nature. This was contrary to what was expected and provides some optimism that the value of learning from nature can perhaps be fully embraced in an increasingly urbanised society by individuals without substantial direct contact with or value for traditionally romanticised notions of wilderness and nature.

Value of Expansive Thinking

In line with existing research (i.e., Tempelman et al. (2015)), several interviewees valued NII as a tool that expands the field of possible solutions. While this is a beneficial aspect of the tool, one former NII consultant commented that although NII is very effective at expanding the possible solution space at the front end of the innovation process, it is less effective in the latter stages when design concept narrows into a tangible design solution. In the context of this study, this comment is rather anecdotal, but it does raise compelling questions regarding the limitations and challenges of expansive thinking in various phases of an innovation process.

Impacts of the Economic Downturn of 2008

All cases reflected on the role that the economic downturn had on their cultures, staffing, corporate strategies, innovation processes, or SOI trajectories, in alignment with Adams and Bessant's (2008) suggestion that economic constraints negatively impact adoption (though not economic impacts alone). For some of the cases, it marked a turning point that disempowered the NII efforts, and for others, it further demonstrated the need to incorporate strategies for resilience as inspired by nature. This is demonstrative of the various corporate perspectives of SOI elsewhere in the literature, in which sustainability is viewed as a necessity, a risk, or an opportunity depending on the organisation (e.g., Haanaes et al., 2011).

In summary, while some combination of these factors is influential for success, when viewed in isolation, the inclusion of a NII specialist, internal NII training, interdisciplinary teams, experiences with nature, or the use of NII for expansive thinking are not indicative of success with NII. Similarly, the trials of an economic downturn also do not define the outcomes of a NII process. These factors are influential in combination with others, but not as isolated factors. At the same time, four other key themes were evident in the data and will be further discussed here.

Theme 1: NII Typology In The Innovation Management Literature

Although several areas of management theory have used biological metaphor to theorise strategy (e.g., organisational ecology, cybernetics, etc.), few studies have addressed the use of NII for SOI, and no known studies were identified using the combination of adoption theory and SOI theory. Consequently, this research aimed

to establish NII for SOI as a subject of inquiry in the innovation management literature through the development of a typology of NIIs in response to RQ1.

Upon analysis of the case study data in light of the existing literature review, it became apparent that the types of innovations attempted and achieved using NII had not been clearly theorised in the innovation management literature. While there are some existing descriptions of how NII can be applied amongst NII practitioners (e.g., Benyus's model of form, process, and system), existing models are of little use as a communication tool for innovators in practical settings because they do not reflect the necessary business acumen, nor do they articulate the intended results of NII in a corporate context. For this reason, it was necessary in this thesis to develop an innovation typology that could be specifically reflective of the experience of NII users in MNC settings. Based largely on existing bodies of research, this typology serves as a categorical guide to define the various types of NIIs found in MNCs and enables the description of NII results comparatively across cases. To return to RQ1, which asks, "What types of NIIs are attempted and achieved in MNCs?", this section highlights some of the variability across innovation types within the cases.

As mentioned above, many innovation and sustainability managers aim to "do biomimicry" as an innovation goal without explicit consideration for the complexity of this *doing* at the outset of the NII activities. This ambiguity about the outcomes does not have a substantial impact on the users' perceptions of the process and its observability, but it does create a great deal of difficulty in the implementation of a NII process. Perceptions of NII are similar to other types of innovation approaches in that innovators typically seek to achieve the first 'low-hanging fruit' or 'easy win' by attempting Technological Innovations (OECD, 2009). While some literature suggests that Technological Innovations are more straightforward to implement (OECD, 2009), this is likely not the case with NII, which may require Organisational Innovations to enable Technological Innovations. Other literature that suggests Organisational Innovations enable Technological Innovations is more applicable to NII. This is mainly because the application of NII to products and processes forces a reconsideration of other organisational factors such as suppliers, sourcing, business models, and consumer relationships, all of which are beyond the scope of R&D departments (in alignment with Khanagha, Volberda, Sidhu, & Oshri, 2013). For the

innovator, it would likely be a more effective strategy to introduce NII as a corporate sustainability strategy or to integrate it into strategic sustainability goals at the organisational level (supported by Haanaes et al., 2011; Mohr, Price, & Rindfleisch, 2015; Tempelman et al., 2015) and identify pilot projects in various departments that could be 'easy wins' - a more top-down starting point compared to the bottom-up approach found in four of the six cases. Given the general difficulty accessing senior level executives of MNCs, this may prove to be a difficult sell for innovators. If Organisational Innovations are not supported by management or are otherwise not possible, an alternative pathway for implementation of NII may be to outsource Nature-inspired NPD processes altogether. The NII typology created herein may assist innovators as they attempt to explain the NII approach to managers and colleagues. The simplistic goal and language of 'doing biomimicry' will likely be insufficient to convince executive level managers of the value of NII. This typology is a useful model to translate complex innovation concepts into language that most managers are comfortable considering.

Organisations that pursue Systems Building Innovations must be prepared to find themselves in the role of policy advocates and social entrepreneurs to accomplish their NII goals. Their aspirations are frequently counter to the status quo of their sectors and sit at the boundary of SOI and organisational philanthropy. As industry leaders, they may also face scrutiny from their customers about their actions. Innovators must maintain a cautious optimism regarding the solvency of Systems Building Innovations and strive for acceptance as long-term innovation strategies that are exempt from shorter-term performance expectations (as suggested by Gaziulusoy, 2015). The level of inter-sector and inter-agency relationship development necessary for Systems Building Innovations should be considered as part of a multi-year process from the outset. It may be necessary to give attention to trust-building activities within new multi-stakeholder innovation processes to create transparency and encourage the participation of outside stakeholders who may not be accustomed to interacting with MNC cultures and procedures.

In summary, regarding RQ1, this thesis distinguishes between types of NIIs and explores some categorical differences related to their implementation. The next section addresses several themes related to RQ2 – "What factors influence the

adoption of NII in MNCs?" – that emerged in light of the NII, SOI, and innovation adoption theory, the most influential of which are described here.

Sustainability Narratives, Senior Leadership Support And Engagement, And Innovation Culture And Infrastructure

Three major themes emerged from the data in relation to RQ2. While there is a great deal of nuance in the amalgamation of these themes (detailed further in Table 30 near the end of this chapter), the most influential factors for the adoption of NII are related to 1) Company sustainability narratives; 2) The role of senior leadership support and engagement; and 3) The innovation culture and infrastructure of each organisation. These themes will be explored in greater detail in the following sections. The categorisation of Ambiguous, Accountable, and Aspirational SOI narratives is then described in greater detail at the end of this chapter to summarise how these four themes interact to create distinct SOI narratives.

Theme 2: Sustainability Narratives

Building on Mohr, Price, & Rindfleisch's (2015) assertion that NII provides a new logic for innovation, NII also introduces new sustainability narratives and considerations related to an ecological worldview (e.g., learning from nature rather than extracting from nature, considering humans and their activities as an integrated part of nature, considerations of reduction in ecological/biodiversity impacts in supply chain, etc.). This novel sustainability narrative challenges numerous underlying assumptions about the relationship between humans and nature. Taken in its purist form as articulated by Benyus (1997), it evokes conceptions of CSR that frequently challenge the status quo of corporate sustainability from a utilitarian and conservationist perspective of nature to one in which nature is viewed as the model for sustainability. In this view, the organisation is perceived as an apperceptive participant in ecological systems. The successful implementation of NII results in *ecologically embedded sustainability narratives* in which nature is *the standard* for sustainability for individuals who participate in the NII activities. Furthermore, these individuals describe how NII has been *transformative* for them on a personal level and frequently poses an ethical conflict with their roles within their organisations. Adopting nature as the standard for sustainability for an organisation requires a *reinvention* of the existing corporate sustainability narratives. Organisations that are

unable to adjust this narrative are more likely to struggle with the implementation of NII.

Organisations in which NII is not fully embraced through the ranks and organisations suffer from *sustainability brain drain*, which has negative consequences for SOI in MNCs. In several cases, individuals described personal perspectives on sustainability that were not mirrored in the larger organisational sustainability narratives, and the misalignment of individual and organisational conceptions of sustainability seems to be of consequence for the implementation of NII and corporate sustainability more broadly. While this study specifically addressed users of NII, there may be larger implications for this incongruence, particularly in MNCs. In four of the six cases, particularly the four with the fewest NII applications (the Ambiguous and the Accountable cases), the Innovators with expertise and motivation to pursue NII resigned from their organisations, resulting in a sustainability brain drain. Several interviewees described a transformational understanding of natural systems and sustainability as they learned of NII. In the four cases with sustainability brain drain, interviewees described frustration with their inability to pursue radical SOI. This likely has larger consequences for MNCs due to the departure of professional skills and institutional knowledge related to sustainability from the organisation and into other sectors or organisations.

An organisation's cultural *perception of its relationship to ecological systems* influences how effectively NIIs are enacted for corporate sustainability. Those Aspirational organisations – the most effective with NII – demonstrated sustainability goals (i.e., Clean Inc. and Textiles Inc.) that were closely tied to the functioning of ecological systems. (Exceptionally, Cosmetics Inc. also described how their business was closely tied to the functioning of ecological systems in their supply chains; however, this was not incorporated into their applications of NII.) This inclusion of ecological systems into organisational sustainability considerations led to SOI strategies with purposeful integration with socioecological systems. Amongst NII users, two specific mechanisms were identified to include ecological systems into corporate sustainability goals.

The first mechanism, *ecological embeddedness* (as defined by Whiteman & Cooper 2000), was an integration of the role of biodiversity in the supply chain, manufacturing, and life cycle of products through the application of NII. In the case of Clean Inc., they were intending to design new products that integrated with the biocycle throughout the product life cycle and chose materials in their supply chain that did not result in deforestation and habitat destruction for other organisms (i.e., they sought a replacement for palm oil due to deforestation in Southeast Asia from growing Western demand). For Textiles Inc., they were using a NII approach to redesign their factories and reconsider how these factories interacted with ecosystems around them. This ecological embeddedness was an important aspect of sustainability at these organisations that was further enabled by NII approaches.

The second mechanism that was enhanced by the NII process was the search for novel sources of materials to be incorporated into supply chains that did not involve the use of virgin resources. The ecological principles of '*waste equals food*' (Benyus, 1997) were implemented in one particularly unique way in organisations that were Aspirational with NII projects. Both Clean Inc. and Textiles Inc. identified novel sources of raw material to be reincorporated into their supply chain by incorporating waste material from the *global commons* (i.e., ocean plastic). They accomplished this task by partnering with stakeholders in the communities where these pollutants are present to collect them from ecological systems and reassimilate them into technical nutrient cycles. This innovation process could be referred to as *Regenerative Innovation* and is worthy of further investigation.

Theme 3: Senior Leadership Support and Engagement To Operationalise “Being Like Nature”

When the NII narrative is embraced by senior leadership, it reduces codification of organisational routines (as suggested by Khanagha et al., 2013) such as existing corporate sustainability and SOI strategies, allowing NII to become a primary driver of SOI goals and even corporate missions (supported by Tempelman et al., 2015). And while the NII narrative does not have to be transformative for all members of an organisation, some key players need to be fully engaged for it to become a viable innovation approach for the entire organisation and to further expand into Systems Building, which is in alignment with Seligman (2006). In the most successful cases,

both innovation managers and C-level executives are supportive of a NII agenda and are able to support other employees in implementation throughout the company. Congruent with Rogers's (2003) discussion of compatibility and new value systems, when managers make the conceptual leap to "be like nature" as an organisational goal, it leads to greater success in the implementation of NII for Technological and Systems Building Innovations. To the contrary, in organisations where senior leadership is not on board with a wide application of NII principles, the application of biological models to management frequently becomes a personal passion or pet project for lower level managers or NII is pigeon-holed into a specific project or department. It informally influences users' thinking and management styles, but it is unlikely that their colleagues are aware of this influence.

The leadership of organisations that are successful with NII demonstrate several common characteristics that are likely applicable to a variety of SOI and NII scenarios. The culture of leadership, as described by both employees and the leaders themselves, demonstrates that they are not just managing for financial solvency, but rather a complex set of values that are embodied by the concept of sustainability. They demonstrate social values that influence decision-making regarding stakeholders inside and outside the organisation regarding the health and wellbeing of suppliers and consumers and the fair distribution of financial prosperity. They also demonstrate ecological values with life cycle awareness of the impact of their products, encourage visionary sourcing strategies that involve unconventional materials, and strive for net positive impacts on ecological systems. These values are not substantially compromised due to economic difficulties and remain steady through difficult periods. They do not view sustainability as a department or an aspect of the CSR agenda. Instead, sustainability is viewed as a cultural element of the entire organisation and the responsibility of every employee (similar to findings of Haanaes et al., 2011). They are fully onboard with NII efforts, participate directly in NII activities, and easily integrate NII into descriptions of their management strategies. And finally, they are perceived as near-equals in the business, with little hierarchical distinction or exclusivity perceived by other employees.

Theme 4: Innovation Cultures and Infrastructure

The Crucial Role Of Designers

Various disciplinary roles on the NII team were analysed, both internally and externally to the organisation, including the professional and interdisciplinary training of each team member and levels of NII training. The specialisation that seems to be the most critical to the success of NII activities is the inclusion of a designer on the project team. Designers served multiple roles including internal product designer, innovation manager, external NII consultant, and contracted NII-trained product designer. Their importance in the NII process is likely due to the transdisciplinary perspective of design training that is part social science and part technical translation of social and physical interactions in a product design process. Designers may be more generally equipped to see the 'big picture' in ways that pose greater challenges to more analytical team members. They may also be more responsive to the aspects of NII that rely on expansive thinking, imaginative application, alternative future scenarios, and external sources of innovation inspiration. In short, they are more accustomed to 'out-of-the-box thinking' than engineers, business experts, biologists, and managers. Their training has given them the cognitive freedom to combine previously disparate ideas into novel forms of innovation. Furthermore, they may be a necessary link to external organisations for R&D partnerships such as NII consultants, suppliers, or other technical expertise that enables the implementation of NII projects. While most NII specialists do bring specific expertise to a project, many do not have technical production skills, and as such, designers can enable further development with other partners.

Importance Of The Innovation Context Compared To Other Characteristics

Also in relation to RQ2, and specifically reflecting on the innovation adoption literature using Rogers's (2003) model, the Characteristics of the Decision-making Unit were highly variable and offered little in the way of distinct trends, but they did provide insights into several subtle distinctions (as described by the categories of SOI narratives). To the contrary, it is evident that the perceived Characteristics of the Innovation remained relatively consistent across cases. By contrast, Characteristics of the Innovation Context were highly variable across cases, and the most critical influences on the success of NII were identified within the larger innovation context. There was a clear trending pattern of these characteristics from least successful to

most successful, as described in the previous chapter. As described by these four themes, variations related to sustainability norms, leadership, and innovation culture and infrastructure were the most influential, though all factors related to the innovation context. Similarly to the SOI narratives described herein, this may be indicative of a larger trend for the implementation of SOI, whereby existing Characteristics of the Innovation Context are the most relevant.

Cultural Acceptance of Ambiguity And Complexity Reduce The Importance Of Observability And Trialability

Furthermore, and related to Rogers's (2003) factors, observability and trialability are less consequential in innovation cultures that are comfortable with ambiguity and complexity. Although previous literature has suggested that clear innovation goals have a positive influence on adoptability because they minimise complexity and ambiguity and increase observability and trialability (i.e., Ceschin, 2013), this is not especially consequential in organisations that are successful with NII. The data revealed that ambiguity regarding intended goals and results was not as detrimental to the NII process as had been initially assumed. This is likely because some organisational cultures simply embrace complexity and ambiguity as part of the everyday operational circumstance. Several interviewees described ambiguity as a regular aspect of their SOI processes and saw little value in differentiating between NII and SOI. A limited number of interviewees described a strong desire to see tangible quantifiable results, but they were amongst the minority. In short, the articulation of clear innovation results does not necessarily influence the adoption of NII, contrary to existing innovation adoption theory. Developing a larger cultural acceptance of complexity and ambiguity may be an important aspect of creating successful SOI narratives.

While Rogers's (2003) framework – which includes Characteristics of the Innovation Context, Decision-Making Unit, and Innovation – provided a helpful structure from which to organise and analyse the data for each case, the resulting discussions and conclusions related to this body of literature were not of particular significance in the overall contribution of the thesis. Using Rogers's (2003) approach was helpful to ground a relatively understudied topic such as NII into a more traditional body of literature, but ultimately, these models were excessively linear and difficult to apply

when attempting to convey multi-factorality in the Results and Discussion. Additionally, the Results and Discussion revealed little opportunity to further contribute to this specific body of literature because the most advanced contributions were related to the more recent SOI literature. For this reason, specific contributions related to this body of theory were omitted from the claimed contributions of the thesis.

Additional characteristics of the Innovation Culture and Infrastructure are described in each of the three SOI narratives specified in the next section.

SOI Narratives: A Unifying Concept

Across the six cases, these four themes demonstrate a great deal of variability and nuance. When viewed in combination with each other and the other described factors, they reveal three distinct SOI narratives. While it was not an initial goal of the research design to explore interview narratives using a formal method of narrative analysis such as that described by Reissman (1993) or Labov and Waletzky (1997), it became clear after several iterations of analysis that some influencing factors were repeatedly described in conjunction with other factors across interviews and cases resulting in distinctive narratives. Interview participants, whether knowingly or not, described their experiences with NII as part of a rich contextual composition that positioned NII within their organisational context. As framed by Bell (2002) the concept of 'narrative' applied herein arises from individual perceptions of current events that have arisen from past experiences and are leading to future occurrences, and furthermore reveal information about a situation that interviewees are not consciously aware of (Bell, 2002). "No matter how fictionalised, all stories rest on and illustrate the story structures a person holds. As such, they provide a window into people's beliefs and experiences" (Bell, 2002 p.209).

For some interviewees, the boundary between the organisation and the NII experience was quite clear. For instance, ICT Inc. interviewees described discreet activities with NII and expected outcomes for isolated applications. Conversely, interviewees at Textiles, Inc. describe shifts in their personal and organisational relationships with sustainability as a concept resulting from their experiences with NII. Their narratives involving NII are intertwined with their experiences of and

relationships with their organisations on a daily basis without being ascribed to particular events. Upon the identification of these differences in the data analysis process, it became apparent that each of the three categories of sustainability norms were also describing unique narratives that reflected a combination of factors influencing their experiences of NII. As described briefly above, these narratives emerged from a combination of factors predominantly related to sustainability norms, innovation culture and infrastructure, and engagement from senior leadership, amongst other key differentiating factors.

The summary of typical statements and values provided in Table 30 offers a categorisation of various SOI narratives based on those identified in the six cases herein. These SOI narratives could also be conceptualised as *ideal types* as described by Max Weber in that they are descriptive units of categorisation based on a grouping of typically demonstrated characteristics of a group that are generally recognisable, but not strictly diagnostic of a particular category. Ideal types are generalisations for the purpose of constructing comparison across categories without being reducibly testable in real-world settings (Weber, 1962). While each case has some nuanced variations related to the factors, the three generalised narratives are a useful model to describe and engage with various MNCs.

Recommendations For Specific SOI Narratives

The strongest defining factors indicative of success with NII are the existing SOI narrative, the engagement of leadership, and the innovation infrastructure and culture. Consequently, adopting organisations should base their NII implementation strategy in light of their overall SOI agenda and staff tolerance for what may be perceived as trendy, distinct, or novel SOI approaches. Technological innovations are rarely culturally controversial, regardless of SOI narratives. However, changes that require higher levels of buy-in from management – as NII frequently does – are more difficult to achieve. Many applications of NII rely on a reconfiguration of supply chain sourcing, knowledge management, and knowledge sourcing that must be embraced by more senior management, as previously suggested by Tempelman et al. (2015). Even within companies with an embedded ethic of sustainability and CSR, managers in some organisations are unable or unwilling to re-invent the company sustainability narrative sufficiently to allow for a reconfiguration of SOI trajectories.

For the most effective organisations, NII initiates a reinvention of the company sustainability narrative to be more aligned with the principles and functioning of ecological systems, viewing nature as the standard for sustainability.

There are also some characteristics of internal innovation cultures that clearly contribute to the implementation of NII. While an innovation culture does not need to be radical per se, it does need to be supportive of failure, free from internal politicking, and not pressured by a constant need to adopt new innovation tools or maintain an innovation record that is accountable to company metrics. Innovators and participants need room for conceptual creativity and “freedom to fail.” Furthermore, organisations that have a high tolerance for complexity also experienced the greatest success with NII, suggesting that building a capacity for tolerating complexity may be a prerequisite for the implementation of NII and perhaps SOI more broadly.

In addition to general recommendations described above, each SOI narrative is characterised by unique opportunities and challenges that can be leveraged for more effective implementation of NII. The following section summarises challenges, opportunities, and recommendations by each SOI narrative.

Ambiguous Organisations

Given that the organisations without clear definitions, drivers, motivations, and responsibilities for sustainability had the most difficulty with NII, it is unlikely that NII is an entry point for SOI. Exposure to other SOI and NII processes and approaches influence the ability of the organisation to succeed with NII. In Ambiguous organisations, there was little indication of a “systematic process of ‘internalisation’ of external effects combined with an ecological consciousness” as suggested by Blattel-Mink (1998, p.50) and little accumulation of SOI resources and capabilities (per Varadarajan, 2015). There was also little demonstration of capabilities such as higher-order learning or continuous SOI (Sharma & Vredenburg, 1998). Ambiguous organisations may have a low threshold of tolerance for experimentation with SOI tools that do not demonstrate immediate monetary returns or are otherwise unaccountable to financial metrics of the organisation. As such, any attempts with NII should have clear integration of financial returns as part of the overarching goals of

the project. Practitioners in or working with Ambiguous organisations should downplay the more visionary and normative aspects of the NII message, instead focusing on the innovative potential and strategic business opportunities of the approach. This may help to circumvent motivational and ethical dissonance amongst NII team members by normalising expectations along existing and established financial performance standards that are already endemic to the organisational culture.

Finally, Ambiguous (and also Accountable) organisations need to be aware of the potential impacts of *Sustainability Brain-Drain* on their organisational culture and the loss of associated intellectual and human capital that ensues from the departure of these employees. Replacing any employee is costly, but it is the loss of institutional memory related to SOI that is of greater concern in these instances. Senior management of Ambiguous and Accountable organisations should remain diligent in the retention of sustainability professionals, as they may have a tendency towards disillusionment with their organisations upon failed SOI attempts.

Accountable Organisations

For those organisations that demonstrate characteristics of being Accountable towards sustainability, a different set of tactics is necessary to implement NII. These organisations are fully aboard with the implementation of NII in principle, but the strength of their management of SOI negatively impacts their ability to pursue the more visionary aspects of their SOI agenda. Managing the SOI process does not necessarily make a company more innovative; to the contrary, it may create a culture of performance pressure that stifles innovation and creative spirit with metric-driven outcomes. Although literature suggests that deliberate and systematic inclusion of environmental criteria improves the effectiveness of SOI (i.e., Wagner & Llerena, 2011), in the case of NII, greater levels of accountability are detrimental to the success of NII projects. Those organisations that had norms of strongly institutionalised or incremental sustainability objectives and intricate systems of accounting for innovation and sustainability were stifled in their ability to implement NII. Given that several interviewees from each case valued NII for 'expansive thinking', it is somewhat obvious that expansive innovation spaces would be necessary to implement it, though these were perhaps constricted within

organisations with Accountable narratives. Although radical innovation was not a body of literature closely examined in this thesis, this finding could be due to NII being a radical SOI for many organisations. The radicalness of NII may not necessarily be tied to the sustainability narratives, but rather to the ability to adapt project management tools and procedures to enable radical innovations more broadly. For these companies with sluggish, established, and/or institutionalised project and innovation management systems, it may be most effective to outsource aspects of the NII activities to external NPD and process consultants, particularly in the earlier concept development phases.

In both Accountable cases, NII was viewed as an additional layer on top of existing sustainability metrics, causing an additional burden that limited the innovation process and became cumbersome to the culture of innovation activities. One way to avoid this intellectual and procedural burden is to articulate NII principles in such a way that they can be integrated into strategic goals rather than being yet another layer on top of already specified SOI metrics. Accountable organisations, which trial numerous approaches, tools, and techniques for SOI, need to remain vigilant to avoid *SOI fatigue*. Employees and innovation managers can begin to view every novel SOI approach as just another tool, without fully engaging in any specific innovation method over the course of time. This over-abundance of SOI approaches inhibits rather than supports SOI results.

These organisations may also benefit from a 'Sustainability Skunk Works' where expansive SOI is unencumbered by (the necessary and important) sustainability accounting systems that are applied consistently throughout the rest of the organisation. In this setting, the sustainability accounting systems could be applied as training modules for staff before beginning SOI activities and again after the late-stages of development to deepen the integration of SOI results into company-wide metrics, but they would not be a primary component of the NPD process. While this type of peripheral activity was not effective to implement NII in the Ambiguous organisations, it may be a practical strategy for Accountable organisations who often find themselves overly-burdened with SOI approaches and tools.

Table 30: SOI Narratives of Organisations Adopting NII

Factors	Ambiguous SOI Narrative	Accountable SOI Narrative	Aspirational SOI Narrative	Related Literature
(REITERATED AND FROM DETAILED ANALYSIS CHAPTER)	Resources Inc. and ICT Inc.	Electronics Inc. and Cosmetics Inc.	Clean Inc. and Textiles Inc.	N/A
	Unclear or inexact definitions of sustainability due to lack of clear interpretation across the organisation.	Incorporation of sustainability is expected and required to justify everyday decision-making within the organisation for incremental improvements.	Demonstrate hopeful and ambitious objectives for organisational sustainability goals without clear accountability to incremental improvements.	N/A
	<i>Aim to learn from nature</i> with NII.	<i>Aim to do like nature</i> with NII.	<i>Aim to be like nature</i> with NII.	N/A
	Limited sustainability leadership; No common sustainability narrative.	Visionary sustainability leaders with a consistent narrative through time.	Visionary sustainability leaders, but a reinvented narrative.	N/A
	Sustainability is political.	Sustainability is practice.	Sustainability is purpose.	(Blattel-Mink, 1998; Jakobsen & Clausen, 2016; Kimberly & Evanisko, 1981)
	Economically motivated.	Ethically motivated.	Intrinsically motivated.	(Adams et al., 2013; Biondi et al., 2002; Jakobsen & Clausen, 2016)
	Sustainability activities are mentioned in annual reports.	Sustainability activities must be measured for everything.	Sustainability activities must be modeled for others.	(Sharma & Vredenburg, 1998; Varadarajan, 2015; Wagner & Llerena, 2011)
	"[Sustainability] is hard to implement because it's such a broad word."	"As a large international global company, we're responsible for what we do..."	We strive to "become restorative through the power of our influence."	(Blattel-Mink, 1998; Brink et al., 2016)
	"In general, sustainability was not seen as a business opportunity."	"How do we make a product that we can still make money that really improves the health of people in places that don't have access to the resources?"	"We've been able to make an extremely resilient product without using any petroleum, new or virgin resources. So there is a path for [sustainable business] and [we've	(Blattel-Mink, 1998)

			created] a model.”	
	External consultants were “shocked by the level of ignorance around sustainability.”	We view “sustainability and innovation as the same thing.”	“[Biomimicry and sustainability] are a part of each other.”	(Adams et al., 2016; Blattel-Mink, 1998)
	“Weak”	“Very strong”	“Same principles as nature”	N/A
Characteristics of the Innovation Context				
SOI Narrative Overview	Organisational ambiguity about the definitions, drivers, motivations, and responsibilities of sustainability, and NII is not an effective entry point to develop a redefined sustainability narrative.	Although there is a strong existing sustainability narrative, sustainability definitions are rigidly tied to specific metrics or historical narratives resulting in an organisational inability to reinvent sustainability narratives when presented with the opportunity to do so.	Sustainability narrative and goals are expansive and aspirational, viewing nature as the standard for sustainability. NII activities are incorporated into strategic sustainability goals and often times are sustainability goals themselves.	(Blattel-Mink, 1998; Brink et al., 2016; Haanaes et al., 2011; Mohr et al., 2015; Tempelman et al., 2015)
Stereotypical Quotes Related to Sustainability	<p>“In general, sustainability was not seen as a business opportunity.”</p> <p>“It's kind of a disadvantage for the word [sustainability] because it's so broadly defined. It's hard to implement because it's such a broad word.”</p> <p>“[Resource Inc.]’s work is nearly all targeted to reduce footprints of CO2, water ...Um you know the, the kind of um I guess the late I ... so is I mean to me it is, it's a lot of a sustainability, it's the kind of</p>	<p>“[Electronics Inc.] was having really good success with getting people to understand [the balance between wellbeing, economic, social, and environmental health] intellectually and then to translate it to product categories that were wins for the business. [...] Like how do we make a product that we can still make money and really improves the health of people in places that don't have access to the resources.”</p> <p>“In [the company] we got kind of stuck into the old sustainability</p>	<p>“We've talked to our business many times about the principle of becoming restorative through the power of our influence.</p> <p>“Our central question...is how to design all our business more like an ecosystem. So we start from fundamental principles that are coming from how ecosystems work, really on a systemic level and translate that into products and services and business model and whatever as much as possible.”</p>	(Adams et al., 2016; Blattel-Mink, 1998; Haanaes et al., 2011)

	footprint we leave on the world.”	<p>model. [...] It’s very ‘90s now.” He went on to describe a “deep cultural crisis” moving away from values being the main drivers of the company to a “very traditional competitive mode that all companies get into. And when you show them [i.e., the management /owners] biomimicry, its kind of a shock.”</p> <p>“It’s difficult for us to set goals like biomimicry and eco-design to be included if [product developers] have 200 things that they have in their checklist for each product.”</p>	“How is it that you can have a sustainable company that you don’t look at what’s already working? And that’s nature.”	
Perceptions of Sustainability	We find it difficult to define sustainability. But we know it can help us reduce costs.	Sustainability is the way we do things and it always has been. It’s about people, planet and profit.	We believe it is our mission as an organisation to make the world more sustainable.	(Adams et al., 2016; Blattel-Mink, 1998)
Reinvented Sustainability Narratives	Individuals take an interest in NII as an expansive sustainability tool that influences their personal narratives and they find it incompatible with their company’s SOI trajectories, resulting in Sustainability Brain Drain	Individual innovators experience personal transformations with NII and sustainability, but remained unable to implement changes in the workplace to reflect this transformation, also resulting in Sustainability Brain-Drain.	Innovators are enabled to integrate their changing perceptions of sustainability and NII into their workplaces and work activities (no Sustainability Brain-Drain).	(Jung et al., 2003; Seligman, 2006)
External Knowledge Sourcing (Designers)	Designers aren’t a part of our NII team.	Designers are sometimes involved in NII...and sometimes drive it.	Designers usually drive NII...and are sometimes just teammates.	(Horbach et al., 2012; Jakobsen & Clausen, 2016; Tempelman et al., 2015)

External Knowledge Sourcing (Further External Specialists)	We worked with a team of NII consultants, but couldn't use it successfully in the way it was delivered. We didn't integrate further with other external consultants.	We were somewhat disappointed with our NII consultants and required additional outside expertise that could take the projects further. Nevertheless we keep trying with other similar NII tools, but we're still not really sure if it creates value.	We utilise additional outside expertise in our supply chain, product design and new materials development to implement NII.	(Horbach et al., 2012; Jakobsen & Clausen, 2016; Tempelman et al., 2015)
We seek SOI...	...as a way to make money and reduce costs.	...as a way to be a responsible company and use a triple bottom line analysis of our sustainability efforts.	...to have a net positive impact on society and the environment and try to be restorative as a company.	(Adams et al., 2016; Haanaes et al., 2011)
Siloing of Sustainability	We produce a sustainability report that will tell you more.	We have a whole department dedicated to sustainability and it is very institutionalised.	Sustainability is everyone's responsibility, not just our sustainability department. It's integrated from the senior leadership to the most junior associate.	(Haanaes et al., 2011; Sharma & Vredenburg, 1998; Varadarajan, 2015)
Senior Management Support	Our senior management hasn't really taken interest in NII and are culturally quite separate from conversations about it. They generally don't see much value in the intangible benefits either.	Our senior management is interested in the business value of NII, but they haven't really seen it materialise yet. In recent years, they've become increasingly removed from the company sustainability agenda.	Our senior management is on-board with our NII approach as part of our overall sustainability strategy.	(Francis et al., 2003; Haanaes et al., 2011; Rogers, 2003; Seligman, 2006; Tempelman et al., 2015)
Characteristics of the Decision-Making Unit				
Our company culture...	...can be quite political and competitive about things like sustainability and NII (which stifles creativity).	...fully supports sustainability and innovation, but we have to see results that make business sense.	...allows the freedom to fail in our innovation efforts and that is empowering. Of course though, we're not a charity so we have to keep the business in mind.	(Amabile, Conti, Coon, Lazenby, & Herron, 1996; Biondi et al., 2002; Kimberly & Evanisko, 1981)
Episodic	NII? We tried that once. It didn't add	NII? We tried that on several	NII? It guides the way that we frame	(Francis et al., 2003; Rogers, 2003; Sharma &

Innovation	enough value to the organisation.	different occasions in different ways (i.e., episodic innovation) and its been effective sometimes and sometimes not. We usually approach innovation incrementally.	SOI at our organisation. We try to do everything like nature would.	Vredenburg, 1998; Varadarajan, 2015)
Formality of Organisational (Innovation) Structures	Most of the organisation is focused on incremental innovation, but we were trying to do something really different.	We test SOI tools and approaches in sophisticated, highly formalised project management channels with institutionalised SOI performance metrics.	"Whenever I try to manage innovation, I just get crappy results." Our innovation culture is flexible and rather decentralised, without strong managerial hierarchies. We support the exploration of radical innovations and are not tied to metric-driven outcomes.	(F. Damanpour, 1992; Francis et al., 2003; Hojnik & Ruzzier, 2016; Kim, 1980; Subramanian & Nilakanta, 1996; Zaltman et al., 1973).
Characteristics of the Innovation				
Monetary Value, Budgets and Returns OR Spending for NII	Our budgets for SOI haven't really affected the implementation of NII, but they aren't very explicitly linked either.	We've had to reduce SOI and NII spending because of shareholder interests, particularly during the recent economic downturn.	We have to make trade-offs between long-term innovations and what we can afford now in the implementation of NII and SOI, but it doesn't compromise our values.	(Adams & Bessant, 2008; Haanaes et al., 2011)
Observability: Type of Inspiration	We didn't get far enough with NII to identify a clear strategy to apply it.	We apply ecological principles primarily within our product development and management processes.	We apply systems-level principles from biology to systems-level innovations in and around our organisation.	(Gaziulusoy, 2015; Tempelman et al., 2015)
Incorporation Into Strategic Sustainability Goals	We meet the minimum about clean water and energy and you can see all of that in our annual report...but its not really related to NII.	We integrate sustainability metrics into our innovation processes...but NII is another layer on top of that system.	We are constantly looking for new ways to be not just sustainable, but actively restorative to humans and nature...and NII enables that.	(Adams et al., 2016; Eccles et al., 2012; Haanaes et al., 2011; Hallstedt et al., 2013; Jakobsen & Clausen, 2016; Tempelman et al., 2015; Wagner & Llerena, 2011)

Both Accountable and Aspirational (analysis following) narratives demonstrated an environmental innovation mode that was defined by objectives at the organisational level (Jakobsen and Clausen 2015), though there were differences in how it was applied. The Accountable organisations had difficulty applying NII in the context of the plethora of other institutionalised sustainability metrics and objectives that were considered in addition to the NII processes. These organisations have highly-institutionalised quantification methods for SOI and are reliant on extensive reporting structures created by sustainability departments. On the other hand, Aspirational organisations described NII as the primary innovation objective and the quantification of sustainability metrics was secondary to the SOI objectives. The Accountable organisations demonstrated a strong sense of responsibility for the impacts of their products and their supply chains, and while Aspirational organisations also had a sense of responsibility, they described it specifically as a goal of being “net positive” or “restorative” as a company-wide sustainability strategy.

Additionally, organisations with both narratives demonstrate Adams, et al.’s (2015) assertion that SOI requires “integrated thinking that includes socioecological dimensions”. This is evident in their descriptions of the motivations for their SOI activities, how they implement sustainability as an organisation (noted by Blattel-Mink, 1998), and how they perceive SOIs as having positive impacts on society and the environment. Additionally, they both demonstrate the internalisation of external effects and ecological consciousness in their communication about the organisational identity and sustainability strategy (Blattel-Mink, 1998). Furthermore, they describe an accumulation of resources and capabilities related to sustainability (Varadarajan, 2015), such as the development of new equipment to recycle textiles, a global distribution of sustainability professionals and departments, sophisticated sustainability accounting systems, budgets dedicated to SOI, etc. And finally, they both demonstrate higher-order learning, continuous innovation, and experimentation behaviors (Sharma & Vredenburg, 1998) related to SOI, such as ongoing professional training for sustainability employees and experimentation with various tools, approaches, and perspectives related to sustainability.

Aspirational Organisations

The companies most effective with NII describe it as an approach to business itself rather than a design process or innovation tool, demonstrating that NII was most effective when applied as a broad ethic guiding integration with socioecological systems into business strategy. The challenges that these organisations face have to do mostly with the public scrutiny that sustainability leaders frequently must endure. These organisations recognise that, as leaders, they are held to a higher standard for sustainability performance compared to other companies, and they consequently strive for conceptual sustainability goals that are difficult to achieve but attractive to the sustainability-motivated consumer who appreciates their vision. They rely on both radical and incremental innovations to fulfil their visionary sustainability goals and recognise the brand value in engaging with a variety of stakeholders. For these organisations, the application of NII provides a valuable communication tool using compelling, iconic, and visual representations to demonstrate their systemic sustainability strategy to stakeholders and customers (aligned with Tempelman et al., 2015). While the vision of mimicking nature did not provoke their sustainability ethic, the implementation of their existing ethic is further enabled by NII. MNCs that already have aspirational sustainability goals may find it beneficial to adopt the principles of NII to expand their sustainability agendas towards more holistic, systemic perspectives and to reach consumers who specifically patronise sustainability leaders.

Aspirational organisations must also be careful to avoid the *sustainability accounting trap* that limits NII for many well-meaning, fully-engaged organisations. They must be vigilant that the time and place for sustainability accounting and reporting is appropriately allocated to support – rather than drive – their SOI processes. They may also benefit from the support of innovation managers who offer “permission to fail” and create “flat” reporting structures that do not rely on top-heavy decision-making hierarchies to progress innovation efforts.

Perhaps most importantly, there were differences between the Accountable and Aspirational organisations in the narratives related to sustainability and the perceived characteristics of the relationship with nature. The Accountable organisations described highly embodied identities related to sustainability as “the way we have

always done things around here” and discussed the *preservation* of nature and resources as part of a *utilitarian* narrative. NII was viewed as one of many tools to meet sustainability standards and goals. When Accountable organisations were given the opportunity to reinvent their narratives with visionary SOI leadership promoting the implementation of organisational NII strategies, the SOI leadership was not supported by senior management and subsequently resigned from the organisation. To the contrary, the Aspirational organisations also had embedded sustainability identities that began with visionary SOI leadership. However, this narrative was continually reinvented in comparison to the static oral histories of sustainability ethics articulated amongst the Accountable organisations. Amongst Aspirational organisations, *integration with nature* and *being a part of nature* are part of a larger organisational narrative in which nature is the standard for sustainability. This narrative is supported by senior management and enabled at multiple levels of the organisation.

Though innovations resulting from NII range substantially in their contributions to SOI, the Aspirational organisations that utilise NII as an innovation philosophy have made significant steps in shifting their own corporate sustainability agendas. This is well-aligned with existing literature, in which “The principles, methods, and tools that NID offers seem to affect the companies beyond the traditional scope of sustainable product design, up to the point of influencing corporate missions” (Tempelman, de Pauw, van der Grinten, Ernst-Jan, & Grevers, 2015, p.327)

Table 30 (above) exemplified stereotypical statements from each of the three SOI narratives that emerged from the cases. These prototypical statements could be viewed as an assessment tool when determining the readiness of an organisation to adopt NII. Organisations that fall into one of these three user types may benefit from prescribed approaches to implementation that reflect the aforementioned descriptions.

Conclusion

This chapter has discussed the diversity of factors that influenced the adoption of NII in six multinational companies and compared and contrasted the findings against existing literature for multiple factors. While some factors were well aligned with

more generalised research related to SOI, other factors were contradictory. A similar situation arose when relating the findings to the limited existing research on NII. These findings present novel insights into the factors that influence the adoption of SOI and contribute to the limited body of research related to NII. The three identified SOI narratives likely benefit from distinctly different approaches to the adoption of NII. Table 30 provides a diagnostic tool that can be used to identify SOI narratives in MNCs, and the adjacent text provides insights into the best approach for organisations with each narrative. Furthermore, while a clear and distinct pattern was present in these cases, the proposed categories require further analysis and practical application to test for relevance and validity in settings other than NII. Additional testing of these cultural differences could reveal additional SOI narratives and refine the need for nuanced approaches to SOI within various organisations. The following Conclusions Chapter summarises the contributions, limitations, implications, and suggestions for further research emerging from this thesis.

Chapter 8: Conclusions

Introduction

This concluding chapter presents an overview of the thesis as it relates back to the Aims, Objectives, and Research Questions. It is divided into four sections: 1) Contributions to the academic literature; 2) Limitations of the research; 3) Implications for academics and practitioners; and 4) Implications for future research.

Review of Aims and Objectives

To reiterate from the Introduction Chapter, the aim of this thesis is to investigate the ways in which biological insights influence SOI in the context of a MNC. The following objectives were pursued:

Objective 1: To create a SOI typology of NIIIs that is relatable to innovation management, particularly as it is used by multinational organisations.

Objective 2: To identify the factors that influence the adoption of NIIIs in a multinational context as a way to support, accelerate, and clarify the NII process in large organisations.

Each objective is addressed below and unique contributions related to each objective are discussed.

Contributions

The application of abductive logic, following Blaikie's (2007) description, was applied with three phases and is summarised in Table 31. At the outset of the research, there were few known case studies evaluating the practical application of NII in multinational contexts and fewer still that addressed the innovation processes themselves. To date, there have been no other known analyses of NII in MNC cases from the perspectives of SOI innovation adoption theory. The combination of NII, SOI, and innovation adoption theories shed light on several assumptions that practitioners and scholars have made in these areas of study. Given that NII is still considered an emerging discipline with only a few journals and credentialed academic programs, many practitioners are situating themselves in uncharted

territory of praxis and theory. These circumstances motivated the combination of theoretical lenses applied herein.

Table 31: Summary of Research Resulting from an Abductive Approach

Process	Abductive	Strategy
Aim:	To describe and understand social life in terms of social actors' motives and understanding	Semi-structured interviewees were used to collect first person accounts of the NII process in MNC settings. Interview questions addressed the experiences, motivations, and understanding of the NII processes as perceived by the participants themselves.
Start:	Discover everyday lay concepts, meanings and motives Produce a technical account from lay accounts	The way in which users perceived NII, sustainability and innovation within their organisations was summarised and analysed against existing theoretical foundations that were more practically oriented. The cross-case analysis revealed more widely applicable concepts than would have been evident in a single case approach. Application of a NII typology, a summary of influencing factors, and accompanying recommendations for specific SOI narratives in the Discussion Chapter create a technical account from lay accounts.
Finish:	Develop a theory and test it iteratively	While several aspects of SOI and adoption theory were considered, the primary theoretical developments were the typology of NII results, identification of distinct SOI narratives (Ambiguous, Accountable and Aspirational), and a few other lesser points.

Although these lenses do not address other compelling and timely questions related to NII (e.g., the connections between NII and sustainability or the ways in which NII has informed international sustainable development narratives, to name a few), it was beneficial to identify tactical solutions that can be used by practitioners in corporate settings. Following from a realist epistemology, this practically-oriented approach to NII research produced useful, applicable, and timely perspectives.

The central position of this thesis is that the effective adoption of NII within MNCs is due to organisational factors related to sustainability narratives, senior leadership

support and engagement, and innovation cultures and infrastructure. An amalgamation of these factors reveals three distinct SOI narratives – Ambiguous, Accountable and Aspirational – across cases of organisations adopting NII. These narratives are likely applicable in a broader range of contexts beyond NII. Table 32 summarises the contributions of this thesis and specifies bodies of theory it has contributed to, themes in the Discussion Chapter leading to the contribution, and RQs addressed by each contribution. Additionally, below are further descriptions of each contribution with details regarding the contributions to bodies of theory.

Table 32: Summary of Contributions

No.	Body of Theory	Contribution	Related Themes	RQ
1	NII	NII – applied as Technological, Organisational, and Systems Building Innovations – is differentiated as an approach to SOI in MNCs.	Typology	1
2	NII, SOI	NII results in transformative, ecologically embedded sustainability narratives for individuals, reinvented narratives for the organisation, and/or sustainability drain-drain.	Sustainability Narratives	2
3	SOI, NII	Supportive leadership guiding the organisation to “be like nature” is necessary to enable the cultural changes required for company-wide implementation of NII.	Supportive Leadership	2
4	NII	Design expertise enables systemic implementation of NII.	Innovation Culture and Infrastructure	2
5	NII, SOI, Adoption	Innovation Context of NII is more important than Characteristics of the Innovation itself or Characteristics of the Decision-Making Unit	Innovation Culture and Infrastructure	2
6	SOI, NII	Multinationals that attempt NII can be categorised as demonstrating one of three SOI narratives – Ambiguous, Accountable, and Aspirational.	Typology, Sustainability Narratives, Supportive Leadership, and Innovation Culture and Infrastructure	2

1. NII – applied as Technological, Organisational, and Systems Building Innovations – is differentiated as an approach to SOI in MNCs.

Various aspects of NII have been analysed through the lenses of science and technology studies, philosophy, design theory, engineering processes, and biological sciences. However, the uptake of this innovation method in the private sector has not been examined with any depth. This thesis contributes to the subject of NII as an area of inquiry in innovation management studies, particularly as it relates to SOI.

While several studies in management have analysed biological models in the context of cybernetics, organisational ecology, and related theoretical positions, this is the first known study that explicitly ties the application of biological metaphor to examine the relationship of MNCs to socioecological systems via the adoption of NII. While it was beyond the scope of the thesis to quantify these relationships, this study aimed to differentiate between those organisations that applied NII for sustainability objectives versus those who did not in the case selection process. Perhaps more importantly, it described the organisational norms that enabled connections to socioecological systems via the application of NII.

Research Objective 1 was to create a typology of SOIs that could be used to describe and categorise NIIs in MNCs. While this is seemingly a clear-cut task, the wide array of user groups and disciplines that engage in NII made a transdisciplinary investigation into the types of NIIs a rather complex endeavor. The contribution of the final typology – Technological, Organisational, and Systems Building Innovations – is intended to be applicable to a multitude of user groups, particularly in contexts where NIIs are discussed in interdisciplinary audiences that involve business expertise.

2. NII results in transformative, ecologically embedded sustainability narratives for individuals, reinvented narratives for the organisation, and/or sustainability drain-drain.

Although NII is typically promoted as an approach to SOI, it also has significant implications for the narratives that guide SOI for the organisations and individual perceptions of their role in SOI agendas. If the gap between sustainability-oriented innovators' desired results is contradictory with actual results through time and

experiences with SOI, it can lead to ethical dissonance and personal dissatisfaction with their role in the organisation, and this can in turn lead to their eventual departure from their professional position. This thesis contributes the finding of the importance of transformative, ecologically embedded sustainability narratives for the organisation, the individual, and SOI results. It also introduces the phenomenon of sustainability brain-drain from the MNC context.

3. Supportive leadership guiding the organisation to 'be like nature' is necessary to enable the cultural changes required for company-wide implementation of NII.

Related to the above contribution regarding individual transformations and conceptions of ecological embeddedness, successful implementation of NII is contingent upon active support and engagement of senior level management. These managers view sustainability as an intrinsic motivational driver of the organisation and enable their employees to implement it in a variety of aspirational pursuits. They are also able to describe how NII is integrated into their overall SOI strategy at the organisational level and how it guides their interactions with other companies and sectors for Technological and Systems Building Innovations.

4. Design expertise enables systemic implementation of NII.

In addition to several other factors related to SOI narratives, one crucial component to an interdisciplinary NII team is the role of the designer. This finding is unique from related findings of Tempelman et al. (2015), in which designers themselves were interviewed to understand their role. This thesis contributes the finding that, given the varied inclusion of biologists and other disciplines on NII project teams, it is conceivable that design expertise is more critical to the success of NII projects than are biologists or other discipline-specific expertise.

5. Innovation Context of NII is more important than Characteristics of the Innovation itself or Characteristics of the Decision-Making Unit

While perceived Characteristics of the Innovation were relatively consistent and Characteristics of the Decision-Making Unit were variable, Characteristics of the Innovation Context demonstrated a clear trend. The main contribution related to this factor is this: The results of a NII process are likely a reflection of the innovation, management, and sustainability norms at the level of the organisation as opposed to

specific characteristics of those individuals or business units attempting to implement it or the way that it is perceived by potential adopters.

6. Multinationals that attempt NII can be categorised as demonstrating one of three SOI narratives – Ambiguous, Accountable, and Aspirational.

Per the extensive aforementioned descriptions, organisations adopting NII can be categorised into one of three cultural types based on variations related to sustainability narratives, leadership support and engagement, and innovation cultures and infrastructure. These SOI narratives can be used to develop customised approaches to NII and likely other SOI approaches, as described in the Discussion Chapter.

Limitations of the Study

Several assumptions and limitations were relevant in this study that contributed to the viability of the research project and the proposed contributions.

First, limitations related to existing NII theory were recognised early on in the research process. Although a body of theory unique to NII exists that relates to several aspects of the practice (e.g., the naturalistic fallacy mentioned above, the philosophical underpinnings of learning from nature, conceptions of the human-nature relationship, the translation of biological strategies into design solutions, the processes that facilitate this translation, etc.), this research addressed NII through the literature related to SOI and innovation adoption theory in an effort to draw attention to these two bodies of theory in practical settings. Many of the conceptual controversies related to the connections of NII to sustainability, the various nuances of the NII design process, and the many tools that have been created to enable NII have been set aside for the purposes of this study and were not addressed.

In regards to the literature review, NII is an inherently interdisciplinary subject, and consequently, the potential bodies of theory included in the literature review were many and diverse. After several iterations, the literature review was reduced substantially to emphasise how NII can be integrated into management and SOI literatures without distraction from other possible ontological, epistemological,

theoretical, and practical perspectives. In the process of eliminating layers of potential complexity to develop a clear research agenda, many of the nuanced questions related to NII were set aside, and what remains is a rather mechanical and rigidly-packaged thesis that makes clear contributions to NII, SOI, and innovation adoption theory, but does not address some other timely, relevant, and related subjects.

Methodologically, it should be noted that there might have been limitations in the disclosure of innovations because of the imprecise definitions and interpretations of NII in the existing literature and within the organisations under study. Results described are limited by the information provided by interviewees and may not fully address all innovations that could be considered NII. For instance, all basic recycling programs or green chemistry projects were not considered to be NIIs for the purposes of this research, though these efforts might be considered to mimic some principles of biological systems. To the contrary, in those cases where users identified their programs and projects as NII specifically, those NII activities qualified for inclusion in this study.

Another methodological limitation was due to the iterative approach to the case studies and interviews. The research process was frequently a dialogue between literature review and interview data collection, leading to some inconsistencies in the approach to the interviews. While identical questions were used to guide every semi-structured interview, the unstructured aspects of the interviews took on various tenors depending on the progress and positioning of the literature review.

An additional limitation imposed by this iterative approach was the inability to include the Characteristics of Innovator (Rogers, 2003) as part of the analysis framework. While the semi-structured interview questions alluded to some data related to this subject, there was ultimately insufficient data to develop results regarding this aspect of innovation adoption theory. It was subsequently excluded from the results of all cases.

A similar situation arose related to the various perceptions of sustainability described across the six cases. Given that distinct means for categorisation emerged rather

late in the analysis process, the interview questions were not amply informed by sufficient literature to alter the trajectory of the research and deepen the analysis in this area. Consequently, potentially valuable contributions to corporate sustainability literature were not included in this thesis and instead were tabled for further research.

Furthermore, when interviewees were contacted for follow-up questions and surveys due to this iterative research process, responses were sparse and inconsistent. While a few interviewees were open to multiple interviews, the majority was unresponsive, making it difficult to further develop the research beyond the initial interview data.

Given that a case study approach was used to support a comparative analysis of six specific cases, the broader applicability of these Results, Discussion, and Conclusions must be carefully considered. These results were derived from MNCs that engaged with outside consultants to apply NII. These two characteristics create a specific innovation context, and similar results are unlikely outside of this context.

A final limitation is related to the Norms of the Social System. Although questions related to the Norms of the Social System could be far-reaching and diverse, the main norms analysed were related to sustainability and innovation, as these were the primary subjects addressed in the literature review. Norms could have included religious, cultural, gender, or national perspectives, each of which would have revealed interesting and relevant findings, such as the norms related to national identities in a multinational context. Nevertheless, these factors were not directly considered.

Research Implications

For Academics

Broadly speaking, one suggestion of this thesis is the relative underdevelopment of corporate sustainability theory in the academic literature compared to practices in organisations at the forefront of corporate sustainability. Although the effectiveness of NII projects varied considerably across cases, the intentions of the innovators were consistently far-reaching and innovative at the conceptual boundaries of

standard practices in corporate sustainability. Currently, the corporate sustainability narratives driven by forward-looking innovators are not sufficiently theorised in the corporate sustainability literature. While this literature is likely available at the unit of the individual in leadership studies (e.g., Hardman 2009; Schein 2015), the influence that these leaders have on the material aspects of their organisations and socioecological systems is not readily available. An expansion of this area of research would benefit the advancement of corporate sustainability.

An additional implication is related to the factors that influence the adoption of NII. The coding strategy (Appendix 3) – created as a result of the literature review and applied in this study – could be used in further research as an analysis tool to evaluate SOI processes. While some of the factors are specific to NIIs, several factors were identified in the SOI literature more broadly. Given the relatively nascent development of the SOI theory and the assertion by several scholars that it must be analysed with different theoretical lenses than conventional innovation theory, additional analytical tools for SOI are required. The coding strategy could provide a starting point for the development of further analytical tools that are applicable in similar contexts.

For Practitioners

Given the practitioner origins of the researcher, much of this research was motivated by practical considerations and supported by academic theory and rigor. Consequently, one overarching objective of the research was to develop assessment and support tools for practitioners applying NII in organisational settings. Several aspects of the research could be easily adapted to practitioner settings, as described in the following paragraphs.

At a minimum, the commonalities across all cases that were described in the cross-case analysis should be considered as integral parts of a NII project. For instance, all cases relied on an interdisciplinary project team and outside consultants. These two commonalities were in alignment with existing literature and should be considered as part of any NII process in MNCs. Other commonalities are likely also applicable and may be referenced in the Chapter 7.

As mentioned above, the coding strategy could also be applied to practical settings to evaluate various aspects of the Innovation Context and the Decision-Making Unit and to support the delivery of NII projects to be more readily received by various organisational types.

Similarly, the table of SOI Narratives of Organisations Adopting NII (Table 30) presented in the Discussion Chapter could be applied as a readiness assessment for NII consultants and corporate practitioners. These norms and characteristics describe variability in SOI narratives and suggest that each would benefit from a customised approach that is tailored to their specific SOI narrative.

Recommendations for categorically customised approaches are presented that may help practitioners to approach organisations with various SOI narratives differently. Understanding these norms and incentives and responding to them in an innovation context could improve the adoptability of NII.

Finally, this research was funded by a Marie Curie Early Career Research network and in partnership with the Academy for Business in Society. As part of this network and the reporting obligations of the European Commission, several reports were produced for public dissemination that addressed the implications of the larger research project for practitioners, policy makers, and education professionals. These reports are available online from the Academy for Business in Society with offices located in Brussels.

Further research

Several areas emerged as potential areas for further research, some of which have been alluded to previously in the thesis.

Epistemological Slide in the NII Process – As suggested, the epistemological slide in the application of NII, from Reductionist to Constructivist to Realist, has implications for the practical applications of biological metaphor to sustainability objectives. The translation of biological strategies into design solutions in social contexts is loaded with normative insinuations that are rarely acknowledged by NII practitioners. Further analysis of this oversight in the context of change-making for socioecological systems would be a valuable contribution to NII.

Influential Factors May Vary by Innovation Type – While the unit of analysis for this study looked at the innovation team and categorised data by innovation type and factors that influenced the adoption of NII broadly, an alternative way of approaching the subject could have been to look at the factors that influenced each type of innovation (e.g., what factors influence the adoption of Technological Innovations versus what factors influence the adoption of Organisational Innovations?). This level of analysis, which could be based on the categorisation and influential factors identified in this study, would contribute further to the body of SOI and NII theory.

Sustainability Brain-Drain – Change agents frequently leave their organisations after corporate investment in NII due to restrictive corporate agendas and move on to pursue NII in other types of organisations. This Sustainability Brain Drain from MNCs may signify a larger phenomenon in which corporate sustainability stagnates because thought leadership migrates to other sectors. This is worthy of further investigation in other contexts.

Criteria that Define Systems Building Innovations – While criteria to evaluate Technological and Organisational Innovations for sustainability have been developed by various agencies for a wide diversity of contexts, the criteria to evaluate Systems Building Innovations are comparatively under-developed from the perspective of the private sector. This gap evokes several research questions related to how they could be evaluated and who should decide.

Perspectives of Ecological Embeddedness at the Level of Corporation – An area of theory that was underexplored in this thesis but clearly demonstrates promise is related to ecological embeddedness as a characteristic of SOI practitioners. For some interviewees, NII enabled apperceptive participation in socioecological systems via conceptual lenses that were previously unavailable to them, but which emerged through the process of applying NII. A more thorough understanding of perceptions of embeddedness at the individual and organisational levels would be beneficial to the SOI literature.

Shifting Narratives of Corporate Social Responsibility: Green to Sustainable to

Regenerative – While comparisons between Green (or weak sustainability) and Sustainable (or strong sustainability) have been described in multiple discussions, a recent conceptualisation is becoming more widely applied in innovations contexts that explicitly includes net positive goals for socioecological systems. Regenerative theory has been applied and developed in the built environment and development theory. However, it is currently lacking theorisation as applied to corporate innovation and social responsibility contexts despite the term being applied casually amongst corporate innovators. Further theorisation is necessary to differentiate it from green and sustainable (and possibly resilient) to avoid conflating these terms in a corporate context and overlooking the potential value of conceptual differentiation for corporate sustainability agendas.

Regenerative Innovation - Two of the six cases view NII as an integral part of their overall sustainability strategy, guiding multiple aspects of their innovation and operational decision-making. Following the Nature-based strategy of viewing waste as raw material (i.e., “waste as food”), these two cases identified novel sources of material by reincorporating polluting synthetic waste from the ocean in to their supply chain to be used for new products. This approach follows several biological and circular economy principles. It is unique in that it creates infrastructure to utilise a pollutant and source of socioecological harm currently present in the *global commons*, creates novel value for the organisation, and develops inclusive social capital while reducing ecological damage. This practice, described herein as *Regenerative Innovation*, is likely a growing trend amongst MNCs and is primed for further inquiry.

Concluding Remarks

This research has attempted to make a modest contribution to the bodies of knowledge related to NII, SOI, and innovation adoption. It is hoped that future academics and practitioners will benefit from the research questions discussed and the conclusions derived will be a source of meaningful and applicable knowledge. While four years of dedicated research may seem like a considerable amount of time to answer just two simple questions, this research is concluding with the humble admission that there are now considerably more questions than were apparent at the beginning of the project.

Appendix 1: Interview Questions

Date:

Company:

Interviewee:

Company Profile:

Public or Private? When became public?

(sector, number of employees, annual revenue, etc.)

General company information

1. What is/was your role at the company?
2. What is the culture of innovation?
3. What innovation tools, systems or frameworks are utilised?
4. Who decides what tools, systems or frameworks should be used?
5. Corporate sustainability agenda and culture? What does sustainability mean at your company?
6. How do you identify more or less sustainable choices?
7. Are life-cycle analyses of your products/services considered?
8. What are the driving forces for sustainability?
9. What are the market demands for sustainability?
10. Where did the idea of using NII come from? Who inspired it in your company?

The NII “Intervention”

11. What problems were you trying to solve with NII?
12. What were the NII intervention(s) at your organisation?
13. What was the timeframe of that intervention(s)? How many months/years?
14. What was the global economic climate like at that time?
15. At what levels of innovation was NII applied? Products? Processes? Organisations? Systems?
16. What is the innovation infrastructure that supports NII? How did/does the innovation process work?
17. How was sustainability incorporated into the process? How were these decisions made?

Who Was Involved and How

18. What were the roles of the participants and what was the purpose of their attendance? What is the composition of teams?
19. What are the characteristics of internal champions?

20. What effect does the position of the internal champion within the company have on the effectiveness of NII interventions?
21. Was/is there anything significant about the leadership that supports the effort?
22. How were budgets managed for NII? As the internal champion, did you have discretionary authority over a budget?

Results

23. What were the results of the intervention?
24. How was it successful?
25. How did it fail?
26. Did NII lead to new innovations and ideas?
27. If it can be clearly quantified, how much money has your organisation invested in NII?
28. Has there been a quantifiable return on that investment?
29. Did the NII intervention lead to a more resource efficient solution? If so, how do you know?
30. Did the NII intervention lead to a more sustainable or environmentally friendly result? If so, why do you think so or how do you know?
31. What barriers are there (cultural, systemic, procedural, or otherwise) for furthering the ideas that emerged from NII interventions?
32. Did you feel limited by the current circumstances of the economy, government regulations, or company procedures? If so, how?
33. Did lack of measurability make the concept less adoptable?
34. How did NII compare to other sustainability initiatives that your organisation has undertaken?
35. What is the value of NII?
36. What is the value of NII as a tool for sustainability versus life cycle analysis, ISO 14001, LEED, Cradle-to-Cradle certification, etc.?
37. Did the use of NII affect competitive or cooperative relationships with other organisations?
38. What advice would you give to others interested in or beginning on a project using NII?

Futures

39. Are you aware of the ISO Biomimetic Certification that is currently under development?
40. Are you interested in participating in follow-up research related to the issues addressed in this interview?

Appendix 2: Preliminary Coding Strategy

Nature Inspired innovation	Socio-ecological systems/ Resilience
Analogies vs. Metaphors	Conceptions of Corporate Sustainability
NII Definitions	Participatory
NII History	Embedded
Influence of Management Innovations (MIs) on other levels	Intertwined
Sustainability-Oriented Management Innovations	Disparate
Nature-Inspired Management Innovations	Visionary leadership
Sustainable Competitive Advantage	Sustainability Oriented Innovation
The Biological Age	Barrier: Lack of managerial support
Cases	Barrier: Global economic crisis
Case 1	Barrier: Short term financial pressures
Case 2	Barrier: Weak company sustainability effort
Case 3	Barrier: Company culture
Case 4	Importance of Personal Values
Case 5	Outcomes
Case 6	Beliefs and Values
Case 7 (Not used)	Intended vs. Actual
Case 8 (Not used)	Marketing (Pre-product ideation)
Methods	Organization
Case Study Methods	Process
Qualitative Evaluation	Product
Sustainability	Systems-building
Embedded Resilience for Business	Team member leaves company
Embedded Resilience for Society	Radical innovation
Embedded Resilience for Nature	Theory of Knowledge
Existing sustainability + BII (?)	Autopoeisis
Planetary Boundaries	Critical Realism
Relationships with Nature	Post-positivism
Sustainability Criteria and Definitions	Systems and Complexity
	The epistemological slide

Impacts on Sustainable Development*		Impacts on Nature	Impacts on Society	Impacts on Business
Innovation (i.e., Biomimicry as a Concept) Characteristics	Perceived Relative Advantage			
	Observability			
	Complexity			
	Trialability			
	Compatibility			
Outcomes– after the innovation	People/Belief			
	Product			
	Process			
	Organization			
	Systems Building			

Adopter Characteristics	Innovators, Early Adopters, Early Majority, Late Majority, Laggards
Innovator Characteristics	Opinion Leadership
	Source Credibility
	Homophily
	Compatibility
	Existing connection with nature
	Interdisciplinary training/background
Extent of Innovator/Change agents' promotion efforts	Length of time using innovation
	Number of engagements/activities
	Level of financial investment
	Type of Internal Innovation Decision – Optional, Collective, Authority
Environment, Infrastructure and Context of Social System (without the innovation)	Physical
	Social
	Economic
	Political
Stage of Sustainability-Oriented Innovation Development	Singular attempt completed, Ongoing development, Culturally and operationally integrated
Existing Sustainability Culture	Compartmentalized, Developing, Integral
Efforts explicitly limited by financial/economic pressures	Yes/No

Appendix 3: Final Coding Strategy

CASE XXX

CASE DESCRIPTION

INNOVATION TYPES		
Techno-logical	Attempted	
	Achieved	
Organisational	Attempted	
	Achieved	
Systems Building	Attempted	
	Achieved	
FACTORS: CHARACTERISTICS OF THE INNOVATION CONTEXT		
Norms of the Social System	Sustainability Narrative	
External Knowledge Sourcing/ Open Innovation	NII Specialist Support	
	NII Team Included Design Expertise	
	Utilised Further External Specialists	
Social Network Collaboration	Informal Collaboration	
Leadership	Values Intangible Benefits	
	No Siloing Of Sustainability	
	Senior Management Support	
	Insularity Of	

	Management	
FACTORS: CHARACTERISTICS OF THE DECISION-MAKING UNIT		
Attitudes Towards Innovativeness	Culture Impedes Creativity	
	Episodic Innovation Or Emphasis On Incremental	
Formality Of Organizational Structures	Formal Structures	
	Flexible, Decentralised Structures	
Professional Training	NII Training Of Staff	
	Cross-Functional Expertise In NII Team	
Selective Exposure And Perception	Influenced By Previous Experiences With Similar Innovations	
FACTORS: CHARACTERISTICS OF THE INNOVATION		
Perceived Relative Advantage	Low Monetary ROI Value	
	Expansive Thinking	
	Cooperation With Suppliers (Material Search Heuristics)	
Observability	Inspiration For Shape, Function, Ecological Principles And/Or Systems-level Design Principles	
	Lack Of Clarity About Results	
Complexity	Descriptions Of Complexity	

Trial- ability	Conflict Between Short Investments And Long Term Results	
Compatibility	Incorporation Into Strategic Sustainability Goals	
	Perceptions Of NII -As An Innovation Tool -An Academic Exercise - As An Environmental Ethic -Others	
	Individual Transformations	

Appendix 4: Example of Coding Application

Case 1: Resources, Inc.

Case Description

The business unit that used NII in this case was an open innovation team within a transnational company of >90K employees. The company is well-established and highly profitable, ranking in the top 5 of Fortune 500 companies and in 2015, claimed US\$264.96 billion in revenue. With a history dating back to the early 1900s, its primary business is resource extraction and processing of raw materials. The business unit under study (decision-making unit) is charged with identifying novel innovations in their sector from outside of the organization that have demonstrated proof of concept and act as an “angel investor” to develop the concept with the innovator. They are also interested in identifying emerging technologies and disruptive innovations relevant to their business so they “don’t get blindsided” by these types of advancements.

The NII activities included a few engagements with various staff members in North America and Europe. Accounts of current activity vary depending on the respondent, but there is no apparent NII activity beyond the testing and possible adoption of a biologically-inspired technology that could be purchased “off the shelf.”

Three interviewees from the team who participated in the NII activities were interviewed but despite multiple, varied attempts to identify and interview other participants, no other interviewees came forward to discuss the NII effort. The initial activities took place in 2009 and today are mostly inactive. The specifics of the applications of NII were not described in detail and to the contrary, were actively withheld. As one interviewee remarked “We’ve been exploring applications for [biologically-inspired technology] in our industry, basically. That’s probably all I can say about it.” Without a greater degree of specificity and general unwillingness to discuss the NII project openly, it was difficult to extract much detail regarding this case.

RQ1: What types of NIIs are attempted and achieved in MNCs?

Case 1: Resources, Inc. Innovation Types		
Technological	Attempted	<p><i>Technological Innovation 1</i> Innovators 1 and 2 contracted with a NII consultant team to engage in an innovation process internally, based out of their offices in North America. The intended outcome was to identify a disruptive technology that could be advanced more fully with the support of Resources Inc. These activities included a research process to identify the company’s resource-based challenges and biological strategies for addressing these challenges.</p> <p>This research was delivered via an on-site workshop with ~20 members of the business unit, each chosen for their connection to the resource-based challenge areas selected by the consultant team and the innovators. Workshop participants included interdisciplinary team members (chemists, biologists, engineers and communications staff.) They were chosen because their areas of expertise aligned with the workshop topics (i.e., CO2 reduction, preventing corrosion, freshwater use) and because they had “innovative mindsets.”</p> <p>However, no existing but novel, disruptive technologies were identified that were developed enough to be pursued further by Resources Inc.. At the time of interview, one NII was still being pursued as an ‘off the shelf’ technology for the physical infrastructure of the company’s supply chain but specific details about implementation were withheld. It was unclear if there was an environmental advantage to using this technology compared to the industry standard.</p>
	Achieved	N/A

Organisational	Attempted	N/A
	Achieved	N/A
Systems-Building	Attempted	N/A
	Achieved	N/A

RQ2: What factors influence the adoption of NII in MNCs?

Case 1: Resources, Inc. Factors: Characteristics of the Innovation Context		
Norms of the Social System	Sustainability Narrative	<p>Interviewee 1: "It's kind of a disadvantage for the word [sustainability] because it's so broadly defined. It's hard to implement because it's such a broad word."</p> <p>According to Interviewee 1, a company-wide effort to reduce water use and CO2 impacts is indicative of their sustainability strategy. "[Resource Inc.]'s work is nearly all targeted to reduce footprints of CO2, water ... Um you know the, the kind of um I guess the late I ... so is I mean to me it is, it's a lot of a sustainability, it's the kind of footprint we leave on the world."</p> <p>Interviewee 1: "One of the things we do in innovation is we look at waste streams and hoping to create something valuable from somebody else's waste stream."</p> <p>Interviewee 3: "Some people felt um that there was too much political agenda behind the story of [the consultants], ... I didn't feel that way, but I know others did."</p> <p>Interviewee 1: "[My colleague who participated in the NII workshop is a biologist] and his area of expertise is genetics. And there's an interesting tension between GMO and biomimicry. And so I'm not sure he would support biomimicry."</p>
	NII Specialist Support	NII activities included a workshop and research project facilitated by external NII consultants.
	NII Team Included Design Expertise	No
Sourcing/ Open Innovation	Utilised Further External Specialists	Interviewees expressed satisfaction with the overall delivery of the workshops and the quality of the content. However, substantial engagement beyond the capacity of the consultant team would have been necessary to advance the content further.

Social Network Collaboration	Informal Collaboration	Interviewee 3: Based in Europe, she was given the option to reapply for her job in a substantial downsizing effort during the economic downturn and instead opted to take a severance package. She has since gone on to undertake intensive training in NII and become a NII consultant with other clients in Europe. She has also worked with her government sustainability unit to create a policy-based initiative to promote NII at the national level in her country. These efforts, however, are outside of the organisation itself.
	Values Intangible Benefits	Interviewee 2 described how he applied NII principles to decision-making within the group outside of the designated NII activities. "I really liked the biomimicry 'cause on the sustainability side obviously nature is sustainable. It's sort of everything intertwined, or interlinked and what I particularly liked in that nature only takes what it needs." Interviewee 1: "I think it's important to appreciate [nature] and preserve it but I always have felt in my life, engineering is biomimicry really. That's what engineers do, they create structures and designs and things to either mimic or celebrate [...] really everything that engineers do is inspired by nature, even if they don't acknowledge it. I just think that the bridge needs to be stronger."
Leadership	No Siloing Of Sustainability	Interviewee 1 described her views on agricultural production and other subjects that were aligned with sustainability conceptions, but did not link it to her work directly.
	Senior Management Support	Interviewee 3 claimed that she was more of an enthusiast about the efforts than either of the other two interviewees who were the designated project leads of the NII project.
	Insularity Of Management	Interviewee 3: The manager of the business unit was only present at the workshop during the introduction and concluding sessions, not demonstrating commitment to the overall program. "If this is something you really want to adopt as a team for a better future, why not participate fully?"

Case 1: Resources, Inc. Factors: Characteristics of the Decision-Making Unit		
	Culture Impedes Creativity	Two interviewees claimed to have introduced the concept into Resources Inc., one in North America and one in Europe. Interviewee 1 claimed that the project did not advance because his colleague who was managing the effort 'sat on' the ideas generated in the workshop. He thought his colleague had political motivations for stalling the project that included ensuring the advancement of her own career. He escalated his concerns about her resistance with his manager. Interviewee 1: "I'm fairly expensive. [...] I didn't worry you with all the things I've done but I've had an amazingly interesting career at [Resources Inc.]."
	Episodic Innovation Or Emphasis On Incremental	Interviewee 1: The rest of organization has a tendency towards incremental innovation, but this is not the goal of their unit, which aims specifically to drive open innovation.

Formality Of Organisational Structures	Formal Structures	The NII project was conducted by a business unit that's primary objective is to support radical innovations in their sector. However, the unit itself seemed to have a procedural rigidity that limited the adoptability of NII due to the need for further conceptual development.
	Flexible, Decentralised Structures	N/A
Professional Training	NII Training Of Staff	Two staff members attended a one-week immersive training with an outside NII consultancy. The NII consultancy offered NII training in the innovation workshop, but Resources Inc. declined this component of the engagement. After engaging with NII in the workshop setting within Resources Inc., a third employee took a severance package and pursued a 1-year certification program.
	Cross-Functional Expertise In NII Team	Interviewee 1: Mechanical Engineering Interviewee 2: Chemical Engineering, Biology Interviewee 3: Psychology, Communication, Business
Selective Exposure And	Influenced By Previous Experiences With Similar Innovations	N/A

Case 1: Resources, Inc. Factors: Characteristics of the Innovation		
Perceived Relative Advantage	Low Monetary ROI Value	Interviewee 2 described how the business unit is charged with supporting new innovations in their sector without expectations of a return. The economic downturn forced budget cuts shortly after the NII activities were completed.
	Expansive Thinking	Interviewee 3: "It can be a very [helpful] to come up with more innovative solutions." Interviewee 2: "So is [nature] innovative? It's probably just innovative by looking at what nature does but obviously it's something just very innovative, seeing that for billions and billions of years. But it's innovative in that sense um, so it's quite interesting. But that's what I really like about it. [...] So much more can be done and that's why I'm particularly interested in it."
Observability	Cooperation With Suppliers (Material Search)	N/A
	Inspiration For Shape, Function, Ecological Principles And/Or Systems-level Design Principles	Interviewee 3: "[The value of NII] is not only making the connections for humans to have with the natural world, but also from all the systems that are helpful".

	Lack Of Clarity About Outcomes	Interviewee 2 described some early misunderstanding about what the consultants could and could not offer. The company was seeking solutions that were further developed than the concepts presented in the workshop, but the consultants were not able to broker relationships with individuals who were developing the new technologies. Consequently, there was difficulty identifying clear next steps to advance the NII project and more tangible outcomes were not within the scope of the engagement.
Comp-lexity	Descriptions Of Complexity	Interviewee 3 commented that the biological components of the NII process were difficult to interpret and implement.
Trial-ability	Conflict Between Short Investments And Long Term Results	Due to the economic downturn, the company went through a downsizing process that resulted in a reduction in one business unit from 15,000 to 10,000 internationally, and all interviewees had to re-apply for their jobs. The business unit that utilised NII downsized from 112 to 12 employees globally, significantly reducing its scope and capacity.
Compatibility	Incorporation Into Strategic Sustainability Goals	No interviewees expressed familiarity with the company sustainability strategy.
	Perceptions Of NII -As An Innovation Tool -An Academic Exercise - As An Environmental Ethic -Others	Interviewee 3: "I feel it can bring about additional paradigms shifts and how we, as the species, can better relate to all the others. But that's probably more of this belief system [that] it can help people relate to nature a bit more and see how everything is, [interconnected] ... you are dependent on [other organisms]." (Former employee who trained in NII in-depth after leaving the organisation.)
	Individual Transformations	Interviewee 3: "I have a much better understanding now of how we are interconnected and more interdependent ... on that sort of level and why it is necessary to do something."

Bibliography

- Adams, W.M. and Jeanrenaud, S. J. (2008). *Transition to sustainability: Towards a humane and diverse world*. Published by: IUCN, Gland, Switzerland.
- Adams, R., & Bessant, J. (2008). Policy considerations in accelerating adoption amongst slower adopters. In J. Bessant & T. Venables (Eds.), *Creating Wealth From Knowledge: Meeting the Innovation Challenge* (p. 416). Cheltenham: Edward Elgar Publishing.
- Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., & Overy, P. (2016). Sustainability-oriented innovation: A systematic review. *International Journal of Management Reviews*, 18(2), 180–205. <http://doi.org/http://doi.org/10.1111/ijmr.12068>
- Adams, R., Jeanrenaud, S., Bessant, J., Overy, P., & Denyer, D. (2013). *Innovating for sustainability: A systematic review of the body of knowledge*.
- Altenburg, T., & Pegels, A. (2012). Sustainability-oriented innovation systems – managing the green transformation. *Innovation and Development*, 2(1), 5–22. <http://doi.org/http://doi.org/10.1080/2157930X.2012.664037>
- Alvesson, M. (2009). (Post-) positivism, social constructionism, critical realism: Three reference points in the philosophy of science. In *Reflexive Methodology* (pp. 15–52).
- Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of Management Journal*, 39(5), 1154–1184. <http://doi.org/10.2307/256995>
- Anderson, R. C. (1998). *Mid-course correction: Toward a sustainable enterprise: The Interface model*. Peregrinzilla Press.
- Armstrong, R. E., Drapeau, M. D., Loeb, C. A., & Valdes, J. J. (Eds.). (2010). *Bio-Inspired Innovation and National Security*. Washington, DC: National Defense University Press. <http://doi.org/10.1037/e584072011-001>
- Ashford, N. A., & Hall, R. P. (2011). *Technology, Globalization, and Sustainable Development: Transforming the Industrial State*. Yale University Press.
- Baker, S. E., & Edwards, R. (2012). *How many qualitative interviews is enough? Expert voices and early career reflections on sampling*.
- Bakker, C. A., Wever, R., Teoh, C., & De Clercq, S. (2010). Designing cradle-to-cradle products: A reality check. *International Journal of Sustainable Engineering*, 3(1), 2–8. <http://doi.org/10.1080/19397030903395166>
- Bakshi, B., & Small, M. J. (2011). Incorporating ecosystem services into life cycle assessment. *Journal of Industrial Ecology*, 15(4), 477–478. <http://doi.org/10.1111/j.1530-9290.2011.00364.x>
- Bar-Cohen, Y. (2006). Biomimetics: Using nature to inspire human innovation. *Bioinspiration & Biomimetics*, 1(1), 1–12. <http://doi.org/10.1088/1748-3182/1/1/P01>
- Bell, J. S. (2002). Narrative Research in TESOL: Narrative Inquiry: More Than Just Telling Stories. *TESOL QUARTERLY Gallas Jalongo & Isenberg*, 36(2), 207–213. <http://doi.org/10.2307/3588331>
- Benne, B., & Mang, P. (2014). Working regeneratively across scales-insights from nature applied to the built environment. *Journal of Cleaner Production*, 109, 42–52. <http://doi.org/10.1016/j.jclepro.2015.02.037>
- Benyus, J. (1997). *Biomimicry: Innovation Inspired by Nature*. HarperCollins.
- Berger, P. L., & Luckmann, T. (1966). *The Social Construction of Reality: Treatise in*

- the Sociology of Knowledge*. Penguin Books.
- Biomimicry 3.8. (2013). Life's Principles. Retrieved February 26, 2014, from <http://biomimicry.net/>
- Biomimicry 3.8. (2017). Biomimicry 3.8 - Innovation Inspired by Nature. Retrieved August 26, 2017, from <https://biomimicry.net/>
- Biomimicry Institute. (n.d.). Biomimicry Institute Website. Retrieved March 3, 2015, from <http://www.biomimicryinstitute.org/about-us/what-is-biomimicry.html>
- Biomimicry NL. (2013). Biomimicry NLs Green Deal. Retrieved October 21, 2013, from <http://www.biomimicrynl.org/en/green-deal.html>
- Biondi, V., Iraldo, F., Filippetti, V., & Meredith, S. (2002). Achieving sustainability through environmental innovation: The role of SMEs. *International Journal of Technology Management*, 24(Nos. 5/6), 612–626.
- Birkinshaw, J., Hamel, G., & Mol, M. J. (2008). Management innovation. *Academy of Management Review*, 33(4), 825–845. <http://doi.org/10.5465/AMR.2008.34421969>
- Blaikie, N. (2007). *Approaches to Social Enquiry: Advancing Knowledge*. Polity.
- Blattel-Mink, B. (1998). Innovation towards sustainable economy: The integration of economy and ecology in companies. *Sustainable Development*, 6, 49–58.
- Blätzel-Mink, B., & Kastenzholz, H. (2005). Transdisciplinarity in sustainability research: Diffusion conditions of an institutional innovation. *International Journal of Sustainable Development & World Ecology*, 12(1), 1–12. <http://doi.org/10.1080/13504500509469613>
- Blok, V., & Gremmen, B. (2016). Ecological innovation: Biomimicry as a new way of thinking and acting ecologically. *Journal of Agricultural and Environmental Ethics*, 1–15. <http://doi.org/10.1007/s10806-015-9596-1>
- Bonser, R. H. C. (2006). Patented biologically-inspired technological innovations: A twenty year view. *Journal of Bionic Engineering*, 3(1), 39–41. [http://doi.org/10.1016/S1672-6529\(06\)60005-X](http://doi.org/10.1016/S1672-6529(06)60005-X)
- Boons, F., & Lüdeke-Freund, F. (2013). Business models for sustainable innovation: State-of-the-art and steps towards a research agenda. *Journal of Cleaner Production*, 45, 9–19. <http://doi.org/10.1016/j.jclepro.2012.07.007>
- Borland, H., & Lindgreen, A. (2012). Sustainability, epistemology, ecocentric business, and marketing strategy: Ideology, reality, and vision. *Journal of Business Ethics*. <http://doi.org/10.1007/s10551-012-1519-8>
- Braungart, M., & McDonough, W. (2009). *Cradle to Cradle: Remaking the Way We Make Things*. Random House.
- Brink, P., Schweitzer, J.-P., Watkins, E., & Howe, M. (2016). *Plastics Marine Litter and the Circular Economy: A briefing by IEEP for the MAVA Foundation*.
- Brown, J. S., & Duguid, P. (1991). Organizational Learning and Communities-of-Practice: Toward a Unified View of Working, Learning, and Innovation. *Organization Science*, 2(1), 40–57. <http://doi.org/10.1287/orsc.2.1.40>
- Bullock, A., Trombley, S., & Lawrie, A. (1999). *The New Fontana Dictionary of Modern Thought*. London: HarperCollins Publishers.
- Cainelli, G., De Marchi, V., & Grandinetti, R. (2015). Does the development of environmental innovation require different resources? Evidence from Spanish manufacturing firms. *Journal of Cleaner Production*, 94, 211–220. <http://doi.org/10.1016/j.jclepro.2015.02.008>
- Capra, F., & Luisi, P. L. (2014). *The Systems View of Life: A Unifying Vision*. Cambridge University Press.
- Carolan, M. S. (2005). Society, biology, and ecology: Bringing nature back into

- sociology's disciplinary narrative through critical realism. *Organization & Environment*, 18(4), 393–421. <http://doi.org/10.1177/1086026605281697>
- Carrillo-Hermosilla, J., del Río, P., & Könnölä, T. (2010). Diversity of eco-innovations: Reflections from selected case studies. *Journal of Cleaner Production*, 18(10–11), 1073–1083. <http://doi.org/10.1016/j.jclepro.2010.02.014>
- Ceschin, F. (2013). Critical factors for implementing and diffusing sustainable product-service systems: Insights from innovation studies and companies' experiences. *Journal of Cleaner Production*, 45, 74–88. <http://doi.org/10.1016/j.jclepro.2012.05.034>
- Clark, A. M. (2008). Critical Realism. In *The SAGE Encyclopedia of Qualitative Research Methods* (pp. 168–171). Thousand Oaks, CA: SAGE Publications.
- Clayton, A. M. H., & Radcliffe, N. J. (1996). *Sustainability: A Systems Approach*. Earthscan.
- Cole, R. J. (2012). Transitioning from green to regenerative design. *Building Research & Information*, 40(1), 39–53. <http://doi.org/10.1080/09613218.2011.610608>
- Collins, H. M. (1981). Stages in the empirical programme of relativism. *Social Studies of Science*, 11(1), 3–10.
- Corlett, R. T. (2014). The Anthropocene concept in ecology and conservation. *Trends in Ecology & Evolution*, 30(1), 36–41. <http://doi.org/10.1016/j.tree.2014.10.007>
- Crossan, M. M., & Apaydin, M. (2010). A multi-dimensional framework of organizational innovation: A systematic review of the literature. *Journal of Management Studies*, 47(6), 1154–1191. <http://doi.org/10.1111/j.1467-6486.2009.00880.x>
- Curnow, R. C., & Moring, G. G. (1968). "Project SAPPHO": A study in industrial innovation. *Futures*, 1(2), 82–90.
- D'Amato, A., & Roome, N. (2009). Toward an integrated model of leadership for CR and sustainable development: A process model of corporate responsibility beyond management innovation. *Corporate Governance: The International Journal of Business and Society*, 9(4), 421–434.
- Damanpour, F. (1992). Organizational size and innovation. *Organization Studies*, 13(3), 375–402. <http://doi.org/10.1177/017084069201300304>
- Damanpour, F., & Aravind, D. (2012). Managerial innovation: Conceptions, processes, and antecedents. *Management and Organization Review*, 8(2), 423–454. <http://doi.org/10.1111/j.1740-8784.2011.00233.x>
- Danemark, B. (2002). *Explaining Society: Critical Realism in the Social Sciences*. Psychology Press.
- De Marchi, V. (2012). Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms. *Research Policy*, 41(3), 614–623. <http://doi.org/10.1016/j.respol.2011.10.002>
- De Marchi, V., & Grandinetti, R. (2013). Knowledge strategies for environmental innovations: The case of Italian manufacturing firms. *Journal of Knowledge Management*, 17(4), 569–582. <http://doi.org/10.1108/JKM-03-2013-0121>
- DePauw, I. C., Karana, E., & Kandachar, P. V. (2012). Nature-inspired design strategies in sustainable product design: A case-study of student projects. In *International Design Conference - Design 2012* (pp. 1–10).
- DePauw, I., Kandachar, P., Karana, E., & Peck, D. (2010). Nature inspired design: Strategies towards sustainability. In *Knowledge Collaboration & Learning for Sustainable Innovation ERSCP-EMSU conference, Delft, The Netherlands* (pp.

1–21).

- Dibrell, C., Craig, J. B., Kim, J., & Johnson, A. J. (2014). Establishing how natural environmental competency, organizational social consciousness, and innovativeness relate. *Journal of Business Ethics*, 1–15.
<http://doi.org/10.1007/s10551-013-2043-1>
- Doblin Innovation Consultants. (2007). A Hierarchy: Sources of Value (Figure). Retrieved from <https://www.doblin.com/>
- Du Plessis, C., & Brandon, P. (2014). An ecological worldview as basis for a regenerative sustainability paradigm for the built environment. *Journal of Cleaner Production*, 109, 53–61. <http://doi.org/10.1016/j.jclepro.2014.09.098>
- Dubberly, H. (2012). *Design in the Age of Biology* (Vol. XV).
- Dubois, A., & Gadde, L. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research*, 55, 553–560.
- Dunlap, R. E., Liere, K. D. Van, Mertig, A. G., & Jones, R. E. (2000). Measuring endorsement of the new ecological paradigm: A revised NEP scale. *Journal of Social Issues*, 56(3), 425–442. <http://doi.org/10.1111/0022-4537.00176>
- Easton, G. (2010). Critical realism in case study research. *Industrial Marketing Management*, 39(1), 118–128. <http://doi.org/10.1016/j.indmarman.2008.06.004>
- Eccles, R. G., Perkins, K., & Serafeim, G. (2012). How to become a sustainable company. *MIT Sloan Management Review*, 53(4), 43–50.
- Ehrenfeld, J. (2004). Industrial ecology: A new field or only a metaphor? *Journal of Cleaner Production*, 12(8–10), 825–831.
<http://doi.org/10.1016/j.jclepro.2004.02.003>
- Ehrenfeld, J., & Gertler, N. (1997). Industrial ecology in practice: The evolution of interdependence at Kalundborg. *Journal of Industrial Ecology*, 1(1), 67–79.
- Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*. <http://doi.org/10.5465/AMR.1989.4308385>
- Ellen MacArthur Foundation. (2012). *Towards the Circular Economy: An Economic and Business Rationale for an Accelerated Transition*. Ellen MacArthur Foundation.
- Ellen MacArthur Foundation. (2015). Ellen MacArthur Foundation Website. Retrieved March 3, 2015, from ellenmacarthurfoundation.org
- Faber, N., Jorna, R., & Van Engelen, J. (2005). The sustainability of “Sustainability”: A study into the conceptual foundations of the notion of “Sustainability.” *Journal of Environmental Assessment Policy and Management*, 7(1), 1–33.
<http://doi.org/10.1142/S1464333205001955>
- Fermanian Business & Economic Institute. (2011). *Da Vinci Index Purpose*.
- Flyvbjerg, B. (2006). Five misunderstandings about case study research. *Qualitative Inquiry*, 12(2), 219–245. <http://doi.org/10.1177/1077800405284363>
- Fogarty, F., Villamagna, A., Whitley, A., & Pippins, K. (2013). The capacity to endure: Following nature’s lead. *Sustainability*, 5(6), 2480–2494.
<http://doi.org/10.3390/su5062480>
- Foster, J. B. (2012). The planetary rift and the new human exceptionalism: A political-economic critique of Ecological Modernization Theory. *Organization & Environment*, 25(3), 211–237. <http://doi.org/10.1177/1086026612459964>
- Fox-Wolfgramm, S. J. (1997). Towards developing a methodology for doing qualitative research: The dynamic-comparative case study method. *Scandinavian Journal of Management*, 13(4), 439–455.
- Frambach, R. T., & Schillewaert, N. (2002). Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research.

- Journal of Business Research*, 55(2), 163–176. [http://doi.org/10.1016/S0148-2963\(00\)00152-1](http://doi.org/10.1016/S0148-2963(00)00152-1)
- Franceschini, S., Faria, L. G. D., & Jurowetzki, R. (2016). Unveiling scientific communities about sustainability and innovation: A bibliometric journey around sustainable terms. *Journal of Cleaner Production*, 127, 72–83. <http://doi.org/10.1016/j.jclepro.2016.03.142>
- Franceschini, S., & Pansera, M. (2015). Beyond unsustainable eco-innovation: The role of narratives in the evolution of the lighting sector. *Technological Forecasting and Social Change*, 92, 69–83. <http://doi.org/10.1016/j.techfore.2014.11.007>
- Francis, D., Bessant, J., & Hobday, M. (2003). Managing radical organisational transformation. *Management Decision*, 41(1), 18–31. <http://doi.org/10.1108/00251740310462023>
- Frosch, R. A., & Gallopoulos, N. E. (1989). Strategies for manufacturing. *Scientific American*, 189(3), 144–152.
- Gaziulusoy, A. I. (2015). A critical review of approaches available for design and innovation teams through the perspective of sustainability science and system innovation theories. *Journal of Cleaner Production*, 107(January), 366–377. <http://doi.org/10.1016/j.jclepro.2015.01.012>
- Gaziulusoy, A. I., & Brezet, H. (2015). Design for system innovations and transitions: A conceptual framework integrating insights from sustainability science and theories of system innovations and transitions. *Journal of Cleaner Production*, 108, 558–568. <http://doi.org/10.1016/j.jclepro.2015.06.066>
- Geels, F. W. (2010). Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy*, 39(4), 495–510. <http://doi.org/10.1016/j.respol.2010.01.022>
- Geertz, C. (1973). Thick description: Toward an interpretive theory of culture. In *The Interpretation of Cultures: Selected Essays* (pp. 3–30).
- Genç, E., & Di Benedetto, C. A. (2015). Cross-functional integration in the sustainable new product development process: The role of the environmental specialist. *Industrial Marketing Management*, 50, 150–161. <http://doi.org/10.1016/j.indmarman.2015.05.001>
- Ginsberg, A. D., Calvert, J., Schyfter, P., Eflick, A., & Endy, D. (2014). *Synthetic Aesthetics: Investigating Synthetic Biology's Designs on Nature*. Cambridge MA, London UK: MIT Press.
- Gladwin, T. N., Kennelly, J. J. I., Krause, T. T.-S., & Hugo, V. (1995). Shifting paradigms for sustainable development: Implications for management theory and research. *Academy of Management Review*, 20(4), 874–907. <http://doi.org/10.5465/AMR.1995.9512280024>
- Gladwin, T. N., Newberry, W. E., & Reiskin, E. D. (1997). Why is the northern elite mind biased against community, the environment, and a sustainable future? In M. H. Bazerman (Ed.), *Environment, Ethics, and Behavior: The Psychology of Environmental Valuation ...* - (pp. 227–34). San Francisco, CA: New Lexington.
- Gleich, A. von, Pade, C., Petschow, U., & Pissarskoi, E. (2010). *Potentials and Trends in Biomimetics*. Berlin, Heidelberg: Springer Berlin Heidelberg. <http://doi.org/10.1007/978-3-642-05246-0>
- Goel, A. K., Bras, B., Helms, M., Rugaber, S., Tovey, C., Vattam, S., ... Yen, J. (2011). Design patterns and cross-domain analogies in biologically inspired sustainable design. In *Artificial Intelligence and Sustainable Design - Papers from the AAAI 2011 Spring Symposium* (pp. 45–52). Association for the

Advancement of Artificial Intelligence.

- Gomišček, B., Maletič, D., & Maletič, M. (2017). TQM Sustainability-oriented innovation practices and their contribution to organizational performance. In *21th International Conference on ISO & TQM 21-ICIT 14-16 Apr 2017, Beijing Normal University ~ Zhuhai Campus, China* (pp. 1–12). Zhuhai Campus, China.
- Government of Canada. (2013). What is an informal social network? Retrieved March 17, 2017, from <http://www.horizons.gc.ca/eng/content/what-informal-social-network>
- Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., & Kyriakidou, O. (2004). Diffusion of innovations in service organizations: Systematic review and recommendations. *Milbank Quarterly*, *82*(4), 581–629. <http://doi.org/10.1111/j.0887-378X.2004.00325.x>
- Groenewald, T. (2004). A Phenomenological Research Design Illustrated. *International Journal of Qualitative Methods*, *3*(31).
- Gual, M. A., & Norgaard, R. B. (2010). Bridging ecological and social systems coevolution: A review and proposal. *Ecological Economics*, *69*(4), 707–717. <http://doi.org/10.1016/j.ecolecon.2008.07.020>
- Gubrium, J. F., & Holstein, J. A. (1997). *The New Language of Qualitative Method*. Oxford, UK: Oxford University Press.
- Haanaes, K., Balagopal, B., Kong, M. T., Velken, I., Arthur, D., & Hopkins, M. S. (2011). New sustainability study: The “Embracers” seize advantage. *MIT Sloan Management Review*, *52*(3), 22–35.
- Hage, J. T. (2016). Organizational innovation and organizational change. *Annual Review of Sociology*, *25*(1999), 597–622.
- Hallstedt, S. I., Thompson, A. W., & Lindahl, P. (2013). Key elements for implementing a strategic sustainability perspective in the product innovation process. *Journal of Cleaner Production*, *51*, 277–288. <http://doi.org/10.1016/j.jclepro.2013.01.043>
- Hammersley, M., & Atkinson, P. (2007). *Ethnography: Principles in Practice* (3rd ed.). London and New York: Routledge, part of the Taylor & Francis Group.
- Hansen, E. G., Grosse-dunker, F., & Reichwald, R. (2009). Sustainability Innovation Cube – A framework to evaluate sustainability of product innovations. *International Journal of Innovation Management*, *13*(4), 683–713. <http://doi.org/10.1142/S1363919609002479>
- Hardman, G. J. (2010). Regenerative leadership: An integral theory for transforming people and organisations for sustainability in business, education, and community. *Integral Leadership Review*, *X*(5), 1–17.
- Hargroves, K., & Smith, M. H. (2013). *The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century. Innovation and Governance in the 21st Century, ...* (Vol. 3). Earthscan.
- Harman, J. (2013). *The Shark’s Paintbrush: Biomimicry and How Nature is Inspiring Innovation*. London, UK: Nicholas Brealey Publishing.
- Heikkurinen, P., Rinkinen, J., Järvensivu, T., Wilén, K., & Ruuska, T. (2016). Organising in the Anthropocene: An ontological outline for ecocentric theorising. *Journal of Cleaner Production*, *113*(1 Feb 2016), 705–714. <http://doi.org/10.1016/j.jclepro.2015.12.016>
- Hekkert, M. P., Suurs, R. a. a., Negro, S. O., Kuhlmann, S., & Smits, R. E. H. M. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change*, *74*(4), 413–432. <http://doi.org/10.1016/j.techfore.2006.03.002>

- Hellström, T. (2007). Dimensions of environmentally sustainable innovation: The structure of eco-innovation concepts. *Sustainable Development*, 15(3), 148–159. <http://doi.org/10.1002/sd.309>
- Helms, M., Vattam, S., & Goel. (2010). The effect of functional modeling on understanding complex biological systems. In *Proceedings of the ASME 2010 IIDETC/CIE 2010 Conference Aug 15-18, Montreal Canada* (pp. 1–9).
- Helms, M., Vattam, S., Goel, A. K., & Yen, J. (2011). Enhanced human learning using Structure-Behavior-Function Models. In *ICALT, IEEE 11th International Conference on Advanced Learning Technologies. Athens, GA, USA.* (pp. 239–243).
- Helms, M., Vattam, S. S., & Goel, A. K. (2009). Biologically inspired design: Process and products. *Design Studies*, 30(5), 606–622. <http://doi.org/10.1016/j.destud.2009.04.003>
- Hock, D. W. (1995). The Chaordic Organization: Out of control and into order. *World Business Academy Perspectives*, 9, 5–18.
- Hoeller, N., Goel, A., Freixas, C., Anway, R., & Upward, A. (2010). Developing a common ground for learning from nature. *Zygote Quarterly*, (7), 1–8.
- Hojnik, J., & Ruzzier, M. (2016). What drives eco-innovation? A review of emerging literature. *Environmental Innovation and Societal Transitions*, 19(June), 31–41. <http://doi.org/10.1016/j.eist.2015.09.006>
- Hollen, R. M. A., Van Den Bosch, F. A. J., & Volberda, H. W. (2013). The role of management innovation in enabling technological process innovation: An inter-organizational perspective. *European Management Review*, 10(1), 35–50. <http://doi.org/10.1111/emre.12007>
- Hollen, R. M. A., Van Den Bosch, F. A. J., Volberda, H. W., & Heij, C. V. (2013). Management innovation: Management as fertile ground for innovation. *European Management Review*, 10(1), 1–15. <http://doi.org/10.1111/emre.12007>
- Horbach, J., Rammer, C., & Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact: The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, 78(June), 112–122. <http://doi.org/10.1016/j.ecolecon.2012.04.005>
- Hornburg, A. (2012). Human Ecology: University of Lund. Retrieved May 20, 2012, from http://www.lucid.lu.se/html/human_ecology.aspx
- Huesemann, M. H. (2003). The limits of technological solutions to sustainable development. *Clean Technologies and Environmental Policy*, 5(1), 21–34. <http://doi.org/10.1007/s10098-002-0173-8>
- Hutchins, G. (2012). *The Nature of Business: Redesigning for Resilience*. Green Books.
- Iansiti, M., & Levien, R. (2004). *The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability*. Harvard Business Press.
- Iouguina, A., Dawson, J. W., Hallgrímsson, B., & Smart, G. (2014). Biologically informed disciplines: A comparative analysis of terminology within the fields of bionics, biomimetics, biomimicry and bio-inspiration, among others. *Design and Nature VII*, 9(3), 197–205. <http://doi.org/10.2495/DNE-V0-N0-1-9>
- Isenmann, R. (2003). Industrial ecology: Shedding more light on its perspective of understanding nature as model. *Sustainable Development*, 11(3), 143–158. <http://doi.org/10.1002/sd.213>
- Jacobs, S. R., Nichol, E. C., & Helms, M. E. (2014). “Where are we now and where are we going?”: The BioM Innovation Database. *Journal of Mechanical Design*

- (Submitted), 136(11), 1–10.
- Jakobsen, S., & Clausen, T. H. (2016). Innovating for a greener future: The direct and indirect effects of firms' environmental objectives on the innovation process. *Journal of Cleaner Production*, 128(August), 131–141. <http://doi.org/10.1016/j.jclepro.2015.06.023>
- Jay, J., & Gerard, M. (2015). *Accelerating the Theory and Practice of Sustainability-Oriented Innovation* (No. 5148–15). SSRN Electronic Journal.
- Johnson, E. R. (2011). *Reanimating Bios: Biomimetic Science and Empire*. University of Minnesota.
- Jung, D. I., Chow, C., & Wu, A. (2003). The role of transformational leadership in enhancing organizational innovation: Hypotheses and some preliminary findings. *Leadership Quarterly*, 14(4–5), 525–544. [http://doi.org/10.1016/S1048-9843\(03\)00050-X](http://doi.org/10.1016/S1048-9843(03)00050-X)
- Kallis, G., & Norgaard, R. B. (2010). Coevolutionary ecological economics. *Ecological Economics*, 69(4), 690–699. <http://doi.org/10.1016/j.ecolecon.2009.09.017>
- Kaye, H. L. (1997). *The Social Meaning of Modern Biology*. New Brunswick, New Jersey: Transaction Publishers.
- Kellert, S. (1995). The Biological Basis for Human Values of Nature. In *The Biophilia Hypothesis* (pp. 42–67).
- Kennedy, E. B., Fecheyr-Lippens, D., Hsuing, B.-K., Niewiarowski, P. H., & Kolodziej, M. (2015). Biomimicry: A path to sustainable innovation. *Design Issues*, 31(3), 66–73. <http://doi.org/10.1162/DESI>
- Kennedy, E. B., & Marting, T. A. (2016). Biomimicry: Streamlining the front end of innovation for environmentally sustainable products. *Research-Technology Management*, 59(4), 40–48. <http://doi.org/10.1080/08956308.2016.1185342>
- Kennedy, S., Whiteman, G., & Van den Ende, J. (2013). Enhancing radical innovation using sustainability as a strategy choice. In *Sustainability and the Corporation: Big Ideas* (pp. 1–24).
- Khanagha, S., Volberda, H., Sidhu, J., & Oshri, I. (2013). Management innovation and adoption of emerging technologies: The case of cloud computing. *European Management Review*, 10(1), 51–67. <http://doi.org/10.1111/emre.12004>
- Kim, L. (1980). Organizational innovation and structure. *Journal of Business Research*, 8(2), 225–245. [http://doi.org/10.1016/0148-2963\(80\)90012-0](http://doi.org/10.1016/0148-2963(80)90012-0)
- Kimberly, J. R., & Evanisko, M. J. (1981). Organizational innovation: The influence of individual, organizational, and contextual factors on hospital adoption of technological and administrative innovations. *Academy of Management Journal*, 24(4), 689–713. <http://doi.org/10.2307/256170>
- Klayman, J., Ha, Y., Edwards, W., Gnepp, J., Hoch, S., Hogarth, R., ... Tra-, T. (1987). Confirmation, disconfirmation, and information in hypothesis testing. *Psychological Review*, 94(2), 211–228.
- Klewitz, J., & Hansen, E. G. (2014). Sustainability-oriented innovation of SMEs: A systematic review. *Journal of Cleaner Production*, 65, 57–75. <http://doi.org/10.1016/j.jclepro.2013.07.017>
- Knippers, J., & Speck, T. (2012). Design and construction principles in nature and architecture. *Bioinspiration & Biomimetics*, 7(1), 1–10. <http://doi.org/10.1088/1748-3182/7/1/015002>
- Kuhn, T. S. (1962). *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
- Lam, A. (2004). Organizational innovation. In J. Jan Fagerberg, D. David Mowery, &

- R. R. Nelson (Eds.), *Handbook of Innovation*. Oxford University Press.
<http://doi.org/10.5897/JAERD12.088>
- Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., ... Thomas, C. J. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science*, 7(Suppl. 1), 25–43.
<http://doi.org/10.1007/s11625-011-0149-x>
- Lange-Merrill, C. (1982). *Biomimicry of the Dooxygen Active Site in the Cooper Proteins Hemocyanin and Cytochrome Oxidase*. Doctoral Thesis.
- Layton, A., Bras, B., & Weissburg, M. (2016). Designing industrial networks using ecological food web metrics. *Environmental Science & Technology*, 50(20), 11243–11252. <http://doi.org/10.1021/acs.est.6b03066>
- Lewis, M. W. (1998). Iterative triangulation: A theory development process using existing case studies. *Journal of Operations Management*, 16, 455–469.
- Linnenluecke, M. K., Russell, S. V, & Griffi, A. (2009). Subcultures and sustainability practices: The impact on understanding corporate sustainability. *Business Strategy and the Environment*, 18(Dec), 432–452.
- Marcus, J., Kurucz, E. C., & Colbert, B. A. (2010). Conceptions of the Business-Society-Nature interface: Implications for management scholarship. *Business & Society*, 49(3), 402–438. <http://doi.org/10.1177/0007650310368827>
- Marshall, A., & Lozeva, S. (2009). Questioning the theory and practice of biomimicry. *International Journal of Design & Nature and Ecodynamics*, 4(1), 1–10.
<http://doi.org/10.2495/DNE-V4-N1-1-10>
- Martin, R., Muûls, M., de Preux, L. B., & Wagner, U. J. (2012). Anatomy of a paradox: Management practices, organizational structure and energy efficiency. *Journal of Environmental Economics and Management*, 63(2), 208–223.
<http://doi.org/10.1016/j.jeem.2011.08.003>
- Martini, D., Loddo, I., & Coscia, M. (2013). Managing complexity in bio-design practice. In *2CO Communicating Complexity: Conference Proceedings* (pp. 117–126).
- Marx, V. (2013). Biology: The big challenges of big data. *Nature*, 498(7453), 255–260. <http://doi.org/10.1038/498255a>
- Mathews, F. (2011). Towards a deeper philosophy of biomimicry. *Organization & Environment*, 24(4), 364–387. <http://doi.org/10.1177/1086026611425689>
- Mcgregor, S. L. T. (2013). Transdisciplinarity and biomimicry. *Transdisciplinary Journal of Engineering & Science*, 4(December), 57–65.
- Mead, T., & Hoeller, N. (2014). The ISO/TC 266 Biomimetics Standard Initiative. *Zygote Quarterly*, 3(10), 72–83.
- Mead, T. L. (2014). Biologically-inspired innovation In large companies: A path for corporate participation In biophysical systems? *International Journal of Design & Nature and Ecodynamics*, 9(3), 216–229.
- Mead, T. L. (2017). *Bioinspiration in Business and Management: Innovating for Sustainability*. Business Expert Press.
- Mead, T. L., & Jeanrenaud, S. (2017). The elephant in the room: Biomimetics and sustainability? *Bioinspired, Biomimetic and Nanobiomaterials*, Online, 1–36.
<http://doi.org/10.1680/jbibn.16.00012>
- Miller, K. D., & Tsang, E. W. K. (2010). Testing management theories: Critical realist philosophy and research methods. *Strategic Management Journal*, 32(May), 139–158. <http://doi.org/10.1002/smj>
- Miller, T. R., Baird, T. D., Littlefield, C. M., Kofinas, G., Chapin, F. S., & Redman, C. L. (2008). Epistemological pluralism: Reorganizing interdisciplinary research.

- Ecology and Society*, 13(2). <http://doi.org/10.1086/494648>
- Mingers, J. (2000). The contribution of critical realism as an underpinning philosophy for OR/MS and systems. *The Journal of Operational Research Society*, 51(11), 1256–1270.
- Modell, S. (2009). In defence of triangulation: A critical realist approach to mixed methods research in management accounting. *Management Accounting Research*, 20(3), 208–221. <http://doi.org/10.1016/j.mar.2009.04.001>
- Mohr, J. J., Price, L. L., & Rindfleisch, A. (2015). *The Paradox of Sustainable Innovation: Reconciling a Clash of Logics*.
- Mulgan, G., & Leadbeater, C. (2013). *Systems Innovations*. Retrieved from www.nesta.org.uk
- Newton, T., Deetz, S., & Reed, M. (2011). Responses to social constructionism and critical realism in organization studies. *Organization Studies*, 32(1), 7–26. <http://doi.org/10.1177/0170840610394289>
- Nidumolu, R., Prahalad, C. K., & Rangaswami, M. R. (2009). Why sustainability is now the key driver of innovation. *Harvard Business Review*, (September), 1–10.
- Norgaard, R. B. (1989). The case for methodological pluralism. *Ecological Economics*, 1, 37–57. [http://doi.org/10.1016/0921-8009\(89\)90023-2](http://doi.org/10.1016/0921-8009(89)90023-2)
- Nychka, J. a., & Chen, P.-Y. (2012). Nature as inspiration in materials science and engineering. *JOM*, 64(4), 446–448. <http://doi.org/10.1007/s11837-012-0304-6>
- OECD. (2005). *The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Innovation Data* (Vol. 3rd). Paris.
- OECD. (2009). *Sustainable Manufacturing and Eco-Innovation: Framework, Practices and Measurement*.
- Owen, R., & Bessant, J. (2013). *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*. John Wiley & Sons.
- Pansera, M. (2012). The origins and purpose of eco-innovation. *Global Environment. A Journal of History and Natural and Social Sciences*, 4(7/8), 128–155.
- Patel, S., & Mehta, K. (2011). Life's Principles as a framework for designing successful social enterprises. *Journal of Social Entrepreneurship*, 2(2), 218–230. <http://doi.org/10.1080/19420676.2011.592407>
- Pauw, I. De. (2015). *Nature-Inspired Design: Strategies for Sustainable Product Development*.
- Phillips. (2015). Circular Economy Phillips. Retrieved March 3, 2015, from <http://www.philips.com/about/sustainability/ourenvironmentalapproach/greeninnovation/circulareconomy.page>
- Pigosso, D. C. a, Zanette, E. T., Filho, A. G., Ometto, A. R., & Rozenfeld, H. (2010). Ecodesign methods focused on remanufacturing. *Journal of Cleaner Production*, 18, 21–31. <http://doi.org/10.1016/j.jclepro.2009.09.005>
- Pina, M., Rego, A., & Vieira, J. (2007). Ecocentric management: An update. *Corporate Social Responsibility and Environmental Management*, 15, 311–321.
- Purser, R. E., Park, C., & Montuori, A. (1995). Limits to anthropocentrism: Toward an ecocentric organization paradigm? *The Academy of Management Review*, 20(4), 1053. <http://doi.org/10.2307/258965>
- Reap, J. J. (2009). *Holistic Biomimicry: A Biologically Inspired Approach to Environmentally Benign Engineering*. Georgia Institute of Technology, Atlanta, GA USA.
- Reed, M. (2005). Reflections on the “Realist Turn” in organization and management studies. *Journal of Management Studies*, 42(8), 1621–1644.

- Rifkin, J. (1999). *The Biotech Century: Harnessing the Gene and Remaking the World*. New York: Jeremy P. Tarcher/Putnam.
- Rogers, E. M. (2003). *Diffusion of Innovations, 5th Edition*. Simon and Schuster.
- Romei, F. (2008). *Leonardo Da Vinci*. The Oliver Press, Inc.
- Rørpke, I. (2005). Trends in the development of ecological economics from the late 1980s to the early 2000s. *Ecological Economics*, 55(2), 262–290. <http://doi.org/10.1016/j.ecolecon.2004.10.010>
- Rossi, M., Charon, S., Wing, G., & Ewell, J. (2006). Design for the next generation: Incorporating cradle-to-cradle design into Herman Miller Products. *Journal of Industrial Ecology*, 10(4), 193–210. <http://doi.org/10.1162/jiec.2006.10.4.193>
- Sartorius, C. (2006). Second-order sustainability: Conditions for the development of sustainable innovations in a dynamic environment. *Ecological Economics*, 58(2), 268–286. <http://doi.org/10.1016/j.ecolecon.2005.07.010>
- Saunders, M., & Tosey, P. (2012). The layers of research design. *Rapport*, (Winter), 58–59.
- Schaltegger, S., Beckmann, M., & Hansen, E. G. (2013). Transdisciplinarity in corporate sustainability: Mapping the field. *Business Strategy and the Environment*, 22(4), 219–229. <http://doi.org/10.1002/bse.1772>
- Schein, S. (2015). Ecological worldviews: A missing perspective to advance sustainability leadership. *Journal of Management for Global Sustainability*, 3(1), 1–31.
- Schiederig, T., Tietze, F., & Herstatt, C. (2012). Green innovation in technology and innovation management: An exploratory literature review. *R&D Management*, 42(2), 180–192. <http://doi.org/10.1111/j.1467-9310.2011.00672.x>
- Seebode, D., Jeanrenaud, S., & Bessant, J. (2012). Managing innovation for sustainability. *R&D Management*, 1–16.
- Seligman, L. (2006). Sensemaking throughout adoption and the innovation-decision process. *European Journal of Innovation Management*, 9(1), 108–120. <http://doi.org/http://dx.doi.org/10.1108/09564230910978511>
- Senge, P. M., & Carstedt, G. (2001). Innovating our way to the next industrial revolution. *MIT Sloan Management Review*, 42(2).
- Sharma, S., & Vredenburg, H. (1998). Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities. *Strategic Management Journal*, 19, 729–753.
- Shrivastava, P. (1995). Ecocentric management for a risk society. *Academy of Management Review*, 20(1), 118–138.
- Shrivastava, P., & Hart, S. (1995). Creating sustainable corporations. *Business Strategy and the Environment*, 4(3), 154–165. <http://doi.org/10.1002/bse.3280040307>
- Simonin, B. L. (1997). The importance of collaborative know-how: An empirical test of the learning organization. *Academy of Management Journal*, 40(5), 1150–1174. <http://doi.org/10.2307/256930>
- Smith, C., & Elger, T. (2012). *Working Paper Series: Critical Realism and Interviewing Subjects* (School of Management No. 1208).
- Snell-Rood, E. (2016). Bring biologists into biomimetics. *Nature*, 529(21 Jan), 277–78.
- Stahel, W. R., & Reday-Mulvey, G. (1981). *Jobs for Tomorrow: The Potential for Substituting Manpower for Energy*. Vantage Press.
- Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015). The trajectory of the Anthropocene: The Great Acceleration. *The Anthropocene*

- Review*, 2(1), 81–98. <http://doi.org/10.1177/2053019614564785>
- Steffen, W., Richardson, K., Rockström, J., Cornell, S., Fetzer, I., Bennett, E., ... Sörlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Scienceexpress*, (15 January), 1–15. <http://doi.org/10.1126/science.1259855>
- Subramanian, A., & Nilakanta, S. (1996). Organizational innovativeness: Exploring the relationship between organizational determinants of innovation, types of innovations, and measures of organizational performance. *Omega International Journal of Management Science*, 24(6), 631–647. [http://doi.org/10.1016/S0305-0483\(96\)00031-X](http://doi.org/10.1016/S0305-0483(96)00031-X)
- Tempelman, E., de Pauw, I. C., van der Grinten, B., Ernst-Jan, M., & Grevers, K. (2015). Biomimicry and cradle-to-cradle in product design: An analysis of current design practice. *Journal of Design Research*, 13(4), 326–344.
- Theyel, G. (2000). Management practices for environmental innovation and performance. *Management Practices*, 20(2), 249–266.
- Tidd, J., & Bessant, J. (2011). *Managing Innovation: Integrating Technological, Market and Organizational Change*. John Wiley & Sons.
- Tsang, E. W. K. (1999). Replication and theory development in organizational science: A critical realist perspective. *Academy of Management Review*, 24(4), 759–781.
- Varadarajan, R. (2015). Innovating for sustainability: A framework for sustainable innovations and a model of sustainable innovations orientation. *Journal of the Academy of Marketing Science*, 45(1), 14–36. <http://doi.org/10.1007/s11747-015-0461-6>
- Vattam, S., Helms, M., Goel, A., Yen, J., & Weissburg, M. (2008). Learning about and learning through biologically inspired design. In *Proceedings from the 2nd Design Creativity Workshop*. Atlanta.
- Vattam, S. S., Helms, M., & Goel, A. K. (2010). Biologically inspired design: A macrocognitive account. In *Volume 5: 22nd International Conference on Design Theory and Methodology; Special Conference on Mechanical Vibration and Noise* (pp. 129–138). Asme. <http://doi.org/10.1115/DETC2010-28567>
- Vattam, S., Wiltgen, B., Helms, M., Goel, A., & Yen, J. (2010). DANE: Fostering creativity in and through biologically inspired design. In *First International Conference on Design Creativity. Kobe, Japan*. (Vol. 8, pp. 115–122).
- Wagner, M., & Llerena, P. (2011). Eco-innovation through integration, regulation and cooperation: Comparative insights from case studies in three manufacturing sectors. *Industry & Innovation*, 18(8), 747–764. <http://doi.org/10.1080/13662716.2011.621744>
- Weick, K. E. (1995). *Sensemaking in Organizations*.
- Whiteman, G., & Cooper, W. H. (2000). Ecological embeddedness. *Academy of Management Journal*, 43(6), 1265–1282. <http://doi.org/10.2307/1556349>
- Whiteman, G., & Cooper, W. H. (2011). Ecological sensemaking. *Academy of Management Journal*, 54(5), 889–911. <http://doi.org/10.5465/amj.2008.0843>
- Whiteman, G., Walker, B., & Perego, P. (2013). Planetary boundaries: Ecological foundations for corporate sustainability. *Journal of Management Studies*, 50(2), 307–336. <http://doi.org/10.1111/j.1467-6486.2012.01073.x>
- Wolfe, R. A. (1994). Organizational innovation: Review, critique and suggested research directions. *Journal of Management Studies*, 31(3), 405–431. <http://doi.org/10.1111/j.1467-6486.1994.tb00624.x>
- World Commission on Environment and Development. (1987). *Report of the World*

Commission on Environment and Development: Our Common Future.
Worldwatch Institute. (2012). *State of the World 2008: Ideas and Opportunities for Sustainable Economies.* Routledge.
Yin, R. K. (2009). *Case Study Research: Design and Methods.* SAGE.
Zaltman, G., Duncan, R., & Holbek, J. (1973). *Innovations and Organizations.* R.E. Krieger Publishing Company.