

Business experimentation for sustainability

Ilka Weissbrod

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Declaration of Originality

I declare that this thesis 'Business experimentation for sustainability' is substantially my own work and no part of the dissertation has been previously submitted to any other university for any degree, diploma or other qualification. Previously published work by the author in the form of a peer-reviewed journal article, conference papers, conference presentations and conference posters are drawn on for parts of this thesis. When reference is made to the work of others, the extent to which it has been used is indicated in the text and bibliography. Any errors within this thesis are the sole responsibility of the author.

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Abstract

Carbon emissions and natural resource depletion are associated with urgent, linear timelines and irreversible damage. In contrast, the commercialisation of radical innovations is associated with timelines of 20-40 years. These two timelines are at tension with each other and a shortening of the organizational radical innovation timeline is needed to address urgent sustainable development challenges through new product and service offers.

This transdisciplinary PhD research investigates the practice of radical innovation in large firms. It generates insights on how firms pursue explorative innovation activities with the goal of creating social and environmental value whilst capturing economic value.

The organizational capability of ‘experimentation’ has been highlighted as the key to improve radical innovation performance in established firms. However, the details of what the experimentation capability might be, and entail in the context of sustainable development challenges is unknown. Furthermore, how experimentation may address the contrasting timelines of organizational innovation and sustainable development challenges has not been explored.

To address this gap in the knowledge, this research gathered qualitative data from leading practitioners through semi-structured interviews, followed by an in-depth case study. The insights generated through the data analysis contribute to knowledge in the strategic management and sustainability literature. This research offers a descriptive framework on how firms might build on the innovation process used in lean startup thinking to shorten the radical innovation timeline with the view to develop products and services that create environmental and social value whilst capturing economic value.

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Thesis structure overview

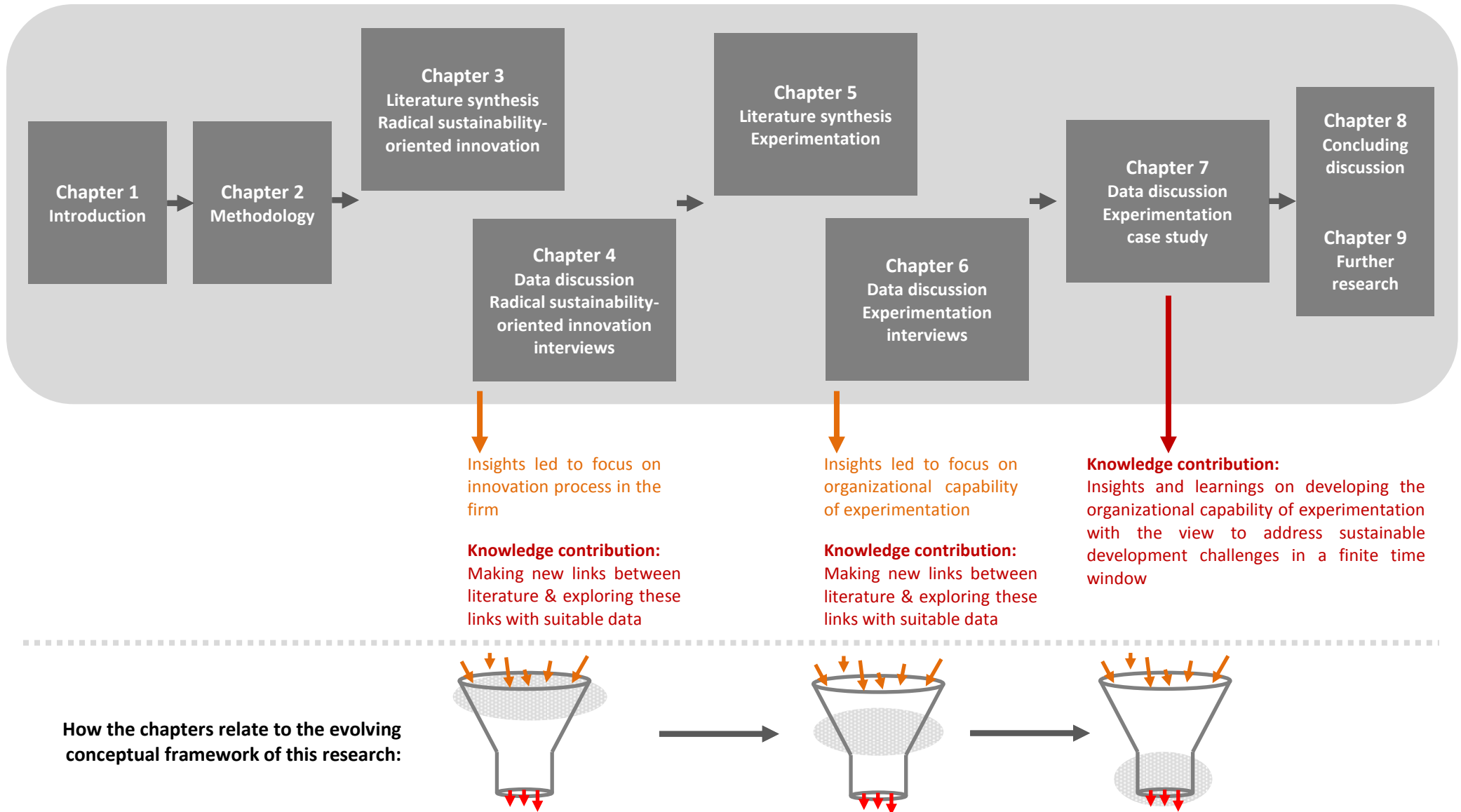


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1. Introduction

Global carbon emissions must be reduced by at least 25% of 2010 levels by 2030 and by at least 50% of 2010 levels by 2050, to stay within emission levels that allow staying beneath an increase of 2°C rise in global temperature (Alcamo, 2013; slide 12). However, in 2013 the required emission peak was already 10% higher than the 2020 target level (Alcamo, 2013). 2015 was the warmest year on record (NASA, 2016b) and evidence of climate change impact on the natural environment is mounting (Belmecheri et al., 2015; Huang et al., 2015). 2016 was the first year where average temperatures across the whole Northern hemisphere exceeded pre-industrial levels each month, with January to June the warmest half-year on record and 1.3°C warmer than pre-industrial temperatures (NASA, 2016a). Breaching 2°C has been argued to be dangerous to human society and the natural environment (Tegart et al., 2014). In 2015, the Conference of the Parties (COP 21) of the United Nations Framework Convention on Climate Change (UNFCCC) agreed that countries will work together to stay below a global temperature increase of 1.5°C.

The key argument here is that sustainable development challenges need to be addressed within a quickly closing time window (Rogelj et al., 2015). The current way of doing business is perpetuating the path to irreversible climate change and it has been asserted that business as usual¹ will lead to an *“effective doubling of CO₂ in the atmosphere between now and 2025 to 2050”* (Tegart et al., 2014; p.19).

At the same time as the pressing need to reduce carbon emission drastically, it has been argued since the early 90s that Western economies need to increase their resource productivity by 90% within one generation (i.e. 30 to 50 years) (Tukker & Tischner 2006 in Hansen and Große-Dunker, 2013; p. 7) to avoid wasting natural resources during economic value creation (Martin et al., 2010). As recently as 2006, approximately 50% of the *“3 billion tonnes of total waste generated in the EU-27 was landfilled”* (Martin et al., 2010; p.73), resulting in economic and environmental value loss (Martin et al., 2010).

However, the current trajectory of change falls short of that which is necessary to avoid the worst impacts and to improve societal conditions globally (Alcamo, 2013; Henderson et al., 2015; Tegart et al., 2014; Tennant, 2013). Change of business as usual is needed to stop run-away climate change

¹ Business as usual as used by the cited authors refers to industrial progress as conducted since the start of the industrial revolution.

and limit global warming to 2°C (Alcamo, 2013; Johnson et al., 2012; Tegart et al., 2014) whilst operating within Earth's resource boundaries (Dewberry and de Barros, 2009; Rockstrom et al., 2009).

For the industrial system, a linear view of economics and the accompanying 'business as usual' paradigm can only result in incremental innovation and improvements of current technologies (Dewberry and de Barros, 2009); such incremental innovation is unlikely to solve climate and resource challenges within a rapidly closing time window (Dewberry and de Barros, 2009; Senge et al., 2008; Westley et al., 2011). Hence business has to fundamentally change: 'do differently' is needed rather than 'do what we do but better' (Bessant et al., 2014). There are innovations that have fundamentally changed industries: radical innovations. However, this type of innovation is rare (Goktan and Miles, 2011) and historically have taken at least 20 years to be widely adopted (Golder et al., 2009; Hanna et al., 2015).

Sustainability challenges such as CO₂e emissions that are threatening to result in runaway climate change or the running out of finite resources are not part of the radical innovation terminology. Only as recently as 2013, defining and exploring radical sustainability-oriented innovation has been identified as a gap in the research landscape (Hansen and Große-Dunker, 2013).

Within the business context, the organizational capability of experimentation has been singled out as the most important organizational capability for radical innovation performance (Chang et al., 2012) because it enables businesses to overcome organizational inertia. Experimentation as a driver of societal transitions and economic transitions has been researched from the angles of socio-technical experimentation (Schot and Geels, 2008), governance experimentation (Sabel and Zeitlin, 2010) and randomised social experiments (Greenberg and Robins, 2007). Academic research has started to set experimentation as a driver of societal transitions in the context of climate change (INOGOV, 2015).

However, there is no research that explores an organizational experimentation capability for radical innovation in the context of sustainable development challenges. This is a significant gap because businesses will have to develop this experimentation capability in order to successfully conduct 'do different' radical sustainability-oriented innovation activities within a limited timeframe.

1.1 Research questions

This PhD research generates insights towards closing the gaps in the organizational radical sustainability-oriented innovation knowledge through the question: “*How might organizations experiment to pursue radical sustainability-oriented innovation projects?*” with the three sub questions of:

- (1) What are the characteristics of radical sustainability-oriented innovation?*
- (2) What are the characteristics of the organizational capability of experimentation?*
- (3) How might an organization develop the organizational capability of experimentation in order to pursue radical sustainability-oriented innovation?*

This documents starts with a presentation of the qualitative data collection and analysis methods used (chapter 2). Research question (1) is addressed linking literature to offer characteristics of radical sustainability-oriented innovation (chapter 3) and through discussing cross-sectoral interviews in chapter 4. Research question (2) is addressed by linking literature to offer characteristics of the organizational capability of experimentation in chapter 5 and through discussing cross-sectoral interviews in chapter 6. In chapter 7 the organizational capability of experimentation is explored in further depth through data from an in-depth case study. Chapter 8 offers a concluding meta data discussion and the thesis ends in chapter 9 with an auto-critique and suggests further research.

2. Research methodology

The research methods used were chosen with a view to generating insights into the practice of pursuing radical sustainability-oriented innovation in established firms. This chapter starts with a brief presentation of theoretical methodology perspectives from the literature this research draws upon. Following this ‘outward lens’ from the literature, the conceptual research framework links the theoretical foundation with the action of research. I then present the methods used in the two stages of this research: firstly, a cross-sectoral snapshot of the characteristics of radical sustainability-oriented innovation, concluding with a narrower cross-sectoral snapshot of the practice of experimentation at the corporate intersection of innovation and sustainability management; and secondly, an in-depth case study of a retailer looking to pursue radical sustainability-oriented innovation through experimentation.

2.1 Theoretical perspectives

Multiple methodology approaches are used by the literature reviewed in chapters 3 and 5, resulting in a number of assertions.

A literature review of the characteristics of sustainability-oriented innovation, without a detailed methodology² offered, argued that exploring radical innovation is a gap in the sustainability-oriented innovation research landscape because technology enabled product innovation and radical process innovation are needed to meet resource efficiency demands that cannot be met by incremental innovation (Hansen and Große-Dunker, 2013).

At the same time, a review of the technological innovation and innovativeness typology has called for researchers to help practitioners to identify “*the characteristics of radical new products*” (Garcia and Calantone, 2002; p.127) despite the assertion that radical innovations are rare, and “*can rarely be planned*” (Ibid.). The authors argue that these characteristics will aid practitioners during the process of pursuing radical innovation (Garcia and Calantone, 2002). This assertion is based on the literature review of 21 empirical studies in the field of new product development, linked to a Boolean decision tree to classify the innovation terminology.

² It is a book chapter; therefore the lack of methodology detail is not surprising.

Radical innovation with a sustainable development dimension has been explicitly linked to entrepreneurship (Hansen and Große-Dunker, 2013). The assertion that radical innovation is “*at the heart of the related concept of sustainable entrepreneurship*” (ibid.; p.8) is based on previous literature. The characteristics of sustainable entrepreneurship have been offered by theory through building on previous literature concepts (Schaltegger and Wagner, 2011) and summaries of previous empirical and theoretical studies (Hall et al., 2010).

A rapid evidence-assessment type literature review of two databases was conducted with keywords to assess the lengths of time it takes for carbon emission reducing technological innovations to reach widespread commercialisation (Hanna et al., 2015).

Using a quantitative approach, Chang et al. (2012) identified the organizational capability of experimentation as the most important organizational capability for organizational radical innovation performance. The authors sent out a five-part questionnaire to 500 Taiwanese manufacturing businesses and conducted regression analysis for four hypotheses about corporate innovation capabilities and performance based on the 112 useable responses they received.

Finally, the urgency of sustainable development challenges relating to the natural environment (Belmecheri et al., 2015; Huang et al., 2015) are explored through quantitative longitudinal studies that depend on spatial and temporal consistency to measure changes in the natural environment.

This research draws on concepts and arguments that have been explored with qualitative methods (e.g. Hall et al., 2010; Hanna et al., 2015; Hansen and Große-Dunker, 2013; Schaltegger and Wagner, 2011), mixed methods (Garcia and Calantone, 2002), and quantitative methods (e.g. Belmecheri et al., 2015; Chang et al., 2012). This transdisciplinary research³ cannot therefore adopt a single method from among those used by the theoretical perspectives drawn upon (Ashford and Hall, 2011; Nooteboom, 2000).

The research questions raised cover transdisciplinary ground and there are no existing frameworks to guide data collection and analysis. I go on to present the conceptual framework developed and used in this research.

³ It has been explained that “*transdisciplinary approaches synthesize and integrate concepts whose origins are found in different disciplines*” (Ashford and Hall; p.13). In contrast, interdisciplinary research draws on two disciplines and “*often precedes the creation of a new, well-defined field*” (Ashford and Hall; p.13).

2.2 Conceptual framework

There are a number of concepts that permeate the reviewed literature. A concept is a generalisation from particulars and enables an individual to categorize and interpret a phenomenon (McKenna, 1997 in Savin-Baden and Howell Major, 2013; p. 137). This PhD research selected research methods in order to explore elements of existing theory concepts that are the basis of the characteristics of radical sustainability-oriented innovation and the organizational capability of experimentation for sustainability. It has been argued that *“engaging in interdisciplinary and transdisciplinary postgraduate research means engaging with a wide variety of disciplines and epistemological standpoints, as well as with the world at large”* (Mitchell and Willetts, 2009; p.9). The aim of this research is to follow the call of Garcia and Calantone (2002) and generate knowledge of relevance to practitioners who take action and lead radical innovation projects, with the added goal of addressing sustainable development challenges.

I did not aim to actively influence the processes and individuals of this research, hence the observational element of the case study could be ‘classed’ as ethnography (Kozlowski et al., 2013) and not as action research. However, according to Flood (2010) this PhD research might be viewed as action research, as the author states that *“it makes no sense to separate action from research”* (Flood, 2010; p.282). This disagreement about the characteristics of differing qualitative research approaches is not unusual according to Savin-Baden and Howell Major (2013).

It has been argued that conducting research benefits from a conceptual framework, used to determine research boundaries (Savin-Baden and Howell Major, 2013). Through the literature review, it seemed appropriate to answer my research questions by starting with a wide approach and narrowing down the data collection area. This approach in relation to the research questions and characteristics is shown in **Figure 1**, the conceptual framework used in this research. Savin-Baden and Howell Major (2013) describe a conceptual framework as *“a model for thinking that is the direct result of a systematic process of reviewing and synthesising information from a related body of knowledge that provides the intellectual underpinning to guide the development and conduct of an empirical research study”* (Savin-Baden and Howell Major, 2013; p. 138).

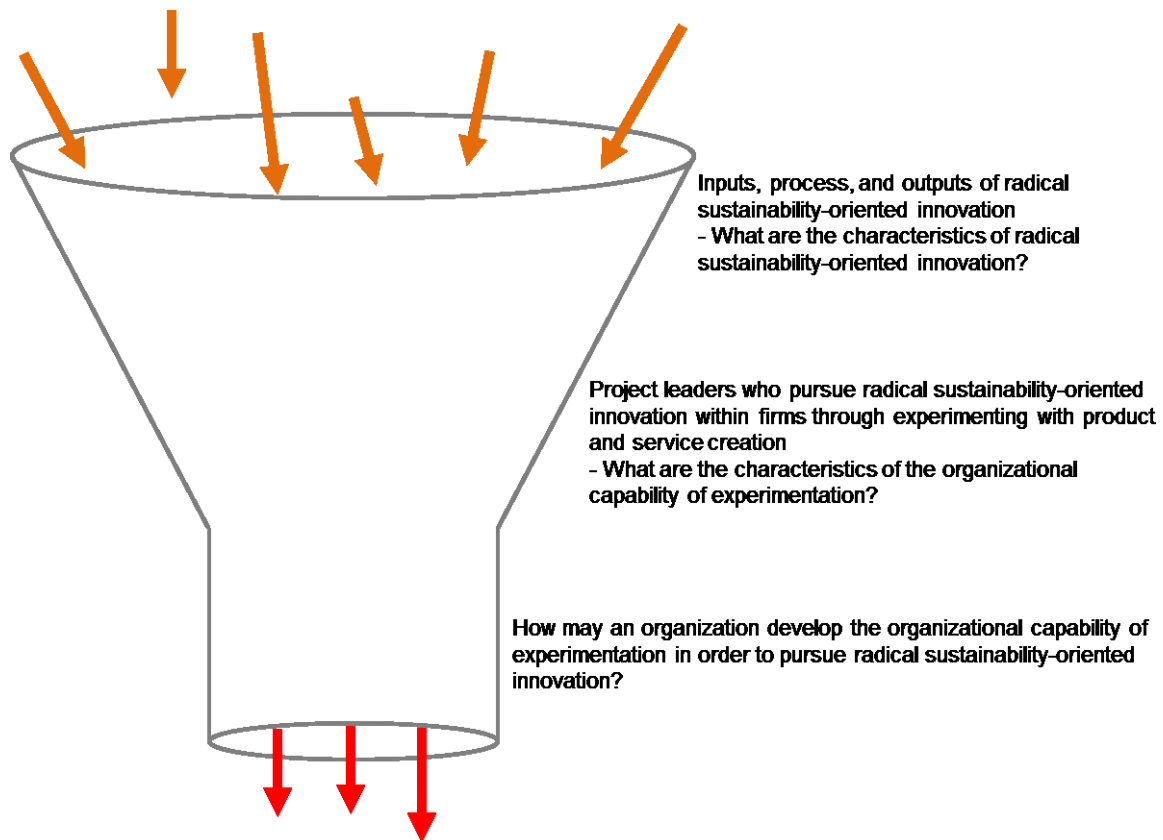


Figure 1: Research conceptual framework (inspired by Savin-Baden and Howell Major, 2013; p. 140)

The conceptual framework evolved throughout this research, and this is not unusual (Maxwell, 1996; Thomas, 2011b). While the effects and impacts of change efforts cannot be predicted with reliability, knowledge should be continually informed and revised as new data is observed and experiences garnered (Barth et al., 2014; Cornell et al., 2013). The details of the final research question and narrowing down of the wider radical sustainability-oriented innovation scope was only possible through the research conducted.

2.3 Research methods

There were two main phases to the data collection: (1) the data collection phase 2013-14, and (2) the data collection phase 2014-16. Phase (1) researched a specific condition at a time through cross-sectional, semi-structured interviews. The key investigation points were the exploration of the characteristics of radical sustainability-oriented innovation and the exploration of experimentation for radical sustainability-oriented innovation. Based on the testing of the theory, data collection phase (2) explored organizational conduct over time in more depth. The chosen case study was

instrumental (Stake, 2005) to exploring the characteristics of radical sustainability-oriented innovation and experimentation for radical sustainability-oriented innovation.

Spender (2014) reasons that the majority of strategy literature sees organizations as entities that are directed by strategic decision-making at the firm level. However, leading such processes are individuals that construct goals that are fit for different stages of the organizational innovation management process (Guarana and Hernandez, 2014). Hence, the individuals are constructing the firm as an entity, as opposed to the view that the firm is shaping the individual (Spender, 2014; p. 14). This mirrors the assertion of Hofstede (2001) that organizational rules and rituals are created by people within organizations. This research views individuals as windows of insight into the practice of innovation in business. In data collection phase (1), the perspective of individuals allows us to gain insights about the input, process, and output characteristics of radical sustainability-oriented innovation, and about the process of developing the organizational capability of experimentation. The unit of analysis during this research phase was the innovation process. During the exploration of the characteristics of radical sustainability-oriented innovation, semi-structured interviews provided the starting point for data collection. Building on the salient insights from these interviews, semi-structured interviews were also used to explore the process of radical sustainability-oriented innovation in businesses, specifically how experimentation may aid this process.

Data collection phase (2) of this research required a fuller picture of the practice of innovation in order to explore how a business was looking to experiment in order to pursue radical sustainability-oriented innovation. Previous research has explored a variety of individual perspectives on how to identify and refine opportunities with a high degree of uncertainty (O'Connor and Rice, 2013; Van de Ven, 1986). However, this research required a broader perspective to generate salient insights. To this end, the case study took an interactive perspective to *“provide additional insights into the refinement of potential opportunities, the transformations of communities around those potential opportunities, and the mutual adjustment involving the two”* (Shepherd 2015; p. 3). The activities carried out in the pursuit of radical sustainability-oriented innovation generated insights into how a business may develop the organizational capability of experimentation. The unit of analysis during the case study was therefore the project activity, a part of the corporate innovation process. During the case study, semi-structured interviews with project team members were conducted to allow the in-depth exploration of the organizational process of pursuing radical-sustainability-oriented innovation activities. These interviews were supplemented through: (1) structured observation, (2) attendance and recording of key meetings and workshops, (3) recordings of key meetings and workshops where in person attendance was not feasible.

Throughout data collection, I actively reflected on the research process through a research diary. This proved invaluable to recognizing research bias during data collection and initial analysis.

For data analysis, a qualitative software data analysis package, ATLAS.ti, was used. I found the analysis software to be a useful tool for analysing my qualitative data, especially when used in conjunction with data collection tracking in an Excel spreadsheet format and the literature management and referencing programme EndNote.

The two research phases are described in detail in sections 2.4 and 2.5 of this chapter.

2.3.1 Positionality statement

Any researcher influences the research conducted and vice versa (Savin-Baden and Howell Major, 2013), and this research is no exception. Prior to conducting the PhD research, I worked as a consultant⁴ in the field of innovation for sustainable development for six years. I also hold an undergraduate⁵ and a postgraduate⁶ degree related to business and sustainable development, and in addition I was a director of a social enterprise⁷ for five years. This means that I will interact with my research subjects and data with a deeply held conviction that economic value capture must be linked to environmental and social value creation. It is inevitable that I find reading and researching content that addresses challenges I have encountered in practice in the past as highly interesting. It has been argued that previous experience may even be beneficial for conducting transdisciplinary research with an *“original and creative contribution to knowledge and/or practice”* because it means that research is conducted on the basis of *“socially robust knowledge in the problem space”* (Mitchell and Willetts, 2009; p.17).

However, I am keenly aware of the influence my previous experience has on the PhD research, and hence acknowledge *“the researcher’s contribution to the construction of meanings throughout the research process, and [...] the impossibility of remaining outside of one’s subject matter while conducting research”* (Willig, 2001; p.10 in Savin-Baden and Howell Major, 2013; p. 73). I have kept a research diary throughout all data collection and interpretation to enable me to reflect on my bias. The bias reflection helped to identify bias in interview questions during data analysis and led to an improvement of data collection during the duration of the research. To test my thinking during data

⁴ For sustainable development NGO Forum for the Future

⁵ BSc Business and Environment

⁶ MSc Environmental Technology, specialised in Global Environmental Policy and Change

⁷ Providing work and education opportunities to at risk inner city youth through beekeeping

analysis with others, I presented preliminary research outputs in academic and academic/practice conferences and PhD student research groups to test the quality of my research approach and arguments. This also enabled me to learn how to effectively communicate this research to diverse audiences, an indicator of transdisciplinary research quality according to Mitchell and Willetts (2009).

2.3.2 Research training

Gaps in my qualitative research capabilities during the first two years of this PhD research were addressed through attending relevant training workshops. In total, five such workshops were completed:

- *Qualitative research design*, NatCen Social Research, London (19-20 February 2013)
- *Annual Cambridge Research Methodology Workshop*, University of Cambridge Institute of Manufacturing, Cambridge (4 – 5 April 2013)
- *Qualitative Data Analysis with ATLAS.ti*, Qualitative Data Analysis Services, Bristol University, Bristol (4-5 February 2014)
- *Depth Interviewing skills*, NatCen Social Research, London (4-5 March 2014)
- *Analyzing Business 'As It Happens' using Observational Data*, British Academy of Management, Newcastle University Business School, Newcastle (7 May 2014)

2.4 Research phase 1

This section presents the methods used to explore the characteristics of radical sustainability-oriented innovation and the characteristics of the organizational capability of experimentation. The thematic literature review informed data analysis of both research phase 1 and research phase 2, however it is solely covered in this section so as to avoid duplication of thesis content.

2.4.1 Literature review

The literature review (**Figure 2**) was conducted through keyword searches in academic search engines (Bielefeld Academic Search Engine, Google Scholar, Imperial College library search engine, ScienceDirect) and the academic research forum Research Gate, and focused on peer reviewed journal papers. The keyword search was related to the research problem: the need to conduct radical innovation to address sustainable development challenges within a limited timeframe. Keywords used were centred on the innovation and sustainable development terminology and included: radical innovation, radical sustainability, innovation process, business and sustainability, business sustainability, sustainable business innovation. The initial review resulted in snowballing: broadening out the literature review to the literature cited in the first batch of literature, plus

recommendation received through members of my research group from Imperial College, Cranfield University and the University of Cambridge.

The initial literature review on the input, process and outputs associated with radical sustainability-oriented innovation informed exploratory semi-structured interviews to gain practitioner and academic insights on how to focus the remainder of the research in 2013. The key outcome of the interviews was that process challenges are at the core of radical innovation in established firms.

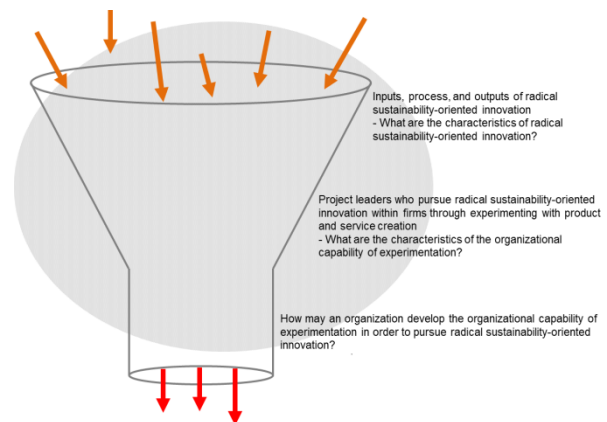


Figure 2: Literature analysis in the conceptual framework

A second batch of interviews in 2014 further informed a thematic literature review as presented in chapter 1 and chapter 2 of this thesis. The thematic literature review had the conceptual angles of: business as a source of innovation; the relevance of sustainable development and innovation in business; sustainable development and entrepreneurship; organizational capabilities for radical innovation; time as boundary for innovation; the principles of scientific experimentation; and leadership for sustainable development. I go on to present details of the two batches of interviews conducted.

2.4.2 Semi-structured Interviews in 2013

In 2013 I explored the radical sustainability-oriented innovation agenda through 31 preliminary semi-structured interviews (**Figure 3**) with a wide pool of practitioners, i.e. from industry, entrepreneurs and ‘applied thinkers’. Interviews are a way of *“tapping people for information”* (Alvesson and Lee Ashcraft, 2009; p. 69) and as well as generating information, interviews are *“seen as expressing not so much actual events as the experiences and meanings of participants”* (Ibid; p. 70). The aim of structured interviews *“is that accurate data can be generated from a range of individuals who are all submitted to the same questions”* (Cassell, 2009; p. 503) and very structured

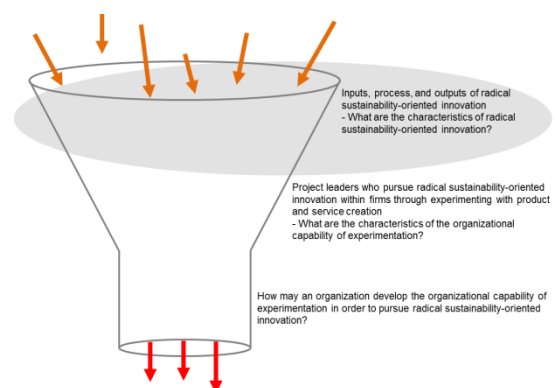


Figure 3: 2013 Radical sustainability-oriented innovation interviews in the conceptual framework

interviews are linked to the quantification of interview data (Cassell, 2009; Yeo, 2013). In contrast, in-depth interviews are less structured and help to map the context and circumstances of events and experiences whilst exploring an individual's perspective of these events and experiences (Yeo, 2013). However, topic guides or interview templates aid to achieve the research purpose of the conducted interview (Yeo, 2013). This research started with semi-structured interviews to capture cross-sectoral practitioner views on radical sustainability-oriented innovation. The same three questions were asked of the interviewees. Where time allowed, the interview explored the answers in more depth, focusing on the organizational context and the urgency of sustainable development challenges.

The purpose of the 31 interviews (**Table 1**) was to gain cross-sectoral practitioner and academic point of views on:

1. What the interviewee considers to be radical innovation
2. What the interviewee considers to be sustainability-oriented radical innovation
3. Who the interviewee thinks has succeeded in radical innovation and why

2.4.3 Data collection

The U.S. is still one of the global hotbeds of innovation and I conducted the interviews there between May and June 2013. The interviews ranged between 5 minutes and 64 minutes each, were voice-recorded, verbatim transcribed, and took place at either an innovation conference in Boston, during a motorcycle journey across the U.S., or in Silicon Valley. Two interviews were conducted on the phone in August 2013, and one interview during an innovation conference in Brussels.

I selected to attend and collect data at the 'Front End of Innovation' conference in Boston in May 2013 because: (1) I could not identify a practitioner forum on radical innovation with an element of sustainable development, (2) the timings went well with my research, and (3) the chair of the conference advisory board was Peter Koen of the Stevens Institute of Technology, and his research was useful during the initial reading stage of this research (i.e. Koen et al., 2001). Interviewees at the conference were selected through opportunity sampling⁸ and through targeting conference speakers and audience members who asked interesting questions.

I screened, in total, about 50 potential interviewees in May and June 2013 to establish their project responsibility within or outside of established firms and the innovation and sustainability

⁸ I identified the Boston Conference as appropriate data sample. Within this sample I asked speakers and participants whether they would take part in my research. No interviewee of the Boston conference was approached prior to the conference through email, social media or any other means.

responsibility within their roles. The face-to-face screening process consisted of initial interaction to determine whether the potential interviewee was sober⁹, was willing to take part in academic research, had significant decision-making responsibility in their respective organization, and had to engage in problem solving in order to react to environmental and/or social challenges. Interviewees (i.e. data number) 1-17 were identified through opportunity sampling at the Boston conference, interviewees 18, 28, and 30 were contacts suggested by previous interviewees (1 suggested 30, 6 suggested 28) and my research network (18). I specifically targeted interviewee 29 because of the obvious fit for the purpose of exploring the characteristics of radical sustainability-oriented innovation. Finally, during an innovation conference in Brussels I had the opportunity to conduct interview 31.

Data No. ¹⁰	Details ¹¹	Current or past project lead	Significant budget duty ¹²	Innovation remit in Role ¹³	Sustainability remit in Role ¹⁴	Area	Gender
1	Futurist, Multinational FMCG Corporation, Mid-Atlantic region, U.S. – 11min	Y	Y	Y	Y	Business	M
2	Innovation Training and Management Lead, Multinational Car Manufacturer, East North Central region, U.S. – 10min	Y	Unknown	Y	Y	Business	M
3	R&D Lead, International Software Company, Austria – 5min	Y	Y	Y	N	Business	M
4	Professor, Human-Computer Interaction, Research University, Mid-Atlantic region, U.S. – 7min	Y	N	Y	N	Academia	F
5	Group interview with 3 branding consultants, did not get any salient data, not transcribed						
6	Senior Product Innovation Lead, International Digital Advertising Agency, Mid-Atlantic region, U.S. – 10min	Y	Y	Y	N	Consultancy	F
7	Industrial Designer, Interiors Manufacturer, East North Central region, U.S. – 9min	Y	Y	Y	Y	Business	M
8	Operations Lead, International Software Company, - 10min: severe English language communication barrier that only became apparent during the interview, did not get salient data, not transcribed						
9	Professor, Corporate Entrepreneurship, Research University, Mid-Atlantic region, U.S. – 20min	Y	Y	Y	Y	Academia	M
10	Marketing Lead, Innovation Management Software, New England region, U.S. – 6min	Y	Y	Y	N	Consultancy	M
11	Professor, Otolaryngology, Research University, South Atlantic region, U.S. – 7min	Y	Unknown	Y	N	Academia	M
12 ¹⁵	Product Innovation Lead, Multinational Electronics Manufacturer, Chile – 5min	Y	Unknown	Y	N	Business	M
13	Innovation Lead, Research and Innovation Consultancy, Mid-Atlantic region, U.S. – 10min	Y	Y	Y	Y	Consultancy	M
14	Innovation Lead, Research and Innovation Consultancy, Mid-Atlantic region, U.S. – 18min	Y	N	Y	Y	Consultancy	M

⁹ There were alcoholic beverages served at the conference and elsewhere during the data collection.

¹⁰ All interviews conducted during the duration of the PhD research are numbered consecutively even not all interviews are data collected for PhD research purposes. For example, other interviews fed into original research conducted for a theoretical paper on system change knowledge creation.

¹¹ Anonymised and following the structure of Professional Area of Responsibility, Organization details, Professional location of interviewee. For professional locations in the U.S., the regional divisions used by the United States Census Bureau were applied to the data.

¹² As indicated during the interview.

¹³ Either indicated by the job title or articulated during the interview when asked to describe the role in the business.

¹⁴ Either indicated by the job title or articulated during the interview when asked to describe the role in the business.

¹⁵ Interviewee attended and contributed to Front End of Innovation 2013 conference in Boston, U.S.; consequently included despite location in Latin America.

Data No. ¹⁰	Details ¹¹	Current or past project lead	Significant budget duty ¹²	Innovation remit in Role ¹³	Sustainability remit in Role ¹⁴	Area	Gender
15	Product Innovation Lead, Interiors Supplier, East North Central region, U.S. – 18min	Y	Unknown	Y	Y	Business	F
16	Professor, BRIC Relations, Research University, Mid-Atlantic region, U.S – 30min	Y	Unknown	Y	Y	Academia	M
17	High Impact innovation Lead, Multinational technology company, Netherlands – 17min	Y	Y	Y	Y	Business	M
18	Founder-Director, Strategic Sustainability Consulting, South Atlantic region, U.S. – 17min	Y	Y	Y	Y	Business / Consultancy	F
19	Cultural Lead, Native American Tribe, West North Central region, U.S. – 40min	Y	N	Y	Y	Business	M
20	Buffalo Lead, Native American Tribe, West North Central region, U.S. – 30min	Y	Y	N	Y	Business	M
21	Founder-Director, General Store and Restaurant, West North Central region, U.S. – 14min	Y	Y	Y	N	Business	F
22	Founder-Director, Historical Hotel, Mountain region, U.S. – 38min	Y	Y	Y	Y	Business	F
23 ¹⁶	Fine Artist Couple, Natural Environment Paintings and Outdoor Installations, Mountain region, U.S. – 40min	Y	Y	N	Y	Business	F/M
24	Director, Internment Camp Memorial Site, Mountain region, U.S. – 20min	Y	Y	Y	Y	Business	M
25	Sumpter Valley Railroad (Pacific region) interviews, no salient data on pursuing radical innovation, entrepreneurial behaviour, or addressing sustainable development challenges. Not transcribed or included in data analysis.						
26							
27							
28	Founder-Director, Atmospheric carbon capture technology firm, Pacific region, U.S. – 64min	Y	Y	Y	Y	Business / Academia	M
29	Founder-Director, Energy & infrastructure firms, Pacific region, U.S. – 20min	Y	Y	Y	Y	Business	M
30	Founder-Director, Stakeholder think tank, Pacific region, U.S. – 13min	Y	Y	Y	N	Consultancy	M
31 ¹⁷	R&D Programme Lead, Multinational conglomerate, Pacific region, U.S. – 12min	Y	Y	Y	N	Business	M

Table 1: 2013 semi-structured interviewees to explore cross-sectoral practitioner and academic point of views on radical-sustainability-oriented innovation

Despite the broad range of interviewees and sectors, at about interviewee 15, points and answers to the three questions seemed like repetitions of previous interviews. However, interviewees 19-24 added new and interesting angles on the social dimension of innovation activities. In contrast, 28-31 added new insights about the technical dimension of radical innovation activities.

In addition to data collection through the semi-structured interviews, I conducted a self-experiment during my stay in the U.S., which I coined the ‘Reflection Journey’. During the Reflection Journey I travelled in the same direction the Pioneers (i.e. East to West) and touched on Lewis and Clark’s Expedition Route as well as on the Oregon Trail. The aim was to explore the mindset of people who persevere with pursuing a stated goal within a finite timeline whilst being faced with unplannable

¹⁶ The recording of the interview stopped after 11 minutes because I failed to notice that the recorder batteries were running low. I wrote down a detailed account of the interview content not recorded in the evening of the same day of the interview. This recounting from memory was added to the transcript of the first third of the interview and uploaded as one interview data document to ATLAS.ti.

¹⁷ This interview took place in March 2014.

obstacles. During my 21 days of travel, I wrote each day a short reflection piece on my daily experience, the places I visited and the people I met. The writing process was done against answers I wrote at the beginning of this Reflection Journey to the three questions I asked the 2013 interviewees (**Table 1**). The Reflection Journey document was not analysed in conjunction with the 2013 interviews. Rather, it formed the starting point of a detailed research diary kept during this research. Furthermore, this in-depth process exploration of pursuing a stated goal whilst having to deal with unexpected challenges and the resulting 10,000 word reflection document fed into the iteration of the second coding cycle of the interviews conducted in 2014, discussed in chapter 6.

2.4.4 Data preparation

26 interviews (i.e. not greyed out in **Table 1**) were verbatim transcribed by a professional transcription organization¹⁸ that transcribed the interviews following the same transcription guidelines for each interview. The transcribers added time stamps into the verbatim transcripts, enabling me to easily revisit the original recording in the qualitative data analysis programme ATLAS.ti to check for tonal nuances where the meaning in the wording may have been unclear through solely the written data. I went through each transcript before marking the transcript as 'final' and uploading to ATLAS.ti to ensure uniform formatting of a natural transcript structure¹⁹ and keeping punctuation close to speech in order to enable the same ease of reading and coding of all transcripts (McLellan et al., 2003).

2.4.5 Data analysis

Primed by the literature lens synthesized in the characteristics of radical sustainability-oriented innovation (chapter 2) the activities, interactions, statements and strategies that appeared meaningful were highlighted: the lens for data interpretation²⁰. As starting point to identifying interesting text sections, the ATLAS.ti auto coding function was used to find sentences that include key words (e.g. 'explore', 'technology', 'new skills', 'value') from the reviewed literature. In addition, all transcripts were read in full to enable the coding of the full data corpus (Frieze, 2012). The highlighted data text received descriptive labels, consisting of nouns and adjectives: these were the emerging 1st order codes. This first cycle of coding used Descriptive coding and In Vivo coding for data analysis (Miles et al., 2014). Descriptive coding means assigning "*labels to data to summarize in*

¹⁸ UK Transcription Ltd, who transcribe for academic and public sector purposes as well as for private organizations.

¹⁹ Such structure makes the transcript useful for human and computer analysis use, in effect looking like a movie script (McLellan et al., 2003).

²⁰ Interpretation "*attempts an explanation or translation of what underlies what was said*" (Savin-Baden and Howell Major, 2013; p. 453) whereas analysis purely "*describes what was said*" (Ibid.).

a word or short phrase –most often a noun- the basic topic of a passage of qualitative text” (Miles et al., 2014; p.74), whereas In Vivo coding refers to using “words of short phrases from the participant’s own language in the data record as codes” (Ibid.). Once all interviews were coded, 85 1st-order codes existed: consisting of 82 content codes and three research process codes²¹. Following this, I used the ATLAS.ti co-occurrence tool to reveal associations between codes (**Appendix 1**), their intensity and meaning (Contreras, 2011; Friese, 2012). Co-occurrence of codes means enclosing or overlapping of different codes when it comes to the same data text section (Contreras, 2011). I revisited the transcripts and paid particular attention to text sections with co-occurring codes, plus took notice to which codes co-occurred. Revisiting the transcripts and paying close attention to text sections with co-occurring codes aided the grouping of the 1st-order codes into 2nd-order –conceptual- codes through developing “a sense of categorical, thematic, conceptual, and/or theoretical organization” (Saldaña, 2009; p.149). **Figure 4** shows the data analysis process. The emerging data insights of the second coding cycle led to exploring the process of radical sustainability-oriented innovation. The analysis and discussion of the 1st-order and 2nd-order codes is presented in depth in chapter 4.

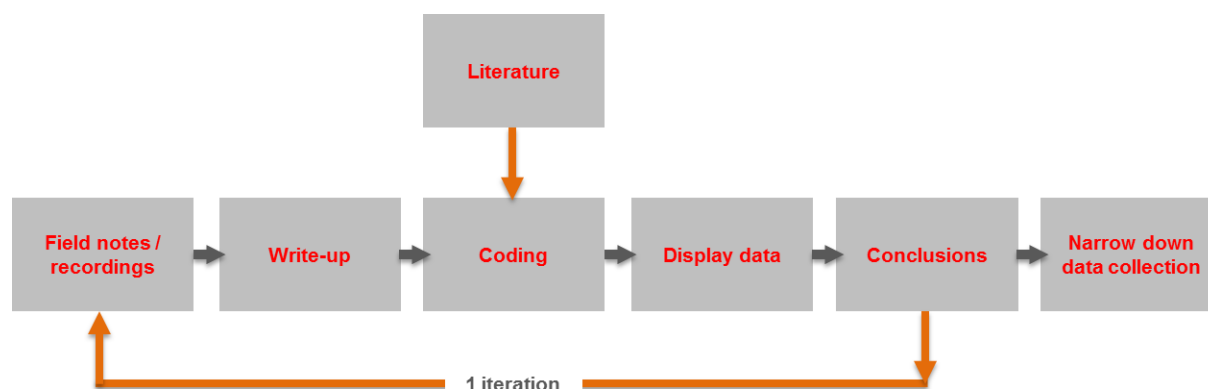


Figure 4: Data analysis process for semi-structured interviews (adapted from (Miles et al., 2014; p.157))

2.4.6 Small excursion into grass root initiatives

Before conducting interviews to explore the process of pursuing radical innovation in established firms, I conducted a one-week pilot case study on the Isle of Eigg in Scotland in 2014. This pilot case study helped to scope the next stage of the research. The case study is an example of a small community that changed the Scottish land ownership structure and used technologies as a tool to do so. I conducted four in-depth interviews with community leaders and kept structured observation protocols (Thomas, 2011b; p. 165-6) about the four interviewees. The verbatim transcribed

²¹ These codes were used to highlight data sections in the questions to keep track and a record of researcher bias.

interviews and the observation protocols provided a rich picture of the motivations and impact that the leaders of the Isle of Eigg community, the role of technological innovation as an enabler of a social transition, and the impact of the natural environment had on the social and economic development of a community. However, as a result of the pilot case study I chose to focus the remainder of my research on the business world as I did not feel equipped to delve into the theoretical background necessary, for example community psychology, human ecology, and UK land ownership history.

2.4.7 Semi-structured experimentation interviews in 2014-15

Building on the 2013 semi-structured interview insights, I went on to explore some entrepreneurship and organizational theory related to radical innovation and sustainable development, through conducting nine in-depths interviews (interview template shown in **Appendix 2**) on the

organizational capability of experimentation (Chang et al., 2012): the challenges associated with commercialising radically new ideas (**Figure 5**). I conducted six of these interviews during a stay at a Sustainable Development Advocacy Organization²² (SDAO²³) in Geneva and three interviews in London. Six interviews were facilitated by the SDAO; one interview was enabled by the EPSRC Centre for Industrial Sustainability (The Centre), the final two interviews were opportunities that arose through my Imperial College research community.

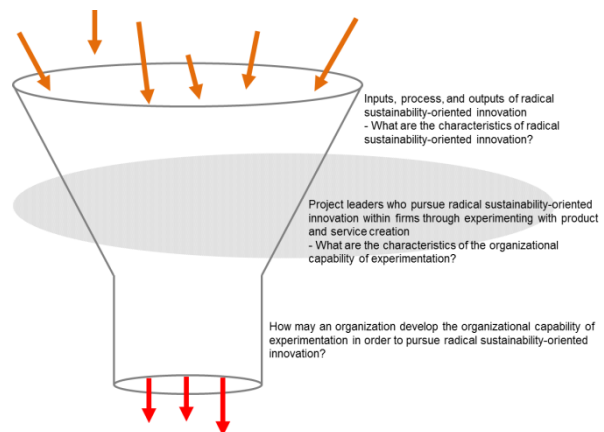


Figure 5: 2014-15 Organizational capability of experimentation interviews in the conceptual framework

2.4.8 Data collection

Some interviewees were suggested by the SDAO contact, whereas in other cases I suggested organizations and the SDAO contact approached individuals in these organizations. In total, around 12 interviewees and organizations were discussed for approach through the SDAO. The interviewee selection was targeted, however there was an element of opportunity sampling involved:

²² A global association of businesses; dealing exclusively with business and sustainable development.

²³ Anonymized abbreviation

interviewee availability and the choices put forward by the SDAO ‘contact gatekeeper’. Some organizations and individuals suggested by myself were not taken forward because the potential interviewee was involved in other SDAO projects and initiatives and the ‘contact gatekeeper’ was, understandably, reluctant to engage the business contact in the research activity because this meant engagement beyond ongoing SDAO core projects. The seventh interview was facilitated by the Centre, which is the academic partner to a project with the stated project approach of *“If we were trying to kill the FIRM business model as an entrepreneur, what would we do?”* (Data, 2014a; Slide 3) and described in project materials as a ‘radical innovation project’. I approached the seventh interviewee directly from the start of the research process, without the involvement of any other organization or individual.

The nine interviewees held senior positions located at the interface of sustainability and innovation within large corporations. The key desired interviewee characteristic was to be currently leading or having led projects that aimed to capture economic value at the same time as creating social and environmental value, whilst necessitating the creation of new organizational capabilities (Teece and Pisano, 1998; Teece et al., 1997). Furthermore, the research aim was to generate data from both genders in equal measure to explore the assertion by some literature that there are particularly ‘male’ entrepreneurial values (McGrath et al., 1992). However, the equal gender split was not achieved, so a discussion of the gender-related entrepreneurship literature assertions in chapter 6 was not possible.

Furthermore, all interviewees would ideally have had both a sustainability and an innovation remit. This would have enabled the innovation process exploration and it could be expected that the interviewees would have insights on the characteristics of experimentation for the pursuit of radical sustainability-oriented innovation. **Table 2** illustrates the interviewee responsibilities and details.

Data No.	Details ²⁴	Current or past radical project lead ²⁵	Significant budget responsibility ²⁶	Innovation Remit Role ²⁷	Sustainability Remit Role ²⁸	Timing	Lengths (hours)
37	Sustainability lead in innovation function, FMCG firm, Switzerland	Y	Y	Y	Y	June 2014	0.5
38*	Sustainability and learning lead, Science and materials firm, Netherlands	N	Unknown	N	Y	July 2014	1

²⁴ Job responsibility, firm detail, interviewee location. All firms are multinational corporations, the location refers to the main professional location of the interviewee.

²⁵ Defined for the purposes of the interviews as ‘projects aimed at addressing sustainable development challenges that fall outside innovation activities that aim to marginally improve an existing product or service’

²⁶ As indicated during the interview. If this information was not given without prompt, the researcher asked questions that ensured that this information would be given.

²⁷ Either indicated by the job title or articulated during the interview when asked to describe the role in the business.

²⁸ Either indicated by the job title or articulated during the interview when asked to describe the role in the business.

Data No.	Details ²⁴	Current or past radical project lead ²⁵	Significant budget responsibility ²⁶	Innovation Remit Role ²⁷	Sustainability Remit Role ²⁸	Timing	Lengths (hours)
39*	External and environmental matters lead, Car manufacturer, Belgium	Y	Unknown	Y	Y	July 2014	1.25
40	Business process innovation lead, Biotechnology firm, Denmark	N ²⁹	Y	Y	N	July 2014	0.5
41	Founder-Director, Corporate social enterprise consultancy, Switzerland	Y	Y	Y	Y	July 2014	0.5
42	Product innovation lead, Biotechnology firm, Denmark	Y	Y	Y	Y	July 2014	0.75
43	Product and process innovation lead, Retailer, UK	Y	Y	Y	Y	August 2014	1
46	Entrepreneurship lead, Public-private innovation partnership, UK	Y	Y	Y	Y	February 2015	1
57	Product technology innovation lead, Pharmaceutical firm, UK	Y	Y	Y	N	June 2015	1

*interviews conducted together with MSc student researching how futures thinking is used in firms. The research interview template stayed the same as that used for the other five interviews conducted.

Table 2: 2014 semi structured interviews to explore the process of pursuing radical sustainability-orientation

An immediate research process finding was that, despite clear prior objectives about the interviewee relevance for research, different understandings of terminology can make it difficult to establish in advance whether an interviewee is a suitable research subject. In the case of the experimentation interviews, it only became apparent during interviews if the interviewee had engaged in experimentation activities within organizational boundaries and led such activities to further radical sustainability-oriented innovation projects. For example, one interviewee (38) had not engaged in experimentation activities. However, the interview was still completed and the innovation and sustainability transcript content analysed in conjunction with the remaining eight interviews.

The interview questions were based on the 10 characteristics of strategic experiments³⁰ as suggested by Govindarajan and Trimble (2005), which were simplified by Clegg et al. (2011; p. 206) as design principles for organizational innovation experiments. The 10 characteristics assume the departure from the current business status quo and uncertainty of the magnitude of value of innovation output. Hence I argue that the 10 characteristics of strategic experiments were a suitable means to explore how individuals within organizational boundaries lead radical sustainability-oriented

²⁹ 40 did lead radical innovation projects; however no radical innovation projects aimed at addressing sustainable development challenges.

³⁰ Strategic experiments [1] require departure from assumption about what makes a business successful; i.e. forgetting is required; [2] build on some existing organizational capabilities, hence are different from acquisitions; [3] depart from existing products lines, geographic expansions, or technological improvements; [4] target emerging and poorly defined industries; [5] have no clear formula for making profit; [6] show a high potential for revenue growth; [7] require development of at least some new knowledge and capabilities; [8] are led by managers who face multiple dimensions of uncertainty across multiple functions; [9] are expected to remain unprofitable for several quarters; and [10] are difficult to assess in terms of their success because feedback is delayed and ambiguous.

innovation projects, whilst building on the theoretical suggestions by Linton (2009) and Chang et al. (2012). The characteristics of experimentation articulated in 3.4 were not refined enough to use as the basis for the interview template at the point in time when the interviews took place. I designed open-ended questions, paying particular attention to the characteristics that were of more relevance to radical sustainability-oriented innovation projects than others (i.e. characteristics 1, 3, 4, 5, 7, 8, 9, 10). Hence two principles that are closer aligned to serving existing market structures (i.e. 2 and 6) were 'neglected' in the interviews. Each of the interviews included some sub-questions that were based on prior research on the interviewees and their respective business. However, the headline questions and the interview structure (**Appendix 2**) remained the same during all interviews.

Each interview lasted between 20 and 90 minutes and was conducted in person: five interviews were conducted face-to-face; four took place on the phone. In the case of one phone interview, a prior 15min conversation took place when the face-to-face opportunity arose by chance.

All interviewees were made fully aware that the interviews would be treated confidentially: any content to be shared with others (including the SDAO) would be signed off by the interviewee prior to sharing. The seven interviews took place in private rooms, with no other people present: all interviews were uninterrupted. Where the interviews took place on the phone, the interviewer/s checked that the interviewee was in a private space, and therefore able to share information that might be outside any 'official' organizational communication boundaries.

2.4.9 Data preparation

The interviews were recorded with the same digital voice recorder from start to finish, with the files being saved on a private hard-drive. All nine interviews were fully verbatim transcribed by the same transcription organization who followed the same protocol as for the 26 interviews conducted in 2013; they also fully transcribed the two interviews that were conducted in co-operation with an MSc student³¹ from Imperial College London.

2.4.10 Data analysis

The interview analysis process (**Figure 6**) was the same as for the 2013 interviews, with the addition of a more in-depth literature lens of the characteristics of the organizational capability of experimentation and the previous codes as lens to prime Descriptive and In-vivo-coding. The 2013

³¹ The student explored futures thinking and she and I closely co-ordinated so we were able to meet our respective research aims. The interview questions I asked did not change during the two interviews with the MSc student present.

Reflection Journey document aided in the coding iteration. The data analysis is discussed in depths in chapter 6.

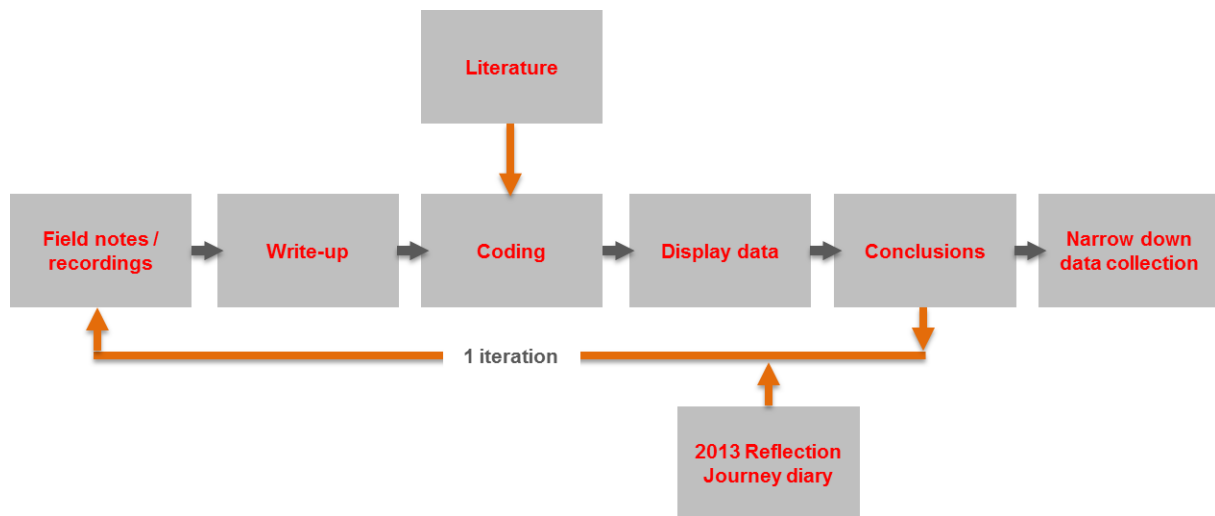


Figure 6: Data analysis process for semi-structured interviews
(adapted from (Miles et al., 2014; p.157)

2.5 Research phase 2

The second phase of this research consisted of a case study of a clothing retailer who set out to experiment with its value proposition in order to meet an ambitious sustainable development challenge and gain learnings about how to transform to a more sustainable business. Building on the insights from the 2013 and 2014 interviews, the case study built on the characteristics of radical sustainability-oriented innovation and the characteristics of the organizational capability of experimentation (**Figure 7**).

The aim of the case study was to explore how a business might develop the organizational capability of experimentation to pursue radical sustainability-oriented innovation. Case studies are a suitable method to investigate contemporary phenomena in a real life context

(Yin, 2013). Furthermore, case studies are suitable for exploratory research (Yin, 2013). It has been asserted that theory building from case study research “*is begun as close as possible to the ideal of no theory under consideration and no hypothesis to test*” (Eisenhardt, 1989a; p. 536). However, the

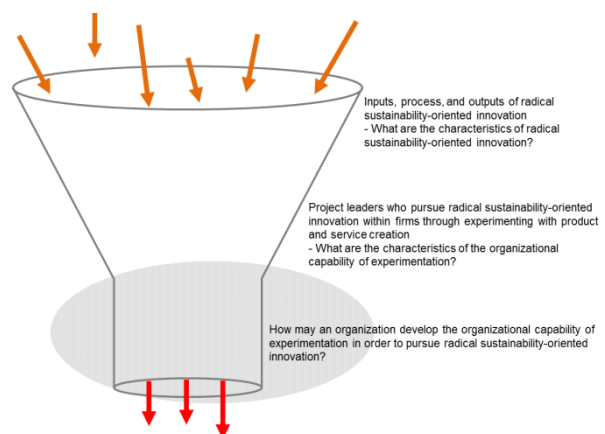


Figure 7: Case study research in the conceptual framework

research aim of this case study also looked to test the characteristics of radical sustainability-oriented innovation and of the organizational capability of experimentation as offered by this research. Therefore, the case study included elements of an instrumental case study (Stake, 2005). Instrumental case studies hold a high degree of risk for confirmation bias (Savin-Baden and Howell Major, 2013), especially when conducted by a single researcher. I go on to present how the case study was selected, data collected and analysed.

2.5.1 Case study selection

One of the 2014 interviewees (Table 2; 43) was the corporate innovation lead for a project in a major retailer headquartered in the UK. The project (PROJECT) was planned as a two-year project with funding from a UK government funding competition. PROJECT was envisaged as a collaboration between the retailer and a leading UK University. PROJECT was forecast to have a total value of £803k. Of this total, the retailer was expected to contribute £279,558 (£78,952 cash; £200,606 in kind), the UK government £279,558 (contractors, pilot costs), and the University £243,883. The purpose of PROJECT was to drive garment recovery and retained value, aiming to:

- *investigate and trial opportunities to increase the volume and value of textile recovery*
- *help FIRM customers give clothes a second life by recycling 20 million items of clothing each year by 2020 (increasing the number of returned garments [...] from the current 4 million per year)*
- *identify how the successful small scale activities can be developed to deliver at scale*
- *consider the range of partners, enabling mechanisms, supply chain configurations, technologies and design factors that are required to enable recovery and reuse of much of the fibre currently sold*
- *conduct experiments to prove key concepts and develop a decision-making toolkit for achieving maximum recovery and value of garments on a large scale (Data, 2014b)*

The approach articulated within the PROJECT steering group meeting on 3 September 2014 states the following as the first point³² under ‘Our approach’: “*Creating an Anti-business – if we were trying to kill the FIRM business model as an entrepreneur, what would we do?*” (Data, 2014a; slide 3). The role of the steering group was articulated as being responsible for key success factors³³ such as

³² The full ‘Our Approach’ content of the Steering group meeting was as follows:

- Creating an Anti-business – if we were trying to kill the FIRM business model as an entrepreneur, what would we do?
- Commercial success is top priority – we will focus on how can we make it work commercially [This will drive scale, encourage other retailers to copy and therefore have greatest environmental impact longer term]
- Lean – agile, learning from prototypes/pilots
- Involving many bright minds not just those we already know
- Key success factors: [1] Steering group can ‘sell’ outcomes into other directors at the FIRM and [2] Pilots are executed well to provide us with learning/confidence in model

³³ The full list of key success factors as communicated in the original bullet point order on 3rd September 2014:

- Not micro-managing project details!

“Holding us true to intent - Use this unique opportunity to be radically disruptive and build commercial business models for FIRM fashion in the future” (Data, 2014a; slide 8).

The initially reviewed materials indicated that PROJECT would be suitable to explore a radical sustainability-oriented innovation process within an established business, because of the need to develop new organizational and technical capabilities, taking an entrepreneurial approach and conducting experiments in order to maximize learning about new value propositions.

The FIRM and the University kindly allowed me to join the ‘academic fringes’ of PROJECT to conduct case study research. This included joining the confidential online project forum, full access to all written project materials, and the freedom to select what I would deem as appropriate case study data for the purpose of this research.

2.5.2 Data collection

This research collected primary data with the aim of covering information in a real-life context (Yin, 2013): recordings of project team meetings and workshops. Additional primary data collected were 12 semi-structured interviews and a detailed structured observation protocol of a residential two-day workshop, plus the project proposal. Therefore, the case study used all of the “*big three*” (Langley, 2009; p. 411) data sources used in qualitative research: interviews, observation, and archival documents (Langley, 2009). **Figure 8** illustrates the primary data collected and how this data fits in the case study method.

-
- Holding us true to intent - “Use this unique opportunity to be radically disruptive and build commercial business model for the FIRM’s fashion in the future”
 - Be on track on meeting key external project criteria
 - Bringing commercial acumen and innovative flair to content (not process)
 - Challenging the design of pilots so we learn the most we possibly can as quickly as we can
 - Challenging the evolution of pilots so we build confidence in the FIRM
 - Joining dots with other initiatives so success can happen before end of 2 years
 - Develop criteria for project success for steering group to assess

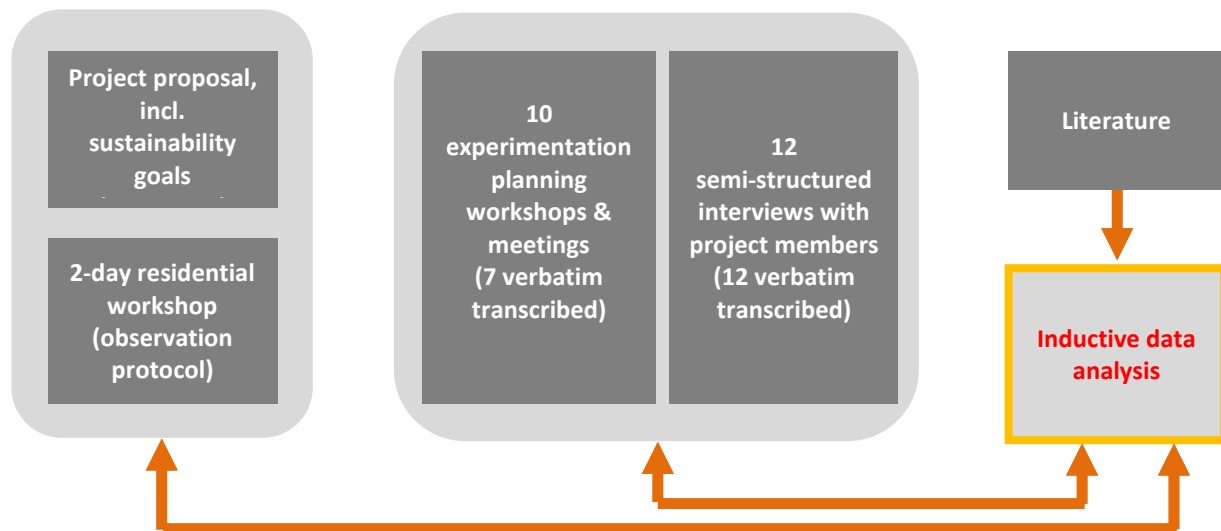


Figure 8: 22 month case study method overview

The first case study data collection to further scope the suitability of PROJECT as a research case study took place in October 2014. This took the form of a two-day workshop that aimed to generate radical ideas for new products and services that would enable the prolonging of clothing, and engage the FIRM's customers and the ability to be tested through experiments within the two-year timeline of PROJECT. The workshop was the first project event that went beyond project proposal and initial planning. Hence the case study data collection started from the ideation stage of PROJECT.

The data collection consisted of a written review of the workshop participant preparation materials which contained a mixture of media and information, keeping a structured observation diary, and additional notes taken after meals and the evening activities at the end of day 1.

During the workshop I used unstructured observation, where I watched informally but methodically in and among the workshop participants (Thomas, 2011b; p. 165), recording what seemed like important facets of what was happening. This type of observation is also called participant observation and Savin-Baden and Howell Major (2013) offer a spectrum of participant observation ranging from peripheral observation (least involved), passive observation, balanced observation, active participation to complete participation (most involved). Within this spectrum I aimed for balanced participation: joining into activities and interacting with the workshop participants but keeping a distance during some activities to allow for adequate observation and recording of data.

During balanced participation I focused on the 6 points suggested by Creswell (1998 in Savin-Baden and Howell Major, 2013; p. 398) . I thus observed the workshop process with an observation

protocol along the structure of (1) physical setting, (2) activities, (3) participants, (4) interactions, (5) delivery of information and (6) subtle factors. That last heading included any observations around body language within teams, how people sat on their table, and interactions during breaks. I picked observation spots³⁴ that allowed the full view of the workshop proceedings. In total, over 10,000 words were written during the two-day workshop. This writing has been chronologically ordered after the workshop and accumulated within a single document. **Appendix 3** shows an extract of the observation diary. Attending the residential workshop confirmed the suitability of PROJECT to explore how a business might develop the organizational capability of experimentation to pursue radical sustainability-oriented innovation.

Following the ideation workshop, project workshops and meetings were attended where possible. Towards the later stage of the project, the FIRM was comfortable with this research and I was able to leave voice recorders in meetings where attending in person would not be possible. Where workshops and meetings were attended by individuals who were not familiar with this research, the voice recorder was accompanied by a short document (**Appendix 4**) on display for the duration of the data collection to ensure informed consent (Miles et al., 2014; p. 59) of all persons that took part in the research.

Table 3 shows the list of PROJECT meetings and workshops that were attended and/or recorded as data for this case study. The table illustrates the rationale for data collection for each of the data events.

Data No.	Details	Organizations present	Why collect data?	Collection method	Timing	Lengths [hours]
0	Project proposal to UK government funding body	n/a	Gain information on project	Shared by academic team member	October 2014	n/a
55	Residential ideation workshop	Firm / University / suppliers / NGOs / Sustainable fashion academics	Gain insight about suitability of case study, how sustainable development challenges of project are framed, articulation of experiment goals	Face-to-face structured observation	October 2014	48
47A, 47B, 47C, 47D	Workshop	Firm / University	Workshop objective is to establish detailed content of the project experiments	Face-to-face recording & verbatim transcript	February 2015	3
51A, 51B	Experimentation Roadmap Workshop	Firm / University	Objective of workshop is to agree main details of experimentation phase	Face-to-face recording & verbatim	March 2015	3

³⁴ During break time and in the evening this was not possible to do in a comprehensive manner.

Data No.	Details	Organizations present	Why collect data?	Collection method	Timing	Lengths [hours]
				transcript		
52A, 52B	Experiment detailed planning workshop	Firm / University	Final case study experiments and their details were to be finalised during this workshop	Face-to-face recording & verbatim transcript	March 2015	2.5
53	Experiment sign-off meeting clothing retailer internal - 1	Firm / University	Gather how the experiments are communicated to decision makers within the clothing retailer, capture their input	Recording & verbatim transcript	April 2015	1.5
54	Experiment sign-off meeting clothing retailer internal - 2	Firm / University	Gather how the experiments are communicated to decision makers within the clothing retailer, capture their input	Recording & verbatim transcript	April 2015	1
61A, 61B, 61C	Experiment Review Workshop	Firm / University	Review of the case study experiments to date	Recording & verbatim transcript	August 2014	4
62	Clothing wardrobe app research meeting	Firm / University / Innovation contractor	Details on how an experiment is conducted	Recording of meeting	August 2015	2
63A, 63B	Data burst - 1	Firm / University	Meeting objective is to close gaps in the knowledge about planned experiments	Recording of meeting	August 2015	7.5
64A-D	Data burst - 2	Firm / University	Meeting objective is to close gaps in the knowledge about planned experiments	Recording of meeting	August 2015	6
65	Project progress meeting	Firm / University / Government funding body	How project process progress and experiment content is communicated to the public funder	Recording & verbatim transcript	August 2015	2

Table 3: 2014-2015 case study documents, meetings and workshops

Throughout the case study, semi-structured interviews were conducted (**Table 4**). The interview template for the first 10 interviews (43-66) is shown in **Appendix 5**. This interview template was shared with an academic project team member³⁵ in May 2016, who conducted 2 interviews with two key project team members to gather feedback on the project process as presented in an academic paper publication. At the same time, the June 2016 interviews were useful to triangulate the case study data analysis of this research. The interviews were transcribed by the same transcription agency as all prior interviews and with the same transcription guidelines.

Data No.	Details	Organizational area	Collection method	Timing	Lengths (hours)
43 ³⁶	Product and process innovation lead, Firm	Product, service, process innovation	Face-to-face interview & verbatim transcript	August 2014	1
48	Project management and research, University	Research	Phone interview & verbatim transcript	March 2015	0.75
49	Sustainable business	Business sustainability	Face-to-face	March 2015	1

³⁵ The academic project team member conducting the interview was the 2nd author of the case study paper (Weissbrod and Bocken, 2017).

³⁶ Same interview as shown in table 2.

	execution lead, Firm		interview & verbatim transcript		
50	Academic lead, University	Research	Face-to-face interview & verbatim transcript	March 2015	1
43A	Product and process innovation lead, Firm	Product, service, process innovation	Face-to-face interview & verbatim transcript	April 2015	1
56A, 56B	Administration lead, University	Project management	Face-to-face interview & verbatim transcript	June 2015	1
58	Technology process and product innovation lead, Firm	Technical development	Phone interview & verbatim transcript	June 2015	1
59	Sustainable business strategy lead, Firm	Business sustainability	Phone interview & verbatim transcript	June 2015	0.5
60A, 60B	Sustainable business fibre reuse and recycling lead, Firm	Business sustainability	Face-to-face interview & verbatim transcript	July 2015	1
66	Government funding body	Project funding monitoring	Phone interview & verbatim transcript	September 2015	0.5
49A	Sustainable business execution lead, Firm	Business sustainability	3 rd party conducted face to face interview & verbatim transcript	June 2016	0.75
60C	Sustainable business fibre reuse and recycling lead, Firm	Business sustainability	3 rd party conducted face-to-face interview & verbatim transcript	June 2016	0.75

Table 4: 2014-2016 case study interviews

All data in table CC and table PP apart from 62 were transcribed by the same transcription agency with the same transcription guidelines as the previous research interviews.

2.5.3 Data analysis

The two-day workshop observation protocol, interview transcripts, and meetings and workshop transcripts were interpreted (Savin-Baden and Howell Major, 2013; Thomas, 2011a) with the recordings of three workshops (August 2015 meeting, ID 62; August 2015 workshops, ID 63A-B and ID 64A-D) supplementing the text files. In addition to the data analysis process described in sections above, two strategies helped to interpret meaning in the data. The first strategy was ‘organizing principles’: how project members talked about themselves in relation to the planning and execution of the project experiments, how decisions were justified, and how project team members saw themselves in relation to each other. The second strategy to interpret meaning in the data was ‘oppositional talk’: project team members defined a project aspect or process by saying what it is not (Savin-Baden and Howell Major, 2013). Recognizing organizing principles and recognizing

oppositional talk are two strategies³⁷ highlighted as key for qualitative data interpretation that explores activities.

The highlighted data text received Descriptive and In Vivo codes. Data analysis took place through interpretation of the data *"in context and examining the values and perspectives of all those involved in the study"* (Savin-Baden and Howell Major, 2013; p. 545). For example, more junior PROJECT team members have a stronger focus on delivering project activities than senior team members; interviews with junior team members therefore contain less content on organizational strategy than interviews with more senior members of the team. This is simply a reflection of the perspective of a junior PROJECT team member, not of the importance placed on organizational strategy within PROJECT. The research attempted to recognize the values and perspectives influencing interview data through a short interview reflection. This reflection was added to interview transcripts³⁸ after the transcription process and prior to data analysis.

A case study narrative emerged relating to developing the organizational capability of experimentation. The data provided a rich picture of the project team's efforts to develop products/services outside the organizational status quo, the organizational process of developing the project experiments, and the collaboration between the clothing retailer and the university.

Interviews 49A and 60C were used to triangulate the themes identified and the contrasts to the reviewed literature, plus added final nuances to the case study data. Throughout the data analysis and interpretation process, I focused on the process characteristics of the case study innovation process, with a view to exploring how the FIRM was looking to develop the organizational capability of experimentation and acknowledge the position that there is *"always a fine line where analysis ends and interpretation begins"* (Savin-Baden and Howell Major, 2013; p.452).

2.5.4 Developing theory

This research developed theory from drawing on transdisciplinary literature concepts, interviewing cross-sectoral practitioners, and through conducting a case study. O'Connor et al. (2003) suggest that conducting case studies are suitable to explore radical innovation projects within established

³⁷ In total, there are four such strategies. The third strategy, 'Examining subtext', requires the analysis of emotion and body language, therefore video interviews are more suitable for this data interpretation strategy. The fourth data interpretation strategy is 'Exploring metonymy and metaphor', useful for researchers to *"see the influence of class and culture"* on the interviewees, a motivation contextual research angle that may be explored in future research (Savin-Baden and Howell Major, 2013; p. 456).

³⁸ This interview reflection was done for the 2013 and 2014 interviews also.

organizations. Eisenhardt (1989a) suggests that choosing *“extreme situations or polar types”* (Eisenhardt, 1989b; p. 537) as case study research subjects will increase theory building and asserts that a random choice of case studies will not fulfil any stated research objectives. I argue that the case study presented an extreme situation due to the assertion that PROJECT may form the basis of the destruction of the FIRM business model (Data, 2014a). Furthermore, I argue that a number of the 2013 and 2014 interviewees represent the extreme of radical sustainability-oriented innovation: some hold the unique position at the interface of sustainable development and innovation within their respective corporations, some look to commercialise new carbon-reducing technologies, some pursue all their business activities in pursuit of social and/or environmental challenges.

Christensen (2006) asserts that *“the value of theory is assessed by its predictive power”* (Christensen, 2006; p. 43), i.e. whether people can use theory to predict the outcome of a phenomenon. Furthermore, he argues that normative theory is more useful than descriptive theory due to a higher degree of predictive power. However, this research did not develop normative theory: enabling decision makers to foresee *“what actions will and will not lead to the desired result”* (Christensen, 2006; p. 43). The uncertainty of the inputs and outputs required for radical innovation projects with the aim to pursue sustainable development means that project leaders need to evaluate whether characteristics of radical sustainability-oriented innovation are met or even desired within their firm. *“Context-dependent knowledge and experience are at the very heart of expert activity”* (Flyvbjerg, 2006; p.5) and this research was structured to capture learnings and insights from experts pursuing sustainable development through radical innovation activities at the level of the firm. Whether to develop the organizational capability of experimentation is a call that needs to be made on a case-by-case basis. The descriptive theory developed through this research aims to aid practitioners during the decision making process on how to evolve the practice of innovation in their respective firms.

3. Exploring radical sustainability-oriented innovation

This PhD research addresses the innovation-entrepreneurship-sustainability nexus from the point of view of the practice of innovation in large businesses. Therefore an interdisciplinary literature review is needed. The two theory chapters, 3 and 5, establish links between concepts in the domains of innovation studies, organizational learning, organizational capabilities, design of experiments and entrepreneurship.

The review starts by exploring the dimensions and definitions of radical innovation (3.1.), and goes on to explore how sustainable development and radical innovation are connected through organizational activities (3.2) and the element of time (3.3). Sections 3.1 to 3.3 end with summaries that build on key arguments and findings in the reviewed literature. The final section 3.4 combines these summaries and offers characteristics of radical sustainability-oriented innovation. These characteristics are the starting point to answer research questions (1) and provide the theory foundation for data discussion and analysis of this PhD research.

3.1 Business activities as source of innovation

The influential economist Schumpeter (1942) asserted that new businesses are the source of change that are able to disrupt the current status quo of markets and industries. He called new businesses the source of ‘creative destruction’ for existing companies that are forced to exit a market place due to the competition of new businesses (Schumpeter, 1942). The definition of what entails a new business has been defined by Schumpeter (1934) as an economic entity that introduces (1) a new or at least partly unfamiliar consumer product, (2) a new production function³⁹, or as (3) using a new source of supply or half-manufactured goods that are new to the company (Schumpeter, 1934; p. 66). Schumpeter does not equate the creation of new economic entities (i.e. new businesses) with innovation. Rather, he asserts that the innovation associated with new business activities is about novelty of combinations for the consumer or about novelty at the sector or industry level⁴⁰.

³⁹ Of all of Schumpeter’s (1911/1934) definitions of innovation, ‘new combinations of production functions’ has been most heavily critiqued in the academic literature. Criticisms include that its analysis isn’t useful to explain details and character of technical change in the innovation process and the infinite number of possible new combinations of production functions (Hagedorn, 1996; p. 887).

⁴⁰ Schumpeter alludes to two further means to create “*new combinations of productive means*” (Schumpeter 1934; p. 66): (1) the creation of a new market in a given country and (2) the reorganization of an industry, such as breaking up of a monopoly. However both these means have their origin outside of the direct control of any given business and its organizational boundaries.

Schumpeter is a commonly cited source in the academic and grey literature (Elkington et al., 2011) on entrepreneurship (Hall et al., 2010; Hockerts and Wüstenhagen, 2010), innovation (Abernathy and Clark, 1985; Utterback and Akee, 2005; Van de Ven, 1986; Wonglimpiyarat, 2005), organizational renewal (Teece and Pisano, 1998), and the intersection of innovation and entrepreneurship (Bessant and Tidd, 2015; Larson, 2000; Schaltegger and Wagner, 2011; Stam and Nooteboom, 2011). It has been observed that Schumpeter's earlier 1934 work is cited by entrepreneurship literature that explores individual entrepreneurs that start new businesses from scratch (Hagedoorn, 1996). In contrast, the literature that explores entrepreneurial activities within existing businesses cites Schumpeter's later 1942 key work as main source of inspiration (Hagedoorn, 1996; Leifer et al., 2000). However, it is consistent in Schumpeter's body of work that both new and established firms can introduce new processes and products and establish or reshape "*the domestic as well as the international marketplace*" (Hagedoorn, 1996; p.892).

Technological development has changed dramatically since Schumpeter wrote his seminal works (Wonglimpiyarat, 2005) and opened up innovation opportunities in the corporate world that were impossible for Schumpeter to address. At the same time, entrepreneurship literature has broadened out the nature of entrepreneurship to equal economic value creation with social value creation (Venkataraman, 1997) to assert that only the combination of the two can create desirable markets. This has been revisited recently, when it was argued that focusing on shared value creation enables businesses to reconnect social progress with corporate success (Porter and Kramer, 2011). Furthermore, it has been argued that the value proposition of businesses – its products and services – should go beyond purely economic value (Schumpeter, 1942) or economic and social value (Porter and Kramer, 2011; Venkataraman, 1997), and include economic, social and environmental value⁴¹ (Bocken et al., 2015; Boons and Lüdeke-Freund, 2013; Schaltegger and Wagner, 2011).

However, Schumpeter's basic notion that business entities have the ability to create and shape marketplaces has not been contested. Innovation driven by changes in the private sector has been coined organizational innovation⁴² (Ashford and Hall, 2011).

Following this distinction, throughout this PhD thesis the term organizational innovation solely refers to innovation linked to changes in the private sector⁴³.

⁴¹ In essence, a sustainable value proposition means that a business looks to capture economic value, whilst it looks to generate social and environmental value.

⁴² In contrast, innovation driven by and relating to "*changes in the organization of government and of non-governmental organizations*" (Ashford and Hall, 2011; p.287) is coined institutional innovation (Ibid.).

This review goes on to cover literature on market-shaping and market-creating innovation activities that originate from businesses.

3.1.1 Radical innovation impact

It has been observed that the majority of innovation literature defines innovation based on degrees of novelty (Bessant et al., 2014; Bocken et al., 2012; Foster, 1986; Garcia and Calantone, 2002). The novelty of the innovation output may apply to an individual business, an industry, a supply chain or the whole world (Bocken et al., 2012; Garcia and Calantone, 2002). The ‘whole world’ is not further defined by the reviewed authors but seems to encompass novelty and commercialisation across the whole of Planet Earth. With regards to novelty, it seems that even authors who look to define innovation in terms other than degrees of novelty (i.e. Bessant et al., 2014) still use the degree of novelty as an indicator of innovativeness, with the novelty applying to a specific perspective taken on an innovation. Consequently, at the core of what defines radical innovation activities, projects and outcomes is the degree of novelty.

The impacts of the novelty of innovation have been separated in micro and macro levels (Garcia and Calantone, 2002). Innovative products at the macro level are *“new to world, the market, or an industry”* (Garcia and Calantone, 2002; p. 118), whereas at the micro level a high degree of innovativeness may apply to newness at the firm or customer group level. It has been argued that that radical innovation results in *“marketing and technical”⁴⁴ discontinuities on both a macro and micro level* (Garcia and Calantone, 2002; p.120). The World Wide Web, the Watt steam engine and the telegraph are given as examples of radical innovation by Garcia and Calantone (2002; p. 118) that caused discontinuities in the whole world.

Radical innovation does not look to satisfy existing customer demand (Chang et al., 2012; Christensen, 1997; Garcia and Calantone, 2002; Linton, 2009). Rather, radical innovation creates new customer demand (Garcia and Calantone, 2002) or it anticipates customer demand (Christensen, 1997) through new product and service offerings. Radical innovation activities are linked to high risk, high uncertainty (Sandberg and Aarikka-Stenroos, 2014), and with the potential to *“vastly influence*

⁴³ Ashford and Hall (2011) argue that there are two further types of innovation: social and technological. These types of innovation are covered in the innovation dimension section of in this thesis.

⁴⁴ ‘Marketing’ and ‘technical’ are radical innovation dimensions, discussed in the next section of this chapter.

the marketplace” (O’Connor and McDermott, 2004; p.13); creating new market domains or as having *“high impact on technology, production, the market and customers”* (Abernathy and Clark, 1985).

At the core of radical innovation lays the notion that its output is new-to-the-world and disrupts the existing status quo of doing things (Chang et al., 2012; Linton, 2009): *“only radical innovation can change the game”* (Leifer et al., 2000; p.2).

3.1.2 Radical innovation dimensions

Dimensions of radical innovation may show different levels of innovation impact (Abernathy and Clark, 1985; Foster, 1986; Garcia and Calantone, 2002; Linton, 2009) and levels of input required into innovation activities (Linton, 2009). Common to the literature reviewed is that the dimensions of innovation aim to characterise innovation along two axes, resulting in a 2-by-2 matrix. Examples of these two axes are ‘Technical Performance’ and ‘Research/Marketing effort’ (Foster, 1986), ‘Technology’ and ‘Marketing’ (Garcia and Calantone, 2002), and ‘Marketing/Customer Linkage’ and ‘Technology/production’ (Abernathy and Clark, 1985). Furthermore, an extensive review of the innovation literature asserts that innovation novelty can be discussed and classified along two dimensions and their relationship to each other: ‘Technical’ and ‘Social’ (Linton, 2009).

It has been asserted that innovation dimensions may describe innovation at the micro level and at the macro level (Garcia and Calantone, 2002). At the micro level the social dimension related to the customer, whereas at the macro level the social dimension relates to the whole market. Regardless of micro and macro level or innovation perspective, the dimensions of innovation are similar: one axis relates to technology and the other to the customer or market. However, solely radical innovation results in discontinuities on both dimensions and at both the micro level and the macro level (Garcia and Calantone, 2002).

A recent review of the innovation terminology mirrors this assertion. Building on the innovation impact framework for analysing competitive advantage at the firm level as proposed by Abernathy and Clark (1985), Linton (2009) argues that the characteristics of 11 innovation terms⁴⁵ can be summarised into two dimensions: technical and social. Furthermore, the intersection between these two dimensions represents the current social and technical status-quo. The framework implies that

⁴⁵ In management practice ‘radical’ innovation is used interchangeably with ‘breakthrough’, ‘discontinuous’, ‘disruptive’, ‘administrative’, ‘architectural’ innovation. Other innovation terminology includes ‘continuous’, ‘incremental’, ‘product’, ‘process’, and ‘technical’ innovation.

the further away from the status quo, the more radical the innovation is. **Figure 9** shows this framework. The innovations can either build on existing social structures and technological capabilities or require completely new social structures and technological capabilities.

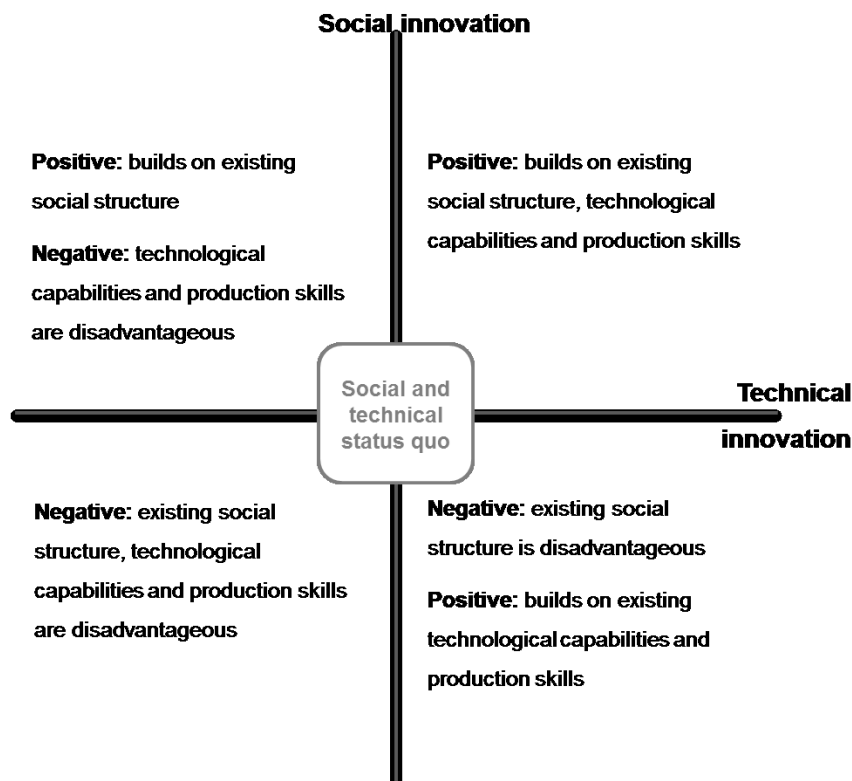


Figure 9: Relationship between technical and social innovation (based on Linton, 2009; p. 730)

This element of 'distance' from the known (i.e. status quo) is mirrored by Nooteboom (2000), who asserts that radical or macro innovation⁴⁶ means a high degree of structural difference at the organizational level. Furthermore, drawing on Schumpeter's (1934) new combinations of productive means, Nooteboom (2000) argues that the more unrelated to each other new combinations were before radical innovations occurred, the higher the degree of radicalness. Therefore, high distance from the current social and technical capabilities during the creation of novel combinations⁴⁷ (as per Schumpeter, 1934) are characteristic of radical innovation according to Nooteboom (2000). The author goes on to articulate that it is very difficult for people within firms to identify an opportunity based on radically novel combinations *"since it literally does not make sense; it cannot be interpreted in terms of existing practices, and therefore extends beyond established meanings and corresponding*

⁴⁶ Nooteboom (2000) asserts that radical innovation and macro innovation are the same; mirroring what Garcia and Calantone (2002) propose.

⁴⁷ Details of what Schumpeter's 'novel combinations' mean are presented in section 3.1.

categories” (Nooteboom, 2000; p.183). Rather, experiences from a variety of old practices known to practitioners in the firm are combined and form the “*basis for reasonable hunches*” (Ibid.).

Tushman and Anderson (1986) argue that technological breakthrough can enhance or destroy the competences of firms (i.e. knowledge and skills) in an industry. However, building on existing technologies and production skills are less radical according to Nooteboom (2000), because more knowledge and skills on how to pursue radical innovation already exist within the firm. **Figure 10** shows where the most radical of innovations are located on the innovation framework proposed by Linton (2009) and the argument by Nooteboom (2000). The implication is that organizations need to create new social and technical structures in order to pursue radical innovation at the organizational level, with a view to impacting the macro level (Garcia and Calantone, 2002) of the industry and market.

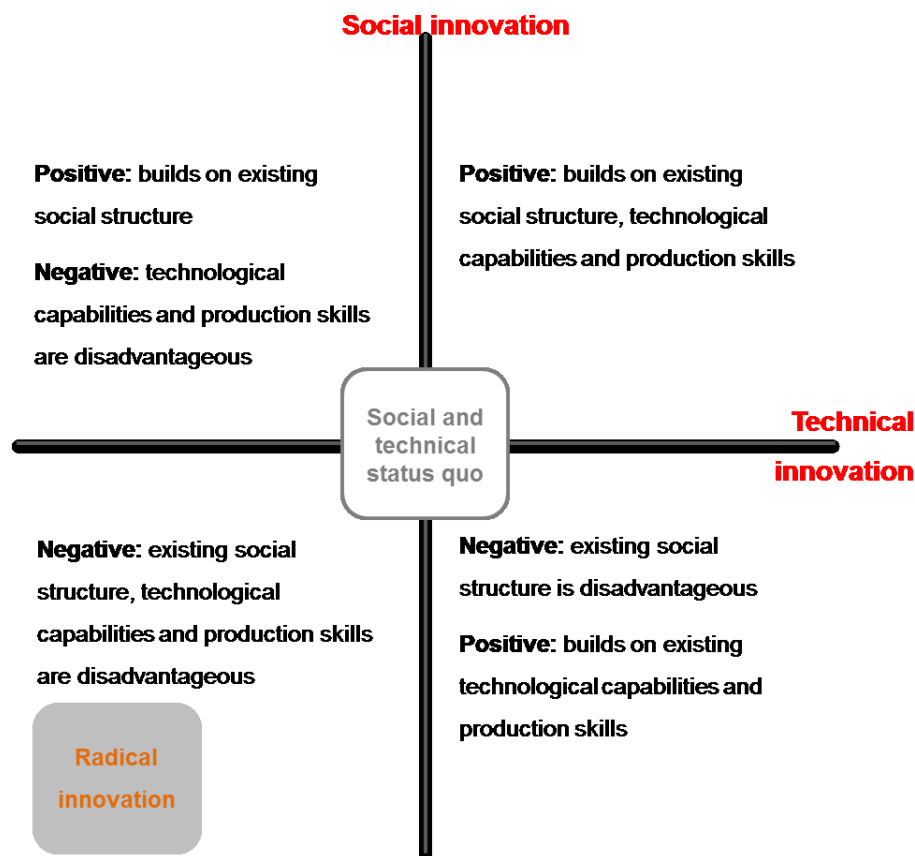


Figure 10: Radical innovation and the relationship between technical and social innovation. (based on Linton, 2009 and Nooteboom, 2000)

Bessant et al. (2009); Garcia and Calantone (2002); Koen et al. (2001); and Linton (2009) assert that defining the radical innovation terminology is needed to further the academic innovation body of

knowledge. All the authors argue that it is not possible to further knowledge in the field because different research approaches use different dimensions, perspectives and units. The Social/Technical framework proposed by Linton (2009) and the Marketing/Technology at Micro/Macro level typology as proposed by Garcia and Calantone (2002) are complementary.

For the purpose of this PhD thesis the radical innovation dimensions mirror Linton (2009): innovation impacts, activities and processes are considered along novelty of a social and a technical dimension. This novelty has to lead to discontinuities at both the micro level and the macro level (Garcia and Calantone, 2002; Nooteboom, 2000).

The further removed, “*different and alien*” (Linton, 2009; p. 732) an innovation is from the social and technical status quo, the more “*unforeseen opportunities and their desirability*” (Linton, 2009; p. 732) become. In other words, the opportunities related to radical innovation outputs become more and more uncertain.

In addition to the technical and social dimension, ‘supply chain’ has been proposed as a third dimension of radical innovation: coined the ‘Extended supply chain’ dimension by Bocken et al. (2012). This dimension applies to radical innovation processes that are pursued in firms and is presented in addition to ‘Technology’ and ‘Product Concept’ by the authors. The research by Bocken et al. (2012) is conducted from the perspective of a firm and researches the difficulty of innovation implementation due to the novelty of the product concept, technology and the extended supply chain. Even though Bocken et al. (2012) cite the initial measures of implementation difficulty⁴⁸ proposed by Ford and Soren (1996), it is unclear how the third dimension of ‘Extended supply chain’ was created. Ford and Soren (1996) made the dimension of ‘Technology’ more granular as opposed to creating a new supply chain dimension.

This literature review goes on to the technical and social dimension of radical innovation in more detail before exploring the innovation perspective of the firm in depths.

3.1.3 The chaos and revolution of the technology dimension

Process technology encompasses the “*tools, devices and knowledge*” that link the inputs into production system with the outputs, whereas product technology underpins the creation or

⁴⁸ Ford and Soren (1996) propose three matrices to measures of innovation difficulty in firms. These three matrices have the following two dimensions: (1) Capability and Technology, (2) Product technology and Process technology, and (3) Product concept and Technology.

improvement of new products and services (Tushman and Anderson, 1986; p.440). However, changes in both types of technology can change industries and markets (Tushman and Anderson, 1986), therefore this section treats process and product technology under the term ‘technology’.

The adoption and evolution of technology from ideation to widespread market adoption is researched by the technology management literature (Chandy and Tellis, 2000). Technology development is at the core of the technical dimension of radical innovation and it has been observed that the novelty of ‘technology’ is the most commonly cited⁴⁹ innovation factor in the literature (Garcia and Calantone, 2002).

Technology innovation follows a three-stage model that includes feedback between the stage and this model can be applied to the level of the firm (Ashford and Hall, 2011). **Figure 11** shows this three-stage model.

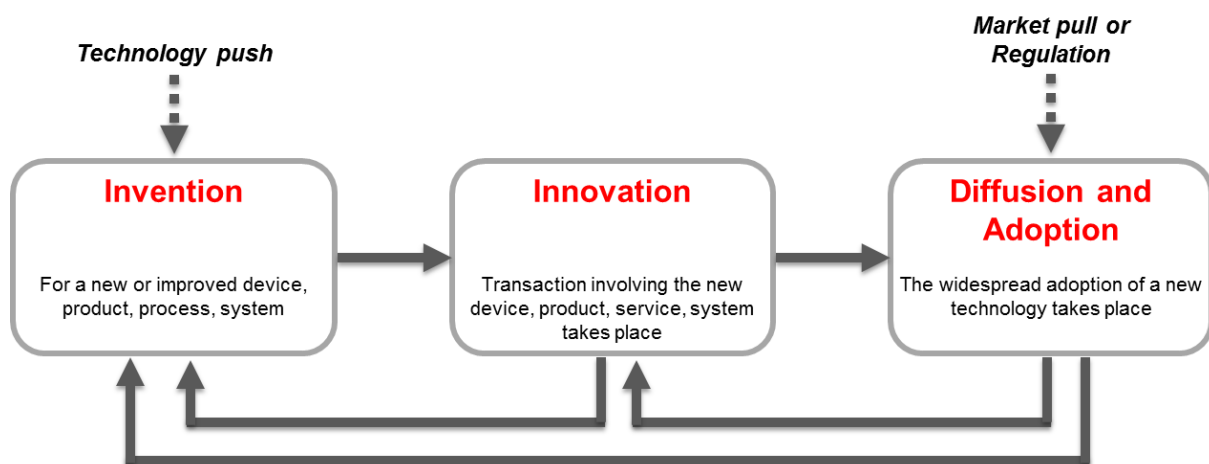


Figure 11: Simple linear model of technological innovation with feedback (adapted from Ashford and Hall, 2011; p.278)

The three stages of technological innovation stay the same, irrespective of the degree of radicalness of an innovation (Ashford and Hall, 2011). However, solely radical technological inventions can change the competitive landscape in the marketplace because they can make established technologies obsolete (Dahlin and Behrens, 2005; Schumpeter, 1934). Dahlin and Behrens (2005; p.725) propose that for a technological invention to be radical, it has to display three criteria. Firstly it must be novel (i.e. “*dissimilar from prior inventions*”), secondly it must be unique (i.e. “*dissimilar from current inventions*”) and thirdly it has to be adopted (i.e. “*influence the content of future*

⁴⁹ Novelty of ‘technology’ is followed by novelty of ‘product line’ and ‘processes’ as most commonly identified characteristic of innovativeness in the literature (Garcia and Calantone, 2002).

inventions”). The first two criteria allow for the assessment of technological inventions prior to innovation, whereas the third can only be applied when the invention is in the innovation stage. Interestingly, Dahlin and Behrens (2005) assert that even inventions that meet all three criteria can only be called an innovation after the invention has been commercialised⁵⁰. It follows that the three criteria of radical technological invention proposed by Dahlin and Behrens (2005) solely apply to innovations that have been commercialised and, therefore, have an impact on the market. This notion concurs with the arguments by Garcia and Calantone (2002) that radical innovation leads to discontinuities in the technological dimension at the micro level and at the macro level.

Two models⁵¹ to describe technological radicalness in innovation are s-curves and technological trajectories (Chandy and Tellis, 2000; Dahlin and Behrens, 2005; Dosi, 1982; Foster, 1986). Irrespective of the innovation perspective taken, the innovation activities and adoption of novel technology has been shown to follow a similar pattern that is visualised in these two models.

The theory of S-curves looks to explain the origin and evolution of radical innovations (Foster, 1986). In particular, the theory suggests that consumer benefits shape the rate of new technology adoption *“along a series of successive S-curves”* (Chandy and Tellis, 2000; p.2). The more time passes, the more consumer benefits can be reaped by a new technology according to the theory (**Figure 12**). Others have argued that the S-curves of technology come in at least pairs, where the gap between curves means a discontinuity in the marketplace (**Figure 13**). It has been asserted that *“(..), in reality, there may be three or four or more technologies involved in a battle, some on defense and some on offense”* (Foster, 1986; p.103). The battle the author refers to are the technologies competing to deliver customer benefits that underpin the value proposition of the business. The position technologies competing with each other is also taken by Tushman and Anderson (1986).

⁵⁰ Meeting all three criteria can make an invention ‘a change agent’, however solely commercialisation, i.e. economic value capture, makes the invention a radical innovation according to Dahlin and Behrens (2005).

⁵¹ ‘Technology cycles’, ‘Hedonistic price models’ and ‘expert panels’ are the other general models and methods to measure radicalness of innovation as summarised by Dahlin and Behrens (2005). Conceptually, ‘technology cycles’ as proposed by Tushman and Anderson (1986) had significant impact. Furthermore, the technology cycle concept allows for measuring of radicalness. However, the technology cycle concept has not been empirically tested according to Dahlin and Behrens (2005). This is in contrast to the other methods assessed by the authors.

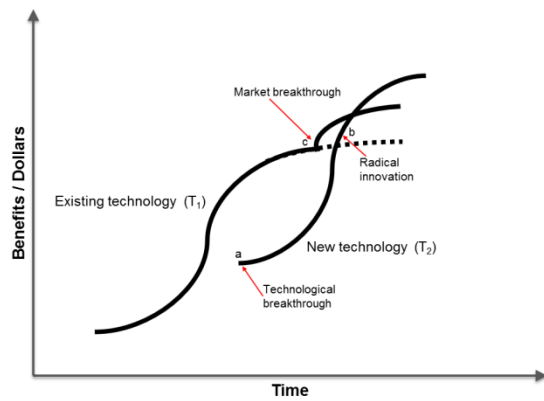


Figure 12: S-Curves (Chandy and Tellis, 2000; p. 3)

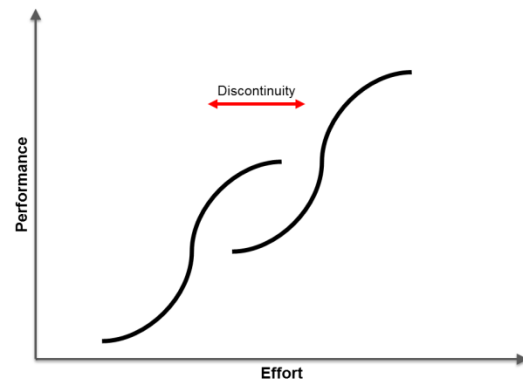


Figure 13: S-Curves almost always appear in pairs (Foster, 1986; p. 102)

Both **Figure 12** (Chandy and Tellis, 2000) and **Figure 13** (Foster, 1986) imply that firms may make the S-curves steeper through maximising benefits of new technologies, through faster processes and launching new products quicker than competing firms. In other words, the curves can be made steeper through incremental innovation (Foster, 1986).

Technology discontinuities (**Figure 13**) take place at a point where firm processes and product do not necessarily overlap (**Figure 12**) with new technology (Christensen, 1997; Foster, 1986). The new technology has been coined a disruptive technology by Christensen (1997). The time during which discontinuity gaps take place have been described as “*chaos*” for people in organizations by Foster (1986; p.103)⁵² due to several new technologies competing in the market during technological discontinuities, failure to keep organizational records of technological productivity, and the fact that “*rarely does a single technology meet all customers’ needs*” (Ibid.). Therefore, the discontinuity gaps are not as easily visualised as in the figures above, however the chaos still applies.

The chaos of the discontinuity in technical change as shown by the S-curves has been argued to be closely linked to the possibility of new technological paradigms that encourage and allow “*extraordinary innovative effort to take place*” (Dosi, 1982; p.158). Making choices where large discontinuities may occur driven by new technologies means a firm has to decide which of the possible competing technology S-curves to move into (Dahlin and Behrens, 2005; Dosi, 1982). It has been argued that technology discontinuities may not necessarily result in market disruptions, it may also result in, and be necessary for, market expansion (Utterback and Acee, 2005).

⁵² Foster credits the word ‘chaos’ to one of his contacts who used it from the practitioner perspective.

Figure 12 and **Figure 13** imply that technology-driven innovations may progress along a linear timeline. However, this does not mean that innovations are evenly distributed over time. Rather, temporal innovation clusters occur when scientific discoveries are successfully commercialised and result in a variety of new customer offers (Freeman and Louçã, 2001). Freeman and Louçã (2001) draw on economic theory and view the diffusion of technology as an irregular process⁵³. They assert that technology-driven innovation clusters “*may give rise to phenomena best described as technological revolutions*” (Freeman and Louçã, 2001p. 139). These innovation clusters and the establishing of a broad new technology paradigm also leads to the clustering of innovations “*in time of their economic impact*” (Dosi, 1982; p.160). Furthermore, it has been argued that ‘revolutionary’ development of technology is driven by the external business environment, for example “*strong societal pressures, or an energy crisis*” (Ashford and Hall, 2011; p.277). It follows that sustainable development challenges may drive a change in the technology paradigm.

3.1.4 A short excursion into the social innovation dimension

Social innovation may refer to society, for example through innovating public service institutions (Drucker, 1985) or the term may refer to changes in the preferences of “*consumers, citizens and workers*” (Ashford and Hall, 2011; p.679) for products, services, activities and working conditions and the processes through which these people influence the preferences (Ibid.). The former is mainly under the influence of governments and can result in policy changes, new regulations and standards. The latter is mainly under the influence of organizations.

It has been argued that “*standards, regulatory and approval processes may require modification*” (Linton, 2009; p. 736) in order for businesses to generate value from technical innovations. At the same time as the uncertainty of innovation activities at the firm level increases, the less innovation activities build on existing competences (Linton, 2009). Radical innovation activities take place in this area of high uncertainty (figure 2). Therefore, waiting for the social innovations at the macro level as driver of innovation at the firm level is not suitable. It has been argued that “*there is no time to wait for evolutionary change*” (Ashford and Hall, 2011; p. 678) due to the urgency of climate change (Ibid.). Public service innovation in the late 19th and early 20th century was comparable to fast technological innovation of recent times (Drucker, 1985). However, the higher number of policies and institutions that exist now make the “*systematic abandonment of outworn social policies and obsolete public-service institutions*” (Drucker, 1985; p.234) very difficult.

⁵³ The authors concur with the view of Schumpeter with this perspective on the irregularity of innovations over a given time. Dosi (1982) also has the same position.

The social dimension as described by Linton (2009) captures the micro perspective of the firm (i.e. skills) and the macro perspective of the market and the governmental influence (i.e. social structure). Radical innovation activities require new skills at the firm level to engage consumers in new product and service propositions (Ashford and Hall, 2011; Linton, 2009). I go on to explore the innovation perspective taken in this research.

3.1.5 *The need for a clear innovation perspective*

The relationship between the technical dimension and the social dimension of innovation varies greatly with the perspective practitioners and theorists take to consider innovations (Abernathy and Clark, 1985; Garcia and Calantone, 2002; Linton, 2009). Defining the perspective is essential to avoid confusion and seems to view two perspectives as useful consideration lenses: (1) a technology or the unit that exploits this technology or (2) the individual, firm, organizational or supply chain perspective (Linton, 2009). The common technical dimension perspectives as highlighted by Linton (2009) are threefold: technology, process and product. Social dimension perspectives may relate to the individual as user, the individual as direct or indirect customer, the business unit, the whole firm or organization, an industry or the supply chain.

The perspective taken will greatly influence how the impact of any innovation is viewed and represented on any innovation impact framework (Abernathy and Clark, 1985; Bessant et al., 2014; Linton, 2009). For example, an engineer in the supply chain may view a technical development as “a *startling breakthrough*” (Abernathy and Clark, 1985; p.4). However, for the user of the product or service (i.e. the social dimension), this technical development might result in minor perceived benefits, therefore being judged as “*completely unremarkable*”(Abernathy and Clark, 1985; p.4). Consequently, the impact of the innovation would be judged very differently by the supply chain engineer and the end user if they were asked to put a technical development on any two-dimensional innovation framework.

Linton’s (2009) view on perspectives does not include the view of the individual as producer of innovation, regardless of the nature of the technological dimension. This might be the case because including the individual perspective would necessitate the inclusion of thinking on individual opinion forming and how this relates to organizational processes, e.g. the body of work on “sensemaking” (Maitlis and Christianson, 2013; Weick et al., 2005). Perhaps Linton (2009) quite simply wanted to keep this can of worms closed.

From the perspective of the firm as producer of innovations, others have mirrored Linton's (2009) conclusion about the need to develop specific capabilities in order to conduct radical innovation activities (Bessant et al., 2014; O'Connor and DeMartino, 2006; Tidd and Bessant, 2013). It has even been argued that from the perspective of a firm, this is a more suitable indicator of the degree of radicalness of an innovation than the degree of novelty of the innovation in the context of the firm's existing products and services (Bessant et al., 2014). In other words: producing dog collars would be a radical innovation activity for an IT Services company due to the fact that the IT Services company has no existing capabilities to produce dog collars. However, this innovation activity would not be classed radical innovation according to the characteristics as proposed by Garcia and Calantone (2002) because the innovation solely impacts the micro level of the firm, not the macro level of an industry or the whole market.

Dynamic capabilities (e.g. Eisenhardt and Martin, 2000; O'Reilly and Tushman, 2008; Teece and Pisano, 1998) are explored in more depth later in chapter 5 (section 5.1). Here, I go on to further explore the perspective of the firm and the challenge of pursuing radical innovation activities because this PhD examines the practice of innovation in large firms.

3.1.6 *The innovation perspective of the firm: challenges*

Search, selection and implementation are the three elements of all organizational innovation activities (Bessant et al., 2014; Tidd and Bessant, 2013). All challenges about managing innovation within the boundaries and context of any business are about optimising these three elements (Tidd and Bessant, 2013) and adapting them to new operational environments (Bessant et al., 2014; Teece et al., 1997). The need to adapt search, selection and implementation capabilities differs for incremental innovation activities and radical innovation activities (Bessant et al., 2014; Bocken et al., 2012; Linton, 2009).

When reviewing innovativeness terminology, Garcia and Calantone (2002) found that radical innovations cannot be planned as easily as innovations that build on existing firm skills, social structures and technological capabilities. However, Garcia and Calantone (2002) state that, despite the difficulty to plan radical innovations, *"it is through the creativity and genius of innovators and marketers that they evolve into commercialized products"* (Garcia and Calantone, 2002; p.127). The

authors therefore single out individual decision-making abilities⁵⁴ as key to advancing radical product inventions to wider commercialization.

Others have systematically reviewed the success factors and barriers to radical innovation in organizations⁵⁵ (Sandberg and Aarikka-Stenroos, 2014) and have come to a similar assertion as Garcia and Calantone (2002) with regards to acting on radical innovation opportunities.

An innovation barrier is *“an issue that either prevents or hampers innovative activities in the firm”* (Sandberg and Aarikka-Stenroos, 2014; p. 1294). The authors selected 103 research articles for inductive content analysis to identify and classify external barriers⁵⁶ to radical innovation. To classify internal barriers⁵⁷, the authors applied the categorization by O'Connor and DeMartino (2006) and other previous studies as the basis for the grouping of innovation activities, types and research methods. Their findings assert that the 103 research articles highlight internal barriers (with 88%) more frequently than external barriers (72%) (Sandberg and Aarikka-Stenroos, 2014; p. 1299). The internal barriers most commonly mentioned in the reviewed studies were ‘restrictive mindset’ (68%) and ‘lack of competences’ (62%). In regard to the lack of competences in the firm, SMEs struggled most with incubation ability according to the reviewed articles whereas the larger firms most lacked radical innovation discovery competence (Sandberg and Aarikka-Stenroos, 2014). The discovery competence encompass organizational activities *“that create, recognize, elaborate, and articulate radical innovation opportunities “* (O'Connor and DeMartino, 2006; p.489). The organizational skills needed to pursue discovery activities are exploration and conceptualisation of new technology and science⁵⁸ within and outside of the boundaries of the business operations according to O'Connor and DeMartino (2006).

This literature review goes on to explore the skills and capabilities needed for the pursuit of radical innovation from the perspective of the firm and through a sustainable development lens.

⁵⁴ This argument is explored in chapter 3, section 3.4.1.

⁵⁵ The authors included 29 ‘new to the firm’ articles, 4 ‘new to the market’ articles, 37 ‘new to the firm and the market’ articles, 19 ‘newness not specified’ articles and 15 ‘disruptive’ articles in their review (Sandberg and Aarikka-Stenroos, 2014).

⁵⁶ *“External barriers originate from a firm’s external environment and emerge when a firm interacts with other organizations or actors in economic and innovation systems; ..”* (Sandberg and Aarikka-Stenroos, 2014; p. 1294)

⁵⁷ *“Internal barriers originate within a firm and are closely related to its management and organization ..”* (Sandberg and Aarikka-Stenroos, 2014; p. 1294)

⁵⁸ O'Connor and DeMartino (2006) assert that ‘discovery’ can include invention, although it is not a requirement for the pursuit of radical product and service innovation.

3.1.7 Summary

The novelty of combinations for the consumer or the novelty at the sector/industry level is at the core of new business creation (Schumpeter, 1934). New business creation can take place within and outside of established firms (Leifer et al., 2000; Schumpeter, 1942).

New businesses create economic, environmental and social value to create desirable markets (Boons and Lüdeke-Freund, 2013; Porter and Kramer, 2011): the value is created through the products and services of the business. Organizational innovation, the creation of new products and services, is driven by changes in the private sector (Ashford and Hall, 2011).

Innovation is defined by degrees of novelty (Bessant et al., 2014; Garcia and Calantone, 2002). When it comes to radical innovation, it impacts both the micro level of the firm and macro level of the market (Garcia and Calantone, 2002). This means radical innovation creates new customer demand. However, radical innovation activities are linked to high risk and high uncertainty (Sandberg and Aarikka-Stenroos, 2014). This makes radical innovation opportunities difficult to identify for businesses (Nooteboom, 2000).

The two dimensions of radical innovation impact and activities are 'technical' and 'social' (Linton, 2009). Radical innovation results in discontinuities in both the 'technical' and 'social' dimension (Garcia and Calantone, 2002). Organizations need to create new social and technical structures to pursue radical innovation in order to change the macro level (Nooteboom, 2000).

Academic research takes different dimensions, perspectives and units on radical innovation. This is undesirable to further knowledge in the field. This PhD follows the summary of radical innovation dimensions by Linton (2009) and the radical innovation novelty characteristics summarised and proposed by Garcia and Calantone (2002). The further removed an innovation from the organizational status quo, the more uncertain the innovation outputs (Linton, 2009).

Technology development is at the heart of the 'technical' radical innovation dimension (Garcia and Calantone, 2002). Technological inventions must be commercialised before they can be considered to be radical (Dahlin and Behrens, 2005). The organizational adoption of new technologies which lead to new consumer benefits follow similar patterns. The patterns are called S-curves (Chandy and Tellis, 2000). Incremental innovation can make S-curves steeper and result in competitive advantages in the short term (Foster, 1986). In contrast, the gap between S-curves equals

discontinuities in the market place (Chandy and Tellis, 2000; Foster, 1986). Technology discontinuities are the proverbial empty space for businesses: associated with extreme uncertainty for product and service development and processes, choices about which new technology to focus on and, in summary, chaotic for organizations and markets (Dahlin and Behrens, 2005; Dosi, 1982).

Technology innovations are not regular over time (Freeman and Louçã, 2001), with S-curves evenly distributed throughout time. Instead, they form innovation clusters (Dosi, 1982), with these clusters driven by pressures external to the business environment, including natural resource challenges (Ashford and Hall, 2011) .

Theorists and practitioners take different perspectives on the two radical innovation dimensions. The practitioner perspective greatly influences how the impact of an innovation is perceived (Linton, 2009). Furthermore, the perspective of the firm is all about the capabilities needed to pursue radical innovation activities (Bessant et al., 2014).

In firms, radical innovation activities require new ways of search, selection and implementation (Bessant et al., 2014; Utterback, 1996). There is little empirical evidence on the development strategies of radical innovations in firms (Garcia and Calantone, 2002). Nevertheless, individuals within firms are credited with commercializing radical innovations (Garcia and Calantone, 2002). However, in large firms, the key barriers to radical innovation have been identified as restrictive mindsets and lack of competences (Sandberg and Aarikka-Stenroos, 2014). The 'Discovery' capability in particular is a barrier. Therefore, the key skills lacking in firms to pursue radical innovation are the exploration and conceptualisation of new technology and science within and outside of the boundaries of the business operations (O'Connor and DeMartino, 2006).

3.2 Sustainable development and radical innovation in established businesses

This section links the perspective of the firm on radical innovation with sustainable development. Starting with sustainable development and how businesses respond to sustainable development challenges, this section homes in on sustainability-oriented innovation and how this is linked to radical innovation, and ends with a short exploration on how such innovation impacts the business models of firms.

3.2.1 Thriving for sustainable development

Defining sustainable development is anchored in a 1987 definition and used in fairly recent literature (e.g. Dewberry and de Barros, 2009; Hall et al., 2010). This definition⁵⁹ is anchored in the notion of human development: sustainable development is defined as “*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*” (WCED, 1987; p.37). However this definition is almost 30 years old and does not include more recent thinking such as the notion that economic growth is not necessarily equal to ‘development’ (Sneddon et al., 2006).

Griggs et al. (2013) build on the necessity to strengthen the definition for sustainable development to include the notion that ‘economic development’ sits within the social pillar of sustainability. Both the economic development and the development of any society are only possible through the Earth’s life support system (Griggs et al., 2013; Senge et al., 2008; p. 102). It has been asserted that all business activities take place within the economy, within human society, and within the natural environment (Charter et al., 2008; Gowdy and Erickson, 2005; Porritt, 2005; Senge et al., 2008), illustrated in **Figure 14**. Business innovation activities

will therefore impact human society and the natural environment⁶⁰. Hence the Brundtland definition of sustainable development is proposed to be redefined as “*development that meets the needs of the present while safeguarding Earth’s life-support system, on which the welfare of current and future generations depend*” (Griggs et al., 2013; p. 306).

Others build on the idea that economic growth has to be decoupled from resource use and emissions. For example, Ashford and Hall (2011; p.138) assert that “*a sustainable development approach must be fashioned to create a competitive and green economy that creates safe, meaningful, and well-paid employment and sufficient earning capacity within the context of rapid technological change and globalization.*” The authors acknowledge that the current change trajectory “*is too slow to make serious inroads*” (Ibid.) to meet the urgency of climate change challenges. They assert that nothing short of “*revolutionary change*” (Ibid.) is necessary to reach the

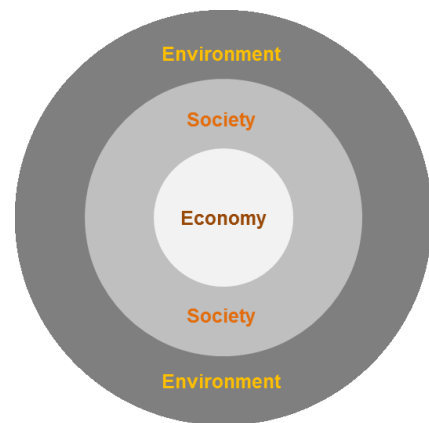


Figure 14: The nested triple bottom line (adapted from Senge et al., 2008; p.102)

⁵⁹ This definition is also known as the Brundtland definition because Gro Harlem Brundtland was the chair the World Commission on Environment and Development (WCED); the WCED itself is known as Brundtland Commission.

⁶⁰ These impacts are viewed as ‘external costs’ to the business because they don’t affect shareholder value or customers in the short term.

sustainable development they articulate. This revolutionary change is to be driven by technology and strategy at the firm level, enabled by changes in the political and social landscape.

This research takes the innovation perspective of the firm. Operationalizing social, environmental and economic development within business has been coined ‘the triple bottom line’ by John Elkington in 1994. Since then, this term has been used widely by academics who research sustainable business models and sustainable entrepreneurship (e.g. Bocken et al., 2014; Boons et al., 2012; Klewitz and Hansen, 2014; Kuckertz and Wagner, 2010). This indicates that finer details of defining sustainable development are avoided even in the academic sustainability-oriented business literature. Hence, simplifying any detailed sustainable development definition to the notion of putting equal importance on economic, social and environmental value creation during business activities is an accepted practice in the practitioners and academic community. This means that the full array of the interconnected factors of sustainable development challenges⁶¹, for instance economic inequality and biodiversity, may not receive the full attention in comparison to factors that have a high impact on firms. Climate change and resource depletion are examples of sustainable development challenges that have an immediate effect on business supply chains. These challenges are therefore likely to provoke business action. This research prioritises sustainable development challenges that will impact business in the shorter term, leading for the need to radically change product and service offers and innovation processes in the firm. It follows that simplifying sustainable development challenges to environmental, social and economic value creation is appropriate for the purpose of this research, succeeding the example of others who research business sustainability and sustainable entrepreneurship.

This PhD research defines sustainable development as seeking to balance economic, social and environmental interests to further human development.

3.2.2 Business response to sustainable development

Focusing on the perspective of the firm this research takes, it has been argued that large firms are better placed than small entrepreneurial companies to tackle a wide span of sustainability issues (Schaltegger et al., 2014). This argument is based on the notion that the business response to

⁶¹ The challenges that impact sustainable development have been articulated by Ashford and Hall (2011) under the categories of environmental, social and economic, with overlap between a number of challenges:

- Environmental: Resource Depletion, Biodiversity/Ecosystems, Toxic Pollution, Climate Change, Environmental Justice
- Social: Environmental Justice, Peace and Security, Economic Inequality, Employment and Purchasing Power
- Economic: Economic Inequality, Employment and Purchasing Power, Competitiveness, Resource Depletion

sustainable development challenges- corporate sustainability- is a cross-functional challenge and quickly involves a number of issues (i.e. water use, CO₂e emissions, labour conditions etc). However, it has been argued that entrepreneurs seeking sustainable development innovation opportunities are needed to incentivise large corporates and whole industries into responding to sustainable development challenges (Hockerts and Wüstenhagen, 2010). The authors assert that large businesses and entrepreneurs will co-evolve and lead to the survival of both types of enterprises (Hockerts and Wüstenhagen, 2010).

Large companies are driven to address sustainable development challenges to make the most of associated economic opportunities, to increase financial profit (Porter and Kramer, 2011; Schaltegger et al., 2012; Schaltegger and Hörisch, 2015). Alternatively, companies may be driven by seeking legitimacy of existing within their wider societal structures of values, beliefs and norms. Schaltegger and Hörisch (2015) analyse the relationship between organizations and their operating environment. The authors compared these two perspectives on organizational motivation to engage in sustainable development challenges and found that management practices “*are primarily characterised by legitimacy seeking*” (Schaltegger and Hörisch, 2015; p.14). The authors further conclude that even if addressing sustainable development challenges is mainly driven by legitimacy, it “*seems sensible*” to do so “*in an economically profitable manner*” (Schaltegger and Hörisch, 2015; p.14).

Irrespective of the motivation to address sustainable development challenges, it has been asserted that at the level of the firm, the response to sustainable development challenges represents “*micro-level progress*” (Dyllick and Muff, 2015; p. 2). In contrast, the global nature of sustainable development challenges represents “*macro-level deterioration*” (Dyllick and Muff, 2015; p.2) and these two are inherently disconnected through their order of magnitude (Dyllick and Muff, 2015). The argument of Dyllick and Muff (2015) is that business activities take place and the organizational level and sustainable development challenges take place at the global level, leading to a disconnect between the scale of activity. It is the responsibility of the business to ensure that micro-level activities have the maximum positive impact at the macro level (Dyllick and Muff, 2015) at the speed necessary to meet climate change and resource challenges (Ashford and Hall, 2011).

How businesses address sustainable development challenges may be considered along an input-output framework of business activities, with the framework as a suitable means with which to link activities of the firm. A business identifies the sustainable development concerns it will address, how it will address these concerns and as a result, for whom it will create value (Dyllick and Muff, 2015).

Table 5 shows the input-output framework as suggested by Dyllick and Muff (2015), contrasting the business status quo (business-as-usual) with business sustainability and the associated key shifts from status quo at the firm level.

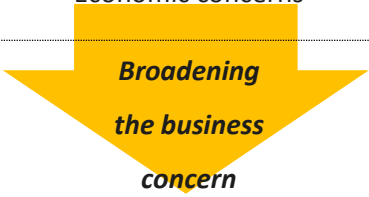
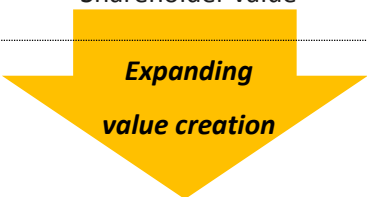
Input	Process	Output
Concerns	Organizational perspectives	Values created
What?	How?	What for?
<i>From 'Business status quo'..</i> Economic concerns  Broadening the business concern	<i>From 'Business status quo'..</i> Inside-out ⁶²  Changing the perspective	<i>From 'Business status quo'..</i> Shareholder value  Expanding value creation
<i>..to 'Business sustainability'.</i> Starting with sustainability challenges	<i>..to 'Business sustainability'.</i> Outside-in	<i>..to 'Business sustainability'.</i> Creating value for the common good

Table 5: A Framework for Considering Different Approaches of Business Sustainability (adapted from Dyllick and Muff, 2015; p. 5 & 13)

I go on to explore the process and output parts of the framework in more depth through the lens of innovation.

3.2.3 Business innovation for sustainability

The business status quo views the business at the heart of economic activities, with solely economic concerns driving business activities⁶³ (Dyllick and Muff, 2015). In contrast, and aligned with the sentiment expressed in **Table 5**, the sustainability-oriented innovation literature asserts that the responsibility of business is to create value through products and services that go beyond creating economic growth (Adams et al., 2015; Bocken et al., 2015; Charter et al., 2008; Dyllick and Muff, 2015; Hall et al., 2010; Hansen and Große-Dunker, 2013; Schaltegger and Wagner, 2011).

⁶² Section 3.2.1. and **Figure 14** explain the inside-out and outside-in perspectives further.

⁶³ As per the notion of “the business of business is business” (Milton Friedman, 1970 in Dyllick and Muff, 2015; p. 8).

It has been argued that “sustainable innovation is a process, the sustainability considerations of which (i.e. environmental, financial and social) are integrated into company systems from idea generation through R&D and commercialisation. This applies to products, services and technologies, as well as new business and organization model”(Charter et al., 2008; p.58). Others have built on this notion (e.g. Boons et al., 2012) and, at the same time, acknowledged that the drivers of such innovations at the organizational level are better understood than its execution (p.2). Since Charter et al. (2008), others have explored this gap in the research landscape.

Recently, two reviews of the sustainability-oriented innovation literature have proposed summary frameworks. Firstly, Adams et al. (2015) identified and reviewed 100 journal papers, 22 grey literature articles and five blogs to answer the question “What are the innovation activities firms engage in to become sustainable?” Through their review they developed a sustainability-oriented innovation model (**Figure 15**) and assert that businesses are pushed by regulation to engage in ‘Eco efficiency’ at the microlevel of the firm. In contrast, a sustainable business impacts the macro level of society and results in “radical change at the large-scale systems level” (Adams et al., 2015; p.2), where the authors refer to the socio-economic “system beyond the firm’s immediate boundaries and stakeholders” (Ibid.; p.5). Therefore, their argument aligns with the assertions of Dyllick and Muff (2015) on the ability of business to link the micro and macro level. Adams et al. (2015) conclude that the final model of sustainability-oriented innovation they propose (**Figure 16**) is a useful tool for decision makers to understand change and influencing points within their respective businesses. This understanding will enable the decision makers to make their businesses more sustainable.



Figure 15: Sustainability-oriented innovation dimensions (Adams et. al., 2015; p.3)

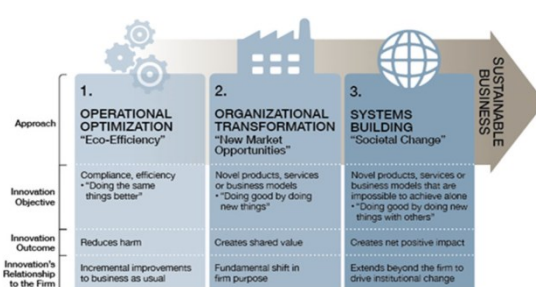


Figure 16: Final model of sustainability-oriented innovation (Adams et al., 2015; p.6)

The framework (**Figure 16**) developed by Adams et al. (2015) is based on the aspiration of businesses to conduct sustainability-oriented innovation in business. In effect, the authors have created a guidance framework for decision makers. However without the wide-spread adoption of

sustainability-oriented innovation, such innovation is worthless (Boons and Lüdeke-Freund, 2013; Hall and Vredenburg, 2004). Furthermore, it has been recommended that the sustainability-oriented innovation⁶⁴ process needs more freedom in execution than conventional innovation (Paech, 2007). The heart of the argument is that such an approach will allow an iterative solution development that is suitable to the high uncertainty associated with addressing sustainable development challenges (Jay and Gerard, 2015; Paech, 2007).

The second academic review of the sustainability-oriented innovation literature was led by Jay and Gerard (2015). They set out “to provide a broad understanding of the concept and process of sustainability-oriented innovation”⁶⁵ (Jay and Gerard, 2015; p.4) through a collaborative research paper. Their research is less focussed on businesses conducting sustainability-oriented innovation than the review by Adams et al. (2015). As a result, the innovation dimensions they offer are broader, and they also separate the radicalness of the innovation impact⁶⁶ from degrees of sustainability (i.e. ‘sustainability-orientation’) (**Figure 17**). However, the evaluation framework offered has two similar dimensions: innovation objective (Adams et al., 2015) and the alignment of mission, goals and objectives (Jay and Gerard, 2015); and approach (Adams et al., 2015) and sustainability potential for systemic impact (Jay and Gerard, 2015).

Overall, the framework offered by Adams et al. (2015) is more clearly positioned for a business audience and summarises impact and input dimensions of pursuing sustainability-oriented innovation. In contrast, the catch-all approach offered by Jay and Gerard (2015) appears fragmented with subsections covering organizational capabilities, operations and general categories such as ‘urgency’ and stakeholders (**Figure 18**).

⁶⁴ According to Paech (2007; p.1), innovation is a “*non-constant, non-linear mode of change*”, however it is unclear how the author derived this assertion. The need for testing of condition during the innovation process is backed up by other academic resources.

⁶⁵ The authors ask four detailed questions to achieve this aim. (1) Sustainability-orientated innovation Definition. What are the characteristics of it, and how does it differ from conventional modes of innovation? (2) Process. How does sustainability-orientated innovation occur? Who is involved, at which stages, and in what capacities? What are some major barriers and critical success factors? (3) Incubation. How can it be incubated and accelerated to reach broad diffusion? (4) Evaluation. How can we evaluate the quality and potential of an sustainability-orientated innovation a priori in order to guide and prioritize subsequent investments and efforts?

⁶⁶ The authors use the term ‘rate’ for their incremental to radical scale; along the same dimension Jay and Gerard (2015) also use a sustaining to disrupting scale.

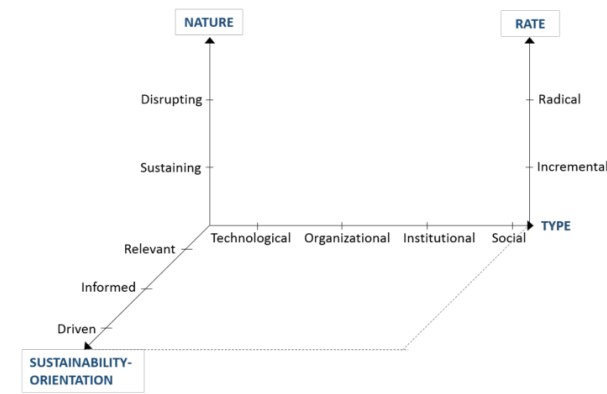


Figure 17 : Sustainability-oriented innovation dimensions (Jay and Gerard, 2015; p.16)

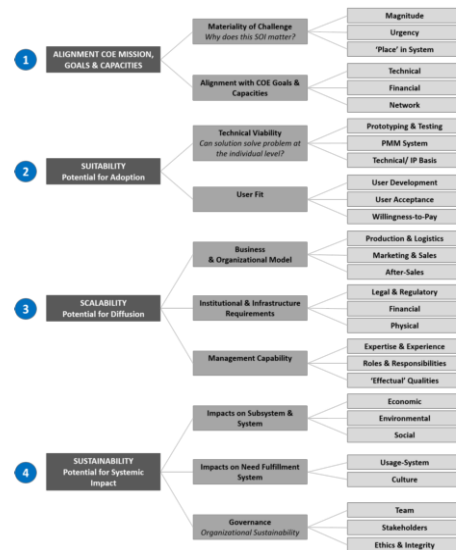


Figure 18: Sustainability-oriented innovation evaluation framework (Dimension & Aspect levels) (Jay and Gerard, 2015; p.9)

The evaluation framework offered by Jay and Gerard appears not very refined in its categories and sections. The authors acknowledge elsewhere in their review that theirs is a work in progress⁶⁷. They do, however, offer a comparison between sustainability-oriented innovation and conventional innovation (**Table 6**).

	'Conventional' innovation	Sustainability-oriented innovation
Nature of need	- Private (Corporate)	- Private (Corporate) - Public (environmental and/or social)
Roles	- Private-problem holder - Incl. Corporate-problem holder - Champion - Knowledge holder - Infrastructure holder	- All of the 'conventional' ones - Public-problem holder (systematically)
Externality problem	Single externality (innovation phase)	Double externality (innovation and diffusion phases)
Challenges / Obstacles⁶⁸	- Access to funding - Innovation culture	- All of the 'conventional' ones - Directional risk

⁶⁷ Their paper has been created with the view to invited other academics in the field to create a Centre of Excellence at the MIT Sloan School of Management.

⁶⁸ In the 'Challenges/Obstacles' row of the table, the original sustainability-oriented innovation column includes the characteristic 'Relationship to imitation?'. This has been removed in **Table 6**. The question mark implies that the authors were uncertain whether to include it and have not received sufficient input from the reviewers and contributors on this point. Neither is it clear from the full text what the authors refer to, another indicator that removal is prudent.

	• Fiscal and regulatory system • Education and training • Coordinated support • Predictability of patterns of final consumer demand	• Success definition and evaluation • User vs. system design duality • Governance (for collaboration across seemingly antagonistic agents) • Lack of innovation management knowledge
Critical success factors	• Inferred from the list of challenges (including interdisciplinary knowledge, appropriate infrastructures, communication/ leadership training)	• All of the 'conventional' ones • User-System-Design thinking methodology • Economic tool to size the market potential of sustainability-oriented innovation • Environmental and social evaluation tool to characterize (and potentially reward) the conventional benefits of sustainability-oriented innovation • Education and training in sustainability and systems thinking

Table 6: Characteristics of sustainability-oriented innovation versus 'conventional' innovation (Jay and Gerard, 2015; p.42)

The summary in **Table 6** implies that sustainability-oriented innovation includes all the input and process components of conventional innovation – plus additional characteristics. The notion of sustainability-oriented innovation going beyond 'conventional innovation' is asserted by others too (Boons et al., 2012; Charter et al., 2008). According to Jay and Gerard (2015) the critical success factors include evaluation tools. This mirrors the assertion of Dyllick and Muff (2015). Based on the summaries by Dyllick and Muff (2015) and Jay and Gerard (2015), two assertions can be made. Firstly, sustainability-oriented innovation includes more characteristics than 'conventional' innovation. It has been argued that despite literature referring to complexity in different ways in the context of innovation⁶⁹, they all share one commonality: factors that influence the process of innovation *"integrated together cause difficulties in transforming into successful products/processes"* (Wonglimpiyarat, 2005; p.866). The more factors there are, therefore, the higher the innovation complexity. Sustainability-oriented innovation has more factors than conventional innovation and this means sustainability-oriented innovation is more complex than conventional innovation. Secondly, the outputs of sustainability-oriented innovation activities should be measurable⁷⁰. Following on from these literature assertions, it can be argued that pursuing sustainability-oriented innovation is more challenging for businesses than pursuing 'conventional' innovation, irrespective of the radicalness of the innovation activity pursued.

3.2.4 Radicalising innovation for sustainability in established businesses

The murky waters of the innovation and sustainability terminology might be the reason for the lack of research in the field of radical innovation for sustainable development, as highlighted by Hansen

⁶⁹ Terms used according to Wonglimpiyarat (2005) are organizational complexity, product complexity and technological complexity.

⁷⁰ Of course, the outputs of conventional innovation activities should be measurable too.

and Große-Dunker (2013). Or, as Hansen and Große-Dunker (2013) coin the term, ‘radical sustainability-oriented innovation’ has been identified as a research field that merits exploration going forward (Boons et al., 2012), especially from an innovation process perspective, to enable the dramatic reduction of carbon emissions and current resource use. It has long been acknowledged that sustainable development challenges require a “*radical step change*” (Charter et al., 2008; p.47), though the details of what this means at the firm level have not yet been offered.

Some literature explicitly states that sustainability-oriented innovation and radical innovation have similar characteristics (Schaltegger and Wagner, 2011; p.232): creating ‘new to the world’ markets, incorporating a new technology, and requiring new production skills. Furthermore, it has been proposed that that ‘radical sustainability-oriented innovation’ is explicitly linked to entrepreneurship – and entrepreneurs are the main drivers of radical innovation (Hall et al., 2010; Hansen and Große-Dunker, 2013). Entrepreneurship is covered in detail in chapter 5. However, here it is worth mentioning the observation that “*competency-destroying radical innovation is needed*” (Hall and Vredenburg, 2004; p.62) to meet the scale and urgency of sustainable development challenges. This mirrors the conclusion made earlier in this thesis on the need for radical innovation to create new technical and social abilities as per the innovation framework offered by Linton (2009).

Dewberry and de Barros (2009) explored how organizations might create an organizational culture with values and attitudes as input to create more radical innovation for sustainability. Through the first stage of the UK government-funded project⁷¹ that formed the basis of the Dewberry and de Barros (2009) research they found that two key points emerged through 15 interviews. Firstly, the people within organizations agreed that individuals were at the core of driving sustainability activities in business. Secondly, the first stage of their project found that the value-system of individuals must be reflected in the organizational value system to further sustainability. The second stage of the research project was looking to link the nature of organizational decision making inside the organization with the organizational outputs, i.e. products and services. However, in the final conclusion of their paper, Dewberry and de Barros revisit the first project stage findings and state that “*the need to rethink current business response to sustainability*” will be “*influenced by the ability of individuals to make sense of goals of sustainability on a personal level*” (Dewberry and de Barros, 2009; p. 37). The authors do not define what they mean by “the need for more radical innovation” in their paper title beyond stating that such innovation is different to traditional innovation in that it goes beyond responding to new technology and market demands.

⁷¹ Called Design Dialogues, funded by the UK Engineering and Physical Sciences Research Council, it ran 2005-2008.

3.2.5 Impact of innovation on business models

This research uses the term radical innovation to encompass innovation impacts, activities and processes along novelty of the social and technical dimensions, leading to discontinuities at both the micro and macro level (Garcia and Calantone, 2002; Linton, 2009). This is combined with the business producing social and environmental value as opposed to solely economic value (Hansen and Große-Dunker, 2013; Schaltegger et al., 2012; Schaltegger and Wagner, 2011).

Such innovation leads to previously untapped value propositions and corporate product and service offerings. They result in business model changes. A business model has been described as an articulation of how a firm converts organizational capabilities and available resources into economic value, i.e. value for customers who are prepared to pay for the offered products, services or information (Teece, 2010). Others have proposed that a business model consists of nine elements⁷², with the unique combination of components and their redesign forming the basis for industry change (Osterwalder and Pigneur, 2009).

Several authors have portrayed (sustainable) business models as an appropriate framework for systems-level change, including Baden-Fuller and Morgan (2010); Bocken et al. (2014); Boons and Lüdeke-Freund (2013); Boons et al. (2012); Porter and Kramer (2011); Schaltegger et al. (2012). Therefore, sustainable business models may be the conceptual and practical bridge between the micro level of the firm and the macro level of the market.

However it has been argued that *“it has remained to a large degree unclear”* (Dyllick and Muff, 2015; p.6) how social, environmental and economic values created or preserved by businesses and their trade-offs should be *“measured and compared”* (Dyllick and Muff, 2015; p.6). Therefore, a focus on business models as a means to link the micro level of organizations and the macro level of an industry or geographic region is not specific enough in itself. Rather, the business model innovation has to be set in the context of specific and measurable social, environmental and economic goals. This has been suggested by the academic literature (Dyllick and Muff, 2015) as well as the grey literature (Ignatius, 2012).

Without the specific and measurable goals as proposed by Dyllick and Muff (2015), the search for a sustainable business model would quickly elevate into the meta discussion about sustainable

⁷² The 9 elements are Key Activities, Customer Relationships, Key Partners, Customer Segments, Key Resources, Value Propositions, Channels, Cost Structure and Revenue Streams (Osterwalder and Pigneur, 2009; p. 18-19).

business activities in tension with the capitalist system (Porritt, 2005). It would become the search for a business model that can challenge the neoclassical economic worldview (Boons and Lüdeke-Freund, 2013; Porritt, 2005). However, such a search is unlikely to drive the business response to sustainability in established firms. There is the challenge of adapting their inputs, processes and outputs to sustainable development challenges (Dyllick and Muff, 2015), with a starting point mainly driven by economic value capture (Porter and Kramer, 2011).

3.2.6 Summary

Economic growth is not equal to 'development' (Sneddon et al., 2006). Rather, economic development has to be combined with social and environmental development (Boons et al., 2012; Charter et al., 2008; Elkington, 1994).

Large firms can address more sustainable development issues at the same time than small firms are able to, because they have more resources and established sustainability management systems (Schaltegger et al., 2014). However, small firms can act more quickly (Hockerts and Wüstenhagen, 2010) to respond to sustainable development challenges and it has been asserted that large businesses and small firms will co-evolve (Hockerts and Wüstenhagen, 2010). Business can connect micro-level sustainability progress with macro-level environmental and social deterioration (Dyllick and Muff, 2015). Even for businesses looking to gain legitimacy in society through addressing sustainable development challenges, pursuing economic viability is needed for longer term business survival (Schaltegger and Hörisch, 2015).

A framework of Input, Process and Output helps to consider different business approaches to address sustainable development challenges (Dyllick and Muff, 2015). It is the responsibility of business to create value through products and services that go beyond creating economic growth (Adams et al., 2015; Hall et al., 2010). The organizational innovation process is key to creating triple bottom line value (Charter et al., 2008), however implementation of sustainability-oriented innovation at the firm level is under-researched (Boons et al., 2012).

Guidance frameworks on sustainability-oriented innovation for decision makers in organizations endeavour to highlight organizational change and influencing points in firms (Adams et al., 2015). However, the literature shows that guidance frameworks can get so detailed (Jay and Gerard, 2015) that they become meaningless for decision-makers in practice.

At the same time, sustainability-oriented innovation is already more complex than conventional innovation - simply because there are more factors involved in such innovation (Charter et al., 2008; Jay and Gerard, 2015). This means more uncertainty. Paradoxically, the solution called for by the sustainability-oriented innovation literature is the creation of innovation output evaluation tools.

Radical sustainability-oriented innovation has been proposed as a suitable mechanism to address urgent sustainable development challenges, however this is a new field of theory with little research conducted to date. Nonetheless, it has been asserted that radical innovation with a sustainability dimension requires new social and technical abilities (Charter et al., 2008; Hall and Vredenburg, 2004).

At the level of individual participants in organizational innovation activities, it has been argued that the value-system of individuals must be reflected in the organizational value system to implement sustainable development (Dewberry and de Barros, 2009). Furthermore, the ability of individuals to make sense of sustainable development goals on a personal level is needed to drive the business response to sustainable development challenges (Dewberry and de Barros, 2009).

New business models with triple bottom line value creation are an output of a business endeavours to create social and environmental value whilst capturing economic value. Sustainable business models may bridge the micro level of the firm with the macro level of the market (Boons et al., 2012; Porter and Kramer, 2011). Finally, it is the role of the innovation project leader to articulate measurable sustainable development goals in the context of sustainable business models at organizational output of sustainability-oriented innovation activities (Dyllick and Muff, 2015).

3.3 Time as a boundary for innovation

Time is limited for businesses to act in order to reduce the CO₂e and resource impacts of their products, services, and operations. However, taking radically new products and services from an idea to market adoption also takes time (Golder et al., 2009; Hanna et al., 2015; Markard et al., 2012; O'Connor and Rice, 2013; Wonglimpiyarat, 2005). The coexistence of these two timelines creates a tension (Dyllick and Muff, 2015).

In this section this tension is explored through (1) the role of time in impacting the organizational ability to act swiftly when faced with complexity, and (2) the timelines associated with developing

and commercialising radical innovations. The reviewed literature that includes a sustainable development dimension is identified as such throughout.

3.3.1 Time within organizational boundaries

The embedding of time within varying social contexts has been explored by the psychology (e.g. Schriber and Gutek, 1978), organizational studies (e.g. Halbesleben et al., 2003; Poole, 2004; Tsoukas and Chia, 2002) and the sensemaking (e.g. Maitlis and Christianson, 2013) literature.

There are different perspectives of exploring innovation speed at the organizational level: Newtonian, transactional, dominant-cultural, and organizational. Each of the four perspectives on time (**Table 7**) corresponds to a different role in the theory of change and innovation, as well as to a timescale in the research of organizations (Poole, 2004).

Perspective on Time	Time's Role in Theory	Time Scales
Newtonian	medium	existence interval
transactional	variable	validity interval
dominant-cultural	predisposition	observation interval
organizational	social construction	recording interval aggression interval

Table 7: Key distinctions related to time in theories of change and innovation (Poole, 2004; p. 22)

Time in its purest form without 'contamination' from human interpretation is Newtonian time. Newtonian time is a "*linear continuum*" (Poole, 2004; p. 21) that can be divided in units (e.g. each day of the week has the same number of hours). In contrast, the perspective of transactional time attaches importance to key events (e.g. the key event irrespective of the day of the week). These key events determine the validity intervals of research. Key events may be identified by the researcher or the research subjects during the study of innovation. The dominant-cultural perspective adds the human experience to Newtonian time (e.g. Sundays have different meaning for Christian people than Mondays). Finally, the organizational perspective on time puts key events on a linear continuum; so this perspective is a combination of Newtonian and transactional perspectives (Poole, 2004). The four perspectives on time are not exclusive to each other and throughout organizational innovation activities, the relationships between the four perspectives influence organizational change. For each innovation activity the relationship dynamics vary, perhaps one of the reasons why time as an explicit change element is often reduced out of organizational studies (Poole, 2004; Tsoukas and Chia, 2002).

The perspective of time is much less ambiguous when it comes to the natural world. Sustainable development challenges derive from the fact that economic value is derived from social value, derived from environmental resources (Senge et al., 2008) as illustrated in **Figure 14**. Whereas time and space is compressed in organizations (Dyllick and Muff, 2015; Poole, 2004), the natural world has absolute “temporal and spatial features”⁷³ (Dyllick and Muff, 2015; p.4). Sustainable development challenges, therefore, need to be addressed within a finite Newtonian timeline through innovation activities. However, the response to the sustainable development challenges requires human action, which makes the perspective on time rather less straightforward: “While time and space are as fundamental to the human sciences as they are to the natural sciences, they are more variegated, lumpy, and idiosyncratic in the social world than in the physical world” (Poole, 2004; p. 25).

Perhaps unsurprisingly, the ability of leaders to deal with temporal challenges in the context of innovation has been argued to be a key success factor for longer term business survival (Halbesleben et al., 2003).

3.3.2 Time & complexity

It is the emerging consensus that complexity in the context of organizational studies is both ontological and epistemological, about the combination of effects from different factors (i.e. ontological) and how combinations are interpreted (i.e. epistemological) (Maguire et al., 2006). A change in organizations as complex systems (**Table 8**) is due to the different states of the different factors. Researchers may choose to break down organization as a complex system into component parts and corresponding factors (Maguire et al., 2006).

Features of complex systems	
1	Complex systems consist of a large number of elements
2	These elements interact dynamically
3	Interactions are rich; any element in the system can influence or be influenced by any other
4	Interactions are non-linear
5	Interactions are typically short-range
6	There are positive and negative feedback loops of interaction
7	Complex systems are open systems
8	Complex systems operate under conditions far from equilibrium
9	Complex systems have histories
10	Individual elements are typically ignorant of the behaviour of the whole system in which they are embedded

Table 8: Features of complex systems (Cilliers, 1998 in Maguire et al., 2006; p. 166)

⁷³ Dyllick and Muff (2015) draw on Bansal and Knox-Hayes (2013): The time and space of materiality in organizations and the natural environment in ‘Organization & Environment’ for this assertion.

The features shown in **Table 8** further assert that the characteristics of sustainability-oriented innovation offered by Jay and Gerard (2015) (**Table 6**) indicate that such innovation includes higher levels of complexity than conventional innovation. In particular, the higher numbers of elements (i.e. feature 1 in **Table 8**) relating to sustainability-oriented innovation in comparison to conventional innovation back this assertion. Furthermore, the assertions of Poole (2004) that the timescales in organizations are 'lumpy' due to the human interaction, and that the perspectives of time (**Table 7**) and their relationships to each other influence each other throughout organizational change, indicate that innovation activities in firms exhibit features of complex systems. This makes the uncertainty associated with innovation outcomes high.

It has long been asserted that the uncertainty associated with the outcome of different factor combinations are what is difficult for innovation activities (Leifer et al., 2001; Linton, 2009; Nelson and Winter, 1977; O'Connor and Rice, 2013): these difficulties may be called success and failure factors (Sandberg and Aarikka-Stenroos, 2014). Uncertainty means, in essence, that humans "*live in a future that moves away as fast as we try to approach it*" (Hofstede, 2001; p. 145), and decisions about the future will always include an element of uncertainty. Organizations address and cope with uncertainty through technology, rules and rituals (Hofstede, 2001). Technology as replacement for human input makes process outcomes more predictable in the short term⁷⁴, whilst rules serve to increase the predictability of human behaviour (Hofstede, 2001). Useful rules set "*energies free for other things*" (Hofstede, 2001; p. 147) and bad rules destroying organizations because the people who make them have different values than those people "*who have to follow*" (Ibid.) organizational rules. Finally, social rituals in organizations, for example the writing of reports or planning and accounting systems, serve the purpose of allowing people in organizations to appear to control their future and "*to continue their lives in the face of otherwise intolerable uncertainty*" (Hofstede, 2001; p. 148). Rituals also serve the purpose of increasing the bond between members of an organization (Hofstede, Ibid.).

The three uncertainty coping mechanisms outlined by Hofstede (2001) are needed in firms that address sustainable development challenges because the content and the urgency of these challenges increases as time goes by, necessitating fast action. However, it has been argued that complexity is linked to the inability to act quickly, resulting in the slowing down of activities, both

⁷⁴ Although Hofstede (2001; p. 147) highlights that using technology to reduce uncertainty "*looks extremely rational but it hides implicit nonrational value choices.*"

within the business context (Kotter, 2012; Van de Ven, 1986) and in the business and sustainable development context in developing markets (Chen et al., 2015). At the heart of the argumentation of ‘complexity results in an inability to act’ (Poole, 2004) is that balancing conflicting information means that individual decision makers can’t rely on familiar information processing. Rather, decision makers have to engage in deliberate problem solving, either by themselves or through communicating with others (Chen et al., 2015; Kotter, 2012; Raaijmakers et al., 2015; Van de Ven, 1986).

One might intuitively argue that more difficult innovation processes from ideation to wide-spread commercialization (i.e. processes with a high level of complexity) take more time than easy innovation processes, i.e. processes with a low level of complexity. However, case study research argues that this is not the case (Wonglimpiyarat, 2005). The author uses the three stages of ‘innovation acceptance by potential users’ over ‘time’ as proposed by Utterback and Abernathy (1975) to represent the innovation process: develop, deliver, and market. Solely ‘develop’, the conception of the technical basis for the innovation to the launch within organizational boundaries, *“took considerable time”* (Wonglimpiyarat, 2005; p. 880) according to the case study research conducted. This finding seems to be linked to dealing with uncertainty and complexity, as it has been asserted that identifying radical innovation opportunities is very difficult for practitioners (Ashford and Hall, 2011). In contrast, ‘deliver’ and ‘market’ were not affected by increased complexity according to the case study research by Wonglimpiyarat (2005).

The generalisation that ‘develop’ takes more time due to the higher complexity associated with this stage of the innovation process is made on the basis of six case studies. Wonglimpiyarat (2005) acknowledges that further research with replication of her analysis framework is needed to explore this generalisation further. Nevertheless, the systematic breakdown of key factors as associated with the innovation process and their respective ease and difficulty may be a useful way for managers to assess capability gaps within their organizations and to identify radically novel combinations based on reasonable hunches (Ashford and Hall, 2011). This interpretation is aligned with the argument that *“(..), defining and understanding what constitutes complexity involves defining and understanding what constitutes information within and about a system”* (Maguire et al., 2006; p. 170). I go on to explore some ‘rules and rituals’ (Hofstede, 2001) proposed by the theory to enable organizations to cope with complexity and uncertainty of radical innovation, whilst acting at speed.

3.3.3 Rules and rituals to enable fast radical innovation processes in the face of complexity

Recent consultancy research looked to evaluate how quickly organizations and managers within these organizations were able to adapt to changing operating environments. This consultancy research explored the link between speed⁷⁵ and organizational stability⁷⁶ in 2014 (Bazigos et al., 2015). They surveyed 161 businesses through 365,000 individual employees between November 2013 and October 2014. The authors asserted that the 12% of surveyed businesses with the ability to balance speed and stability – called ‘agile’ organizations by the authors- had the best organizational health: “*..align, execute, and renew [...] faster than the competition [...] and [...] sustain exceptional performance over time*” (Bazigos et al., 2015; p.1).

The research report by (Bazigos et al., 2015) uses the terms ‘agile’ and ‘startup’ to describe the businesses that show this positive correlation. However, there is no theory link to the practice of agile development or startup literature, either from grey or academic sources. Nevertheless, the report findings are interesting because they show that the top performing ‘agile’ (i.e. fast moving and stable) businesses have a set of management practices that strongly differentiate the most ‘agile’ from the least ‘agile’ businesses. These management practices are (1) role clarity, (2) top-down innovation, (3) capturing external ideas, (4) process-based capabilities, (5) operationally disciplined, (6) internally competitive, (7) meaningful values, (8) knowledge sharing, (9) inspirational leaders, and (10) people-performance review. These ten practices are associated with organizational outcomes. The outcome of ‘Innovation and learning’ is the most important⁷⁷ (Bazigos et al., 2015; p.5) because it is the only outcome associated with three differentiating management practices: [2], [3], and [8]. The research does not contain a sustainable development component. However, the management practice of having ‘meaningful values’ [7] is closely related to the business response to sustainable development challenges (Bocken et al., 2015; Schaltegger and Wagner, 2011) and the assertion of Hofstede (2001) that the basis of good organizational rules are aligned values between the rule makers and the rule followers. The link between values and the business response to sustainable development challenges is further explored in the entrepreneurship section 5.3 of chapter 5.

Even if the findings of Wonglimpiyarat (2005) with regards to the time associated with developing and commercialising innovations associated with highly complex factor variables may not hold true;

⁷⁵ Speed was measured “by asking survey respondents how often they observed their leaders (and separately, managers) making important decisions quickly and their organizations adjusting rapidly to new ways of doing things” (Basigoz et. al, 2015; p. 7).

⁷⁶ Stability was measured “by asking respondents how often they observed their organizations implementing clear operating goals and metrics, setting clear standards and objectives for work, establishing structures that promote accountability, designing jobs with clear objectives, and devising processes to document knowledge and ideas” (Basigoz et. al, 2015; p. 7).

⁷⁷ Followed by the associated outcomes of ‘culture and climate’ and ‘motivation’ (joint 2nd place), then ‘accountability’, ‘capabilities’, ‘coordination and control’ (joint 3rd place).

it seems that breaking innovation complexity down into key factors and their respective difficulty is much needed to enable action within organizations.

A longitudinal study of 12 radical innovation⁷⁸ projects in ten large U.S. companies resulted in a multidimensional model of radical innovation uncertainties (O'Connor and Rice, 2013). This three-dimensional framework splits innovation uncertainties along the two axes of 'latency' and 'criticality' (Figure 19), and into four categories: technical, market, organizational, and resource (Figure 20).

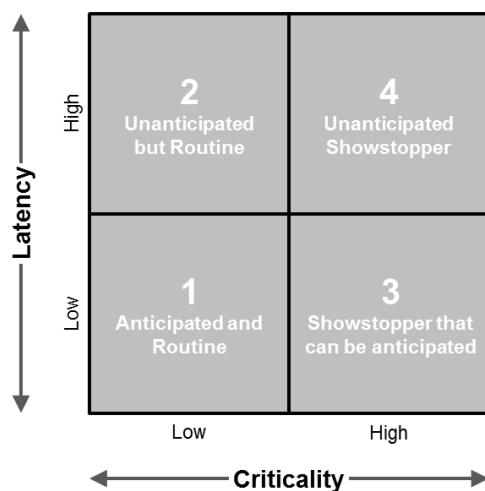


Figure 19: Criticality versus Latency (adapted from O'Connor and Rice, 2013; p.14)

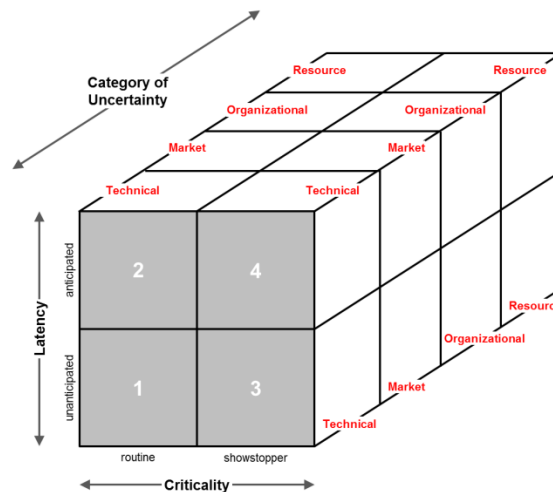


Figure 20: Three dimensions of project uncertainty (adapted from O'Connor and Rice, 2013; p.15)

The 'latency' and 'criticality' radical innovation framework axes of O'Connor and Rice (2013) break down the innovation success factor scales as proposed by Wonglimpiyarat (2005) into specific categories. In contrast to Wonglimpiyarat (2005), the findings of the 2013 research by O'Connor and Rice do not assert that the early stages of the innovation life cycle (develop, deploy, market) is more time-intensive due to uncertainty.

Rather, O'Connor and Rice (2013) assert that criticality constantly fluctuates across their four categories (technical, market, organizational, resource) of uncertainty. Managing this fluctuation is the key challenge for radical innovation project teams and may require increased time and effort (O'Connor and Rice, 2013) –resulting in a 'lumpy' organizational timescale (Poole, 2004). However, O'Connor and Rice (2013) found that even 'showstoppers' –*"a critical discontinuity or transition"*

⁷⁸ Defined as "a product, process, or service with either unprecedented performance features or with such dramatic changes in familiar features or cost that new application domains become possible. Radical innovations transform existing markets or industries, or create new ones" (O'Connor and Price, 2013; p. 3).

(O'Connor and Rice, 2013; p.15)- that could be anticipated⁷⁹ to be major obstacles to radical innovation activities were sometimes ignored. This was the case when project managers were uncomfortable with the categories of uncertainty that were showstoppers. Of the four project uncertainty categories, *“management seemed more comfortable dealing with technical uncertainties than others”* (O'Connor and Rice, 2013; p. 16).

The usefulness of managing innovation uncertainty frameworks such as proposed by O'Connor and Rice (2013) and Wonglimpiyarat (2005) is not further explored by currently available follow-up research. This is not surprising according to this recent assertion by Raaijmakers et al. (2015): *“(..), we are only just beginning to identify how decision makers navigate complex environments under various conditions”* (Raaijmakers et al., 2015; p. 104). However, the need for decision-makers within firms to engage in complexity in order to develop sound organizational strategy has strongly been asserted by Spender (2014).

It has been argued that decision-makers who engage in many decision-making factors during innovation processes will make bad decisions due to stereotyping. Stereotyping enables decision-makers to cut through decisions that involve more than five to nine separate decision components (Miller, 1956 in Van de Ven, 1986). The more complex the decision situation is, the more the decision process (as opposed to the information that feeds into the process) dominates the evaluation that leads to the final decision (Van de Ven, 1986). It thus follows that a complex decision situation with a highly refined decision-making process has the same uncertain – or erroneous- future outcome as a complex decision situation without a refined decision process. However, decision makers are likely to feel better because they see the refined decision process as a means to legitimize their decision (Van de Ven, 1986). Therefore, frameworks that focus on the information that feeds into a decision-making process (O'Connor and Rice, 2013; Wonglimpiyarat, 2005) may be usefully combined with established process tools such as stakeholder engagement. This strongly aligns with the Hofstede (2001; p.147) assertion that organizations cope with uncertainty through *“technology, rules and rituals”*. It seems that applying process tools well has the potential to speed up the three perspectives on time (transactional, dominant cultural, organizational), as highlighted by Poole (2004; **Table 7**), as a cause of a firm timescale that is slower than the timescale of the natural environment (i.e. Newtonian). Speeding up of organizational innovation processes, as complex and

⁷⁹ An example of an anticipated showstopper (cell 3 in Figure 20) is the use of a limited amount of governmental funding *“which had a clear end date”* (O'Connor and Rice, 2013; p.15).

uncertain as they may be for decision-makers in firms, is necessary to meet sustainable development challenges.

3.3.4 Radical innovation commercialization speed

It has been argued that radical process innovation⁸⁰ is positively related to innovation speed (Goktan and Miles, 2011): the more radical the process innovation, the faster the innovation speed. The survey-based research upon which this assertion is based took place in the high-tech industry⁸¹ because of its highly competitive nature, which results in a high speed of change in the industry and requires the ongoing development of new organizational capabilities (i.e. radical process innovation). The authors acknowledge that the survey respondents have different views of radical innovation but still assert that there is also a positive link between radical process and product innovation according to their survey findings. In other words, radical product innovation and radical process innovations go hand in hand within organizations. The authors assert that future research should explore the link between radical product innovation and radical process innovation further.

Others have argued that radical innovation impact is characterized by longer term timelines: 10 years or more (O'Connor and McDermott, 2004), about 20 years for post-1945 innovations (Goktan and Miles, 2011), 42 years (Hanna et al., 2015), and more than 50 years for pre-1945 innovations (Goktan and Miles, 2011).

How customers benefit from radical product and process innovations is key to all business innovation activities because increased customer value means increasing the company market share in the existing market or growing a new market from scratch. However, radical product innovations that mean substantial new customer benefits are rare. A 2009 review that assessed customer benefits of product innovations since 1900 asserts that there are only 29 radical innovations that brought substantial new customer benefits (Golder et al., 2009). The authors define radical innovations “*as new products that provide substantially higher customer benefits relative to previous means of providing similar benefits*” (Goktan and Miles, 2011; p. 168), include global data and divide data collection up into three time periods: pre-1900, 1900-1945 and post-1945. The authors identify 29 radical innovations and assert that they take more than 50 years from first appearance to widely

⁸⁰ The research survey conducted by Goktan and Miles (2011) included the following definition of innovation radicalness: “Radicalness is determined by the degree of newness of the innovation. The most radical innovations are innovations that are new to the world.” (Ibid.; p. 540)

⁸¹ 500 companies from the semi-conductor, audio video equipment and computer hardware industries, all with more than 10 employees were randomly selected. The survey had a 9.4% response rate.

adopted commercialization⁸² (called ‘macrocommercialization’ by the authors) for pre-1945 innovation. Post-1945 innovation takes on average 20 years according to Goktan and Miles (2011). With regards to the pre- and post-1945 timeline and the speedier commercialization after WW2, the findings mirror those of Chandy and Tellis (2000), who assert that large businesses are responsible for a larger number of radical innovation introductions to the market than small businesses post-1945. It has been summarised that this shift is due to the fact that large firms have learned to develop “*dynamic organizational structures and cultures*”(Van de Ven and Engleman, 2004; p. 49), improve technological competencies, and learned to cannibalize smaller competitors that may threaten their position in the market (Van de Ven and Engleman, 2004). The high-tech industry assertions of Goktan and Miles (2011) about large firms benefitting from developing specific capabilities to speed up the innovation process are therefore mirrored in the arguments of Van de Ven and Engleman (2004).

Recent sustainability-related research has also investigated the time it takes for technological innovation to go from fundamental research to wide-spread commercialisation. This research was prompted by the need to use technology to reduce CO₂e emissions (Hanna et al., 2015). Their product-level research findings, based on the review of 14 innovations, are comparable to the less specific “*50 years and more*” (Markard et al., 2012; p.956) timeline suggested by Markard et al. (2012) for social-technical transitions⁸³, and, hence, sustainability transitions⁸⁴ that were not given a separate timeline by Markard et al. (2012). The 2015 research found that innovations that aim to create new markets take 42 years “*from invention to widespread commercialisation*” (Hanna et al., 2015; p. 75), therefore radical innovations take 42 years to commercialise. In contrast, innovations that replace existing products take less time to achieve widespread commercialisation: on average 29 years. Both types of innovations take roughly the same amount of time for the early stages of innovation (i.e. invention, development, demonstration phases) and the latter stages (i.e. market deployment, commercialisation phases).

⁸² Annual average sales “*are nearly 1 million units*” (Golder et al., 2009; p. 170)

⁸³ According to Markard et al. (2012) socio-technical transitions involve ‘far-reaching changes’ along the following dimensions: (1) technological, (2) material, (3) organizational, (4) institutional, (5) political, (6) economic, and (7) socio-cultural. According to Markard et al. (2012), new products, services, business models and organizations may substitute or complement these existing market components during a transition. A major drawback of this all-encompassing ‘definition’ of socio-technical transitions is that anything and everything can be included. This is acknowledged by Markard et al. (2012) in their concluding remarks when they acknowledge that the research community is “*just beginning to understand the analytical and practical implications of fundamental shifts in established socio-technical systems*” (Markard et al.; p. 965). However, what is meant by ‘fundamental shifts’ remains undefined, therefore the authors do not offer any insights or guidance on how such ‘fundamental shifts’ might impact any or all of the seven dimensions of socio-technical transitions.

⁸⁴ Sustainability transitions differ from socio-technical transitions in that they are purposeful and seek long-term goals associated with shifting socio-technical systems “*to more sustainable modes of production and consumption*” (Markard et al.; p.956).

Despite presenting a linear product innovation process in the theory framing⁸⁵ for their review, the authors state in their key findings that for both innovation-creating new markets and serving existing markets, *“technologies rarely move out of the R&D stage completely following market introduction”* (Hanna et al., 2015; p. 75). Consequently, the 2015 research points to the fact that for radical innovations that look to create new markets, there is no linear innovation model and ongoing R&D is the norm, even when the radical innovation is close to or at the point of being widely commercially adopted.

3.3.5 Summary

Four perspectives on time influence organizational innovation activities, with three of those four perspectives dependent on the human interpretation of time (Poole, 2004). However, the natural environment takes only one perspective: linear Newtonian time (Dyllick and Muff, 2015). Therefore, sustainable development challenges can be addressed within a limited time window only.

The three time perspectives that include human activities and perception affect business innovation activities. Businesses have to deal with a lumpy timescale of internal events and human perception during innovation activities that address sustainable development challenges (Halbesleben et al., 2003; Poole, 2004). At the core of lumpy organizational timescales is complexity: it hinders organizational innovation and learning. Complexity in the organizational context is about the combination of effects from different factors (i.e. ontological) and how combinations are interpreted (i.e. epistemological) (Maguire et al., 2006). Complexity increases uncertainty (Hofstede, 2001) and impacts not only the business directly but also the business operating environment. It is linked to the inability to act swiftly, hence resulting in the slowing down of activities, both within the micro business context and in the macro industry/market and sustainable development context (Chen et al., 2015; Van de Ven, 1986). Complexity increases uncertainty. Organizations cope with uncertainty through rules, rituals and technology (Hofstede, 2001).

The early stage of radical innovation is most affected by complexity and uncertainty (Wonglimpiyarat, 2005). It has been shown that even without explicitly acknowledging the perspective on time, research can explore the differences between the element of time within and outside of organizations (e.g. Bazigos et al., 2015). Such research found that in the most fast moving and stable established organizations, the management practices of top-down innovation, capturing

⁸⁵ Drawing heavily on the theory of innovation life cycle by Utterback and Abernathy (1975)

external ideas and knowledge sharing are key to enabling innovation and learning (Bazigos et al., 2015).

It has been shown that it is easier for decision-makers in business to deal with technical uncertainty than with organizational, behavioural and resource uncertainty (O'Connor and Rice, 2013). As for decision-making frameworks, those might push decision-makers to engage with long-term strategy (Spender, 2014). However this is a young field of research (Raaijmakers et al., 2015). Decision makers feel better about addressing uncertainty with a decision-making process based on tools and rituals. They are useless for the outcome – but people feel better for having used them (Hofstede, 2001; Van de Ven, 1986).

Customer benefits from radical product and process innovations are key to all business innovation activities because increased customer value means increasing the company market share in the existing market or growing a new market from scratch (Goktan and Miles, 2011; Golder et al., 2009). The time it will take for technological innovation that looks to solve climate change challenges to go from fundamental research to wide-spread commercialisation⁸⁶ will be between 29 and 42 years (Hanna et al., 2015). For 'conventional' radical innovations to be widely commercialised, adoption takes between 10 and 20 years (O'Connor and McDermott, 2004). Even this is too long to meet the Newtonian timeframe of sustainable development challenges.

3.4 Characteristics of sustainability-oriented innovation

This literature review presented an interdisciplinary overview of the research landscape relevant to enable businesses to innovate new products and services within the limited time available to avoid run-away climate change. This section synthesises what the characteristics of radical sustainability-oriented innovation are from the perspective of the established firm. The synthesis is based on the three section summaries on this chapter and links literature arguments in an input, process, output framework.

Synthesis: characteristics of radical sustainability-oriented innovation

Following the assertions of others (Jay and Gerard, 2015), this research proposes that radical sustainability-oriented innovation is distinguished from 'conventional' radical innovation. As per the

⁸⁶ For radical innovations, there is no linear innovation model and ongoing R&D is the norm even when the radical innovation is close to or at the point of being widely commercially adopted (Hanna et al., 2015).

framework to consider different approaches of business sustainability offered by Dyllick and Muff (2015), the characteristics of radical sustainability-oriented innovation are offered as contribution to theory. The characteristics are structured along the input, process, and output associated with firms pursuing radical sustainability-oriented innovation.

Input characteristics of radical sustainability-oriented innovation

- Products and services are created with the view to measurably addressing sustainable development challenges (Dyllick and Muff, 2015).
- The innovation goal includes an absolute timeline associated with creating products and services, with commercialization speeds of less than 10 years (Hanna et al., 2015; O'Connor and McDermott, 2004).
- Technology discontinuities in the marketplace and the associated innovation clusters act as enablers of fast commercialization speed (Ashford and Hall, 2011; Dosi, 1982; Freeman and Louçã, 2001).
- Technology discontinuities lead to extreme uncertainty for product/service development and processes (Dahlin and Behrens, 2005; Dosi, 1982).
- Higher complexity than conventional radical innovation because of the need to consider a larger number of input, process and output factors (Hofstede, 2001; Jay and Gerard, 2015).

Process characteristics of radical sustainability-oriented innovation

- Requires new ways of search, selection and implementation (Bessant et al., 2014; Utterback, 1996), with little prior experience or theory on how to develop these new ways (Garcia and Calantone, 2002).
- Can take place in new and established firms (Leifer et al., 2000; Schumpeter, 1942).
- If taking place in established firms, sustainable development challenges are addressed holistically due to high financial resources and existing sustainability management systems (Schaltegger et al., 2014).
- Leads to the development of new innovation process capabilities (Goktan and Miles, 2011; Van de Ven and Engleman, 2004).
- Both the creation of new social and technical abilities in the firm are required (Linton, 2009; Nooteboom, 2000), specifically project management and corporate processes (Leifer et al., 2001; O'Connor and Rice, 2013).
- Exploration and conceptualisation of new technology and science is needed (O'Connor and DeMartino, 2006).

- The further removed from existing social and technical abilities, the more radical an innovation is (Garcia and Calantone, 2002; Linton, 2009; Utterback, 1996).
- The ability of individuals to make sense of sustainable development goals on a personal level is needed (Dewberry and de Barros, 2009).
- The combination of effects from different input, process and output factors (Utterback, 1996) and the interpretation of these combinations (Poole, 2004) impede the discovery of new ways of search, selection and implementation (Bessant et al., 2014).
- Specific impediments are restrictive mindsets and lack of competences (Sandberg and Aarikka-Stenroos, 2014), with the early stages of innovation activities being most affected (O'Connor and DeMartino, 2006; Wonglimpiyarat, 2005): creation, recognizing, elaboration, and articulation of radical innovation opportunities (O'Connor and DeMartino, 2006).
- Likely to occur concentrated together instead of in regular intervals over time due to technology clusters (Foster, 1986) and the innovation perspectives of the firm (Poole, 2004)
- Cannot be aided by detailed guidance frameworks (Adams et al., 2015; Jay and Gerard, 2015) due to uncertainty and inability of many practitioners to apply detailed theory concepts (O'Connor and Rice, 2013).

Output characteristics of radical sustainability-oriented innovation

- New products and services lead to the capture of economic value and the creation of social and environmental value (Boons and Lüdeke-Freund, 2013; Porter and Kramer, 2011).
- Addresses an environmental or social issue that is relevant for others in the industry or market other than the firm itself (Bocken et al., 2015; Charter et al., 2008; Elkington, 1994).
- Creation of the new product or service impacts both the micro level of the firm and macro level of the market (Dyllick and Muff, 2015).
- Creates new customer benefits (Goktan and Miles, 2011; Golder et al., 2009).

The perspective of the firm is about the capabilities needed to pursue radical innovation activities (Bessant et al., 2014) and it has been argued that the organizational innovation process is key to create triple bottom line value (Charter et al., 2008). However, implementation of sustainability-oriented innovation at the firm level is under-researched (Boons et al., 2012). Building on the characteristics of radical sustainability-oriented innovation offered above, the literature chapter 5 focuses on the process (**Table 9**) of how a business may seek to pursue radical sustainability-oriented innovation.

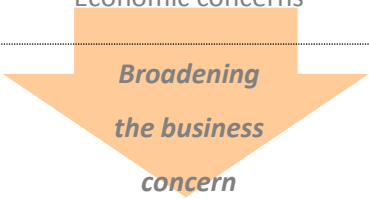
Input	Process	Output
Concerns	Organizational perspectives	Values created
What?	How?	What for?
<i>From 'Business status quo'..</i> Economic concerns  <i>Broadening the business concern</i>	<i>From 'Business status quo'..</i> Inside-out  <i>Changing the perspective</i>	<i>From 'Business status quo'..</i> Shareholder value  <i>Expanding value creation</i>
<i>..to 'Business sustainability'.</i> Starting with sustainability challenges	<i>..to 'Business sustainability'.</i> Outside-in	<i>..to 'Business sustainability'.</i> Creating value for the common good

Table 9: A Framework for Considering Different Approaches of Business Sustainability (adapted from Dyllick and Muff, 2015; p. 5 & 13)

4. Data discussion 1: characteristics of radical sustainability-oriented innovation

This chapter presents the data analysis of the 27 transcribed interviews conducted in 2013 with a view to exploring how cross-sectoral practitioners view the characteristics of radical sustainability-oriented innovation. **Figure 21** acts as a reminder of how these interviews fall within the conceptual framework of this research.

The questions asked to the interviewees were:

1. What do you consider to be radical innovation?
2. What do you consider to be sustainability-oriented radical innovation?
3. Who do you think has succeeded in radical sustainability-oriented innovation and why?

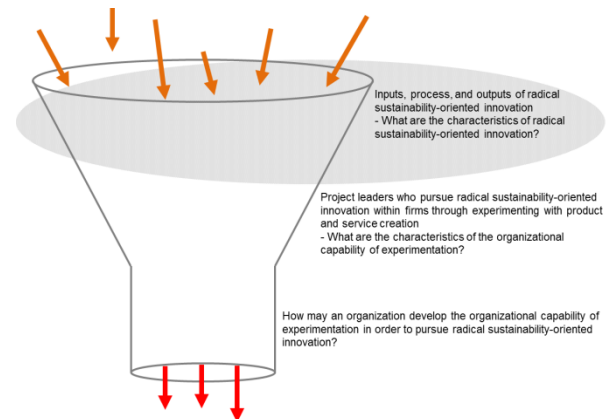


Figure 21: Radical sustainability-oriented innovation interviews in the conceptual framework

At this stage of the research, it was desired to explore the characteristics as openly as possible. One interviewee answered the second question with *“I would say that it’s [radical sustainability-oriented innovation] not different [to radical innovation]. Yeah, I would say it’s not different”*⁸⁷ (4: p.2, ATLAS.ti line 53)⁸⁸, therefore the final question was adapted to *“Who do you think has succeeded in radical innovation and why?”*. Finally, some interviewees answered with sustainable development concerns embedded in their answers at the beginning of the interview, for example: *“(..) if we don’t [solve specific sustainability problem] (..) then obviously society is going to collapse”* (29: p.1, ATLAS.ti line 39). There were three interviews in which sustainable development challenges were strongly embedded in the answers from the very start of the interview⁸⁹ (20, 28 and 29): firm activities and innovation activities were talked about in the context of sustainable development challenges and concerns. These three interviews were used as opportunities to explore radical sustainability-oriented innovation input, process, and output challenges in more depth within the context of the interviewee activities.

⁸⁷ Another interviewee answered with *“I don’t know that I would separate my first answer from this. You just changed the context.”* (13: p.2, ATLAS.ti line 47) but then went on with answering the question anyway.

⁸⁸ All ATLAS.ti quotes and text sections use the first line of coded text as reference.

⁸⁹ Initially I thought that 28 and 29 were primed to answer with a sustainability lens because I approached them through email. However, this was not the case for 20. Furthermore, 18 and 30 were approached with a similar email request for an interview as 28 and 29. Therefore, I argue that the means of the initial contact made with a potential interviewee had no impact on the sustainable development content of the interview answers.

I go on to present the breakdown of the data sources for this research phase, continue with a presentation of the 1st and 2nd-order codes generated through the data analysis, and follow this with a discussion of how the data analysis compares to the characteristics as synthesised from the transdisciplinary literature review presented in section 3.4 of chapter 3. This chapter ends with the key insights generated in each discussion section and concluding remarks, leading to the exploration of the process of pursuing radical sustainability-oriented innovation in large firms in chapter 6.

4.1 Data sources, types and use

The cross-sectoral interviews formed the main basis of the data analysis, with ongoing research reflections (i.e. Reflection Diary) and notes used to support the data collection and analysis process.

Table 10 presents the data sources, details on data type and the use in the data analysis during this research phase.

Data Sources	Type of Data	Use in the Analysis
Semi-structured interviews (231 pages)	Interviews with academics (4 in total): - Professors pursuing technology-driven innovation research (Data 4 and 11) - Professor pursuing entrepreneurship research (Data 9) - Professor pursuing emerging economies innovation research (Data 16)	Gather academic perspectives from different expertise areas on innovation.
	Interviews with entrepreneurs (5 in total): - Driven by non-sustainable motivation (Data 21 and 22) - Driven by local sustainable development concerns (Data 18) - Driven by 'whole world' sustainable development challenges (Data 28 and 29)	Gather entrepreneurial perspectives on innovation.
	Interviews with consultants (5 in total): - Innovation software (Data 10) - Overall corporate process innovation (Data 13 and 14) - Early stage innovation (Data 30) - Commercialising new product and service offers (Data 6 and 10)	Gather insights from people who have experience with supporting a range of businesses with innovation activities.
	Interviews with innovation practitioners in large firms (8 in total): - Internal capacity building (Data 2) - Discovering new innovation opportunities (Data 1) - Whole world impact innovation (Data 17 and 31) - Complete organizational product and service innovation process (Data 3, 7, 12, and 15)	Gather perspectives from people practising innovation in large firms.
	Interviews with societal change stakeholders (4 in total): Native American tribe leaders (Data 19 and	Gather perspectives from people creating new products and services whilst addressing social and/or environmental challenges.

Data Sources	Type of Data	Use in the Analysis
	20) • Landscape artists (Data 23) • World War Two remembrance site (Data 24)	
Interview notes (part of 231 pages)	Written at the end of 18 interview ⁹⁰ transcripts.	Track and examine interaction and immediate data stand-out points of semi-structured interviews.
Reflection Diary (12 pages)	Reflections written every day during the data collection in 2013.	Not significantly used in the analysis for this research phase. ⁹¹ Track and examine researcher thoughts.
Images from 2013 U.S. stay (761 images)	Photos taken during the conference and the Reflection Journey in 2013	Corroborate and test data narrative

Table 10: Radical sustainability-oriented innovation data sources, types and use

4.2 Reflecting on data collection and analysis

Table 10 shows the data overview of this research phase. There were process challenges of collecting data and analysing the data for this research phase. This section reflects on these challenges. These reflections are presented at the beginning of this chapter to enable the reader to engage with the data narrative and discussion without distraction by research process details. These details are presented here to demonstrate the ability of the researcher to recognize, appropriately respond to, and learn from the challenges encountered during this research phase.

4.2.1 Interview process reflection

This section is based on the notes I wrote down after the interviews and the Reflection Diary kept during the U.S. stay. The individual interview notes are included at the end of each interview transcript, uploaded and analysed in ATLAS.ti. The interview notes did not follow a predetermined structure. Rather, their purpose was to capture what seemed important factors influencing the interview interaction and reflections on where I felt I could have probed further into answers given. Furthermore, the notes included practical information such as whether the interviewee was willing to be contacted for follow-up research.

The interviewees were made aware that the interviews would be treated confidentially: any content to be shared without interviewee anonymity would be signed off by the interviewee prior to dissemination. However, some interviewees (1, 19, 30) seem to misunderstand the nature of

⁹⁰ Interviews 6, 7, 12, 14, 18, 19, 20, and 22 did not include notes. 6, 7, 12, and 14 did not include anything that stood out and felt necessary to be captured in separate notes. 18, 19, 20, and 22 included things that stood out and these were captured in the Reflection Diary.

⁹¹ The Data source is included in the table because the Reflection Diary is referred to in this chapter.

academic research and asked me after the interview process “when will the book come out”⁹². Therefore, despite asking before the interview commenced, whether the interviewee was willing to participate in academic research was a flawed opening question.

It is clear from the notes and the Reflection Diary that I felt intellectually out of my depth with a number of interviewees: those of academic (4, 9, 11) and entrepreneurial (23, 28, 29) backgrounds⁹³. However, the interview transcripts where the feeling of intellectual inadequacy was apparent in the notes do not show a lesser richness of information and insight offered by the interviewees. I therefore managed to conduct the interview adequately for the purpose of gathering the interviewees’ points of view on the characteristics of radical sustainability-oriented innovation.

In some cases (9, 14, 15, 16, 23, 28), the interviewees ‘corrected’ my questions and told me that the questions were not specific enough, not rooted in any academic discipline, or asked me to clarify the concept of sustainability for them. In all of those cases, I asked them for their opinion on the matter instead of providing answers that would have influenced the interviewees to provide information that would seem aligned with my views about the characteristics of radical sustainability-oriented innovation during the time of data collection. If the interviewee still struggled with the concept of sustainability, I offered a triple bottom line description: “*So when I mean sustainability I mean economic, environmental and social aspects*” (15: p.1, ATLAS.ti line 26). In one interview (23) the interviewee questioned my personal motivation in pursuing this academic research and asked why I was not exploring it from a religious angle. The notes and the Research Diary show that the interviewees who questioned my research angle and assumptions helped to increase the quality of this research through their critical engagement with my questioning, because they pushed me to think through research aspects I might have failed to consider otherwise.

Some interviews were conducted more informally than others and included walking (19, 20, 28), consuming food (28) or going for coffee/tea (6, 7, 14, 15, 16, 21). The interview transcripts show that trust between the interviewee and myself is established very quickly in these situations and answers seem not to be ‘filtered’ through any corporate or academic institution lens. However, the interview content turned to subjects outside the research scope faster than in more formal interviews. As a result, for the remainder of the data collection for this PhD research I chose formal interview settings and situations.

⁹² This quote is not attributed to any of the three interview transcripts as the interviewees asked this question after the recorder was switched off.

⁹³ Interviewee 28 sat at the intersection of academia and entrepreneurship.

4.2.2 Interview data analysis reflection

The analysis presented in the next sections of this chapter is based on the coding of interview transcripts. This coding was conducted after the data collection process was completed. This means that I have read literature and formed thoughts about the information presented in the transcripts that I would not have been able to see during the time of data collection. I chose not to engage any of the interviewees with follow-up enquiries. This would have resulted in the necessity to clarify meaning and probe for similar information across the whole data set. Otherwise the data set would have been inconsistent in its information content due to the fact that different data sources were collected with varying understandings of the research aims and literature grounding making it difficult to analyse the data set as one unit.

The 2nd round of data analysis took place in October 2014. This means that by the time the data analysis iteration was conducted, I had a more in-depth understanding of the literature concerning the input, process, and output characteristics of radical sustainability-oriented innovation. This deeper understanding did not change the existing 1st-order codes of the first coding cycle. Rather, some 1st-order codes were added. After this, revisiting the co-occurring codes (**Appendix 1: 2, 3, 4**) added depth and richness to the data interpretation. This iterative approach worked well in answering the research questions of this PhD and was adopted for the remainder of the research.

4.3 Data analysis overview

The coding of the 231 pages of interview transcripts and corresponding notes resulted in 85 1st-order codes: 82 content codes and three research process codes. Through using the co-occurrence function in ATLAS.ti as a prompt to discover deeper meaning in the interview transcripts, the content 1st-order codes were grouped into 2nd-order codes.

4.3.1 1st and 2nd-order codes

The 1st-order codes presented in **Table 11** are a reproduction of the ATLAS.ti codes. The text sections of these 1st-order codes were all printed out. Following the co-occurrence analysis of the 1st-order codes, the hardcopies of the 1st-order codes were revisited and grouped in 2nd-order codes. Using hardcopies for this process instead of electronic grouping in ATLAS.ti was simply due to personal

preference. The visual outputs of the ATLAS.ti process are not easily visually understood⁹⁴ and this made it difficult to develop a narrative.

1 st -order codes		2 nd -order codes
• Company anticipating market need • Corporate mission • Corporate strategy • Customer collaboration • Distance • Need to learn new process in firms	• New combinations of things • Outside accepted parameters • Pioneer • Radical innovation is not defined • Technology	Indicators of radicalness
• Biodiversity • Biomimicry • Finite resources • Life cycle thinking	• Triple bottom line • Natural resources • Susty is context dependent	Sustainability framing
• Business model with sustainable development goal • Inno for susty vs susty inno • Purpose-driven	• Solving humanity's problems • Solving problems • Sustainability goal of innovation activities	Innovation goal
• Separate radical & susty innovation • Sustainability = firm innovation process more ambitious	• RSOI costs more • RSOI more factors	Radical sustainability-oriented innovation = more factors
• Complexity • Data as decision aid	• Experimenting	Breaking down uncertainty
• Fast technology change • Intergenerational relevance • Lack of urgency • Long-term economic thinking	• Radical inno implementation time • Short-term economic thinking • Short-term vs long-term human ability	Time
• Corporate structure resists change • Focus during radical innovation process • Individual leadership • Innovation space outside corporate structure	• Need to change corporate culture • Reluctance to change • Risk acceptance	Corporate inertia
• Intrapreneur driving radical innovation • Startup	• Startup funding	Large firm vs Startup
• Academic practitioner grounding • Being an outsider • Escape rat race • Source of inspiration	• Spirituality as driver of sustainability • Startup founder motivation • Values	Personal motivation
• Individual analytic capability • Individuality of entrepreneur • Innovation as culture • Innovation potential in everyone • Intuition required	• Male superhero • Perseverance • Person processing many decision factors • Self-belief • Sustainability knowledge	Decision-maker abilities
• Bottom of pyramid • Changing the life of the end-user • Disrupting existing business model • Diversion from status quo • Economic viability • Ethnic minority	• Inclusiveness • Increasing consumption • Infrastructure improvements • Original knowledge holders • Societal impact of business • Technology isn't the answer	Innovation output
• Geographical region • Support of societal leaders	• Government ruled by economic interest	Institutional impact

⁹⁴ I 'played' with the transcripts and coded some images taken during data collection too. Furthermore, revisiting images after the data interpretation process was completed was useful. It helped to recapture the interview situation in the light of the Reflection Diary and corroborate my mental recollection with the data interpretation narrative.

1 st -oder codes		2 nd -order codes
• Radical the word	• Superweird	Rhubarb bag
• Leading question • Researcher points interview to answer	• Interview edited during coding	Research process

Table 11: 1st and 2nd - order codes derived from semi-structured interviews conducted in 2013 (+1 in 2014)

From this point onwards in the thesis, interview and document text extracts are referenced in the following format:

- Data number as presented in the methodology chapter 2
- Page number of the interview transcript in rich text or portable document format
- The text section start line in qualitative data analysis programme ATLAS.ti
- Example of the three-part data referencing format in this thesis: (31:p.3, ATLAS.ti line107)

Table 11 is reproduced in **Appendix 6** with examples of quoted text sections. Parts of the whole of the text extract examples presented in **Appendix 6** may be coded with more than one 1st-order code. For example, the following text section is coded with ‘Individual leadership’ and ‘Corporate structure resists change’:

“the major changes are with any other team, you just build, you know, hierarchies become established and, you know, some of it’s good, some of it’s bad. On the one hand, er, you know, I can, one person can be responsible for something as opposed to er, the blurry line. Like, “Oh we were all trying to get it done and we all kind of screwed it up.” Erm, so on the one hand, that’s great. It’s, for a team to be successful as it grows, I think it needs leadership. On the other hand, and then the flip side of that is, once you have leadership you have to respond to that leadership, one way or the other. Erm, so group dynamics come in and er, the same with any group. 31FIRM is a special company, it’s focused on its people. But at the core, it’s still a huge multinational corporation. It suffers the same political shenanigans that any large corporation does” (31:p.3, ATLAS.ti line 107)

The extract from the above text is presented in **Appendix 6** under ‘Individual leadership’ because it is the 1st-order code shown first in ATLAS.ti. The full text was therefore coded with ‘Individual leadership’ prior to ‘Corporate structure resists change’. This indicates that ‘individual leadership’ appeared more salient than ‘Corporate structure resists change’ at the time of coding the full text section. The text extract example omits filler words and what seems unnecessary to adequately reproduce the meaning of the full coded text section. This approach was taken to provide evidence of data for each of the codes without adding a large bulk of data to this thesis:

“hierarchies become established and (..) one person can be responsible for something (..) that’s great. For a team to be successful as it grows, I think it needs leadership. (..) the flip side of that is, once you have leadership you have to respond to that leadership (..) group dynamics come in. 31FIRM (..) suffers the same political shenanigans that any large corporation does” (31:p.3, ATLAS.ti line107)

For the data discussion and narrative, the whole transcript section was considered.

Codes that did not provide salient information are shown, for completeness, at the bottom of **Table 11**.

4.4 Discussion

This section offers a discussion of the data collected to explore the characteristics of radical sustainability-oriented innovation. The discussion narrative is based on the 2nd-order codes and the literature reviewed in chapter 3 of this thesis. The text extracts included in this discussion section are a mixture of the text extracts presented in **Appendix 6** and text extracts directly from the interviews. The discussion follows the narrative of input, process, and output characteristics of radical sustainability-oriented innovation.

4.4.1 *Radical sustainability-oriented innovation characteristics and the data*

The opportunity sample as identified in the Boston conference was appropriate to capture academic and practitioner points of view, because all interviewees were willing to offer thoughts on radical innovation. The key insight generated was that radical sustainability-oriented innovation was perceived as being distinct from ‘conventional’ radical innovation by almost all interviewees. The main difference between conventional radical innovation and radical sustainability-oriented innovation was twofold. It was either signified through the nature of the problem addressed with innovation activities, or through extra effort or factors needed for the pursuit of radical sustainability-oriented innovation. The problem addressed through innovation activities is aligned with the assertions of Dyllick and Muff (2015) that business activities need to be broadened beyond traditional economic concerns only. The latter assertion is aligned with the assertions of Jay and Gerard (2015) that sustainability-oriented innovation includes more factors than conventional innovation (**Table 6**).

I go on to discuss these and other data insights in depth. All conceptual, 2nd-order codes show overlap with each other, as do the respective 1st-order codes. However, a distinct narrative emerged during engagement with the data in ATLAS.ti, through revisiting the literature and the interview notes. The discussion starts with the data insights on sustainability framing and the innovation goal, before contrasting the radical innovation literature with the indicators of radicalness as proposed by the interviewees. This leads towards the data assertion that radical sustainability-oriented innovation

consists of a higher number of factors than conventional radical innovation.

The process-focused data starts with the exploration of innovation in corporates, closely linked to the element of time. The data discussion ends with the key differences between the literature explored in chapter 3 on the characteristics of radical sustainability-oriented innovation and the insights generated through the data.

4.4.2 What makes innovation radical?

The degree of novelty as an indicator of innovation radicalness (Bessant et al., 2014; Bocken et al., 2012; Garcia and Calantone, 2002) permeated the data. This novelty related at the micro level to impact on personal lifestyle (1, 7, 19, 22), especially when driven by recent technological development. The internet and the capabilities of smart phones were used as examples. The perspective on radical innovation as impacting lifestyle was also offered from those interviewees, who abstracted the personal level to phrases such as “impact on customers” (2, 12, 13). Some interviewees expressed the opinion that new products and services that change the lifestyle of the customer are not products and services the customer might be able to articulate yet: “(..) *historically [Apple] had the vision of looking ahead and looking at things that people didn't necessarily know they wanted and still forged ahead developing those*” (2: p.3, ATLAS.ti line 100). The customer as driver of radical innovation was an interesting point because even if customers were not able to articulate what they might want (2, 10), firms that were able to extract this information were highlighted as radical innovators. The examples of firms who successfully managed to do this were, according to the data set, Apple, Google, and IBM. All of these companies are technology companies. This was not explicitly acknowledged by interviewees, however is an interesting point because the literature on radical innovation asserts that novelty along the technical dimension is an indicator of radicalness (Linton, 2009).

At the macro level, the degree of novelty of radical innovation is linked to changing the market place in the literature (Abernathy and Clark, 1985; Garcia and Calantone, 2002). However, this link was solely made by the two academic interviewees with economics expertise (9, 16). For the remaining interviewees, this part of the social dimension novelty (Garcia and Calantone, 2002; Linton, 2009) was not proposed as an indicator of radicalness. In contrast, novelty as new combinations of things (Nooteboom, 2000; Schumpeter, 1934) was offered by practitioner (e.g. 10, 13, 17) interviewees: “*Radical innovation, wow. I think that it's all new, new combinations of things that create something brand new to the world*” (13: p. 2, ATLAS.ti line 33). Equally, academic (e.g. 4, 9) interviewees offered

new combinations of things to indicate radicalness: *“I think the people who have succeeded in (changing the way things work) the most, are those who bring together 2 areas of study that have not previously been thought of together. Maybe that is actually from an outside point of view what radical innovation looks like. It’s taking insights from 2 different places or more, or multiple places where people have done prior work but haven’t thought of them together yet. (..) Nicholas Negroponte⁹⁵, even though I disagree with his ideas a lot how education should be done, is an example of somebody who has changed the way that we’re moving toward producing educational environments”* (4: p.2, ATLAS.ti line 59). The data showed that novel combinations of previously unconnected factors were perceived as indicator of innovativeness. This suggests that Schumpeter (1934) has managed to permeate Western perceptions of what innovation is.

A salient finding from the data was that radicalness at the firm level definitely means new processes (e.g. 17, 31) for established companies: *“(..) the 1 thing that is often overlooked (..) [is that] this new business, this disruptive innovation⁹⁶ is just going through the same pipes and the same process that everything else goes through, if you try to squeeze it in, chances are that it’s going to fail. And if you don’t do it differently, it is going to fail. That’s the 1 difference, the 1 insight, the 1 skill, that’s successful innovation teams are able to do to increase the chances of success of their disruptive innovation”* (17: p.6, ATLAS.ti line 102). Not a single interviewee voiced the opinion that firms might be able to pursue radical innovation of products and services without changing its processes. This confirms the technology dimension literature (Chandy and Tellis, 2000; Foster, 1986). However, technology itself was perceived as an enabler of innovation in the data, for example through allowing widespread and easy access to information: *“things would go from (..) where we had to go to a library to learn things [to] where you could immediately have access to any of the world’s information from anywhere. (..) that’s like humanity acquiring a nervous system”* (29: p.2, ATLAS.ti line 65). In contrast, in the reviewed literature technology was portrayed as the driver of radical innovation (Ashford and Hall, 2011; Chandy and Tellis, 2000; Foster, 1986). Even the interviewees who set up and run large firms (or divisions of such firms) that commercialise new combinations of technology (29, 31) or develop new technology (28, 29) articulated technology as an enabler of radical innovation, rather than the driver of radical innovation. However, their firms develop new technologies in order to address sustainable development challenges, and so their innovation activities result in new technologies. In the case of the two interviewees (28, 29) that develop new technologies with the goal to address sustainable development challenges, both technologies aim to

⁹⁵ Nicholas Negroponte is a machine-computer interaction practitioner and academic. He is the founder of the Massachusetts Institute of Technology's Media Lab and the 'One Laptop per Child' initiative.

⁹⁶ The interviewee used radical innovation and disruptive innovation interchangeably.

reduce carbon emissions and existing carbon in the Earth atmosphere through new ways of energy generation, use and distribution. This aligns with the assertions of Ashford and Hall (2011; p.277) that pressures such as an energy crisis might drive ‘revolutionary’ technology development. In the case of the interviewees 28 and 29, solving carbon emissions and energy generation problems⁹⁷ were the motivation to set up new businesses and, consequently, develop new technologies.

Finally, some interviewees indicated that pursuing radical innovation is associated with resistance and even fighting at the level of the individual (17, 19): “(..) *the old saying, the pioneer took the most arrows, right? Not politically correct, but a true statement* (..) [Napster⁹⁸ founder] *Shawn Fanning had to fight all the legal battles, he took all the heat* (..)” (17: p.3, ATLAS.ti line 78). Though not articulated by the interviewees, this seems closely aligned with the radical innovation challenges at the firm level, where individuals are singled out as key to overcoming these challenges (Garcia and Calantone, 2002).

Key insights: What makes innovation radical?

The data suggests that novel combinations of previously unconnected factors are perceived as indicator of innovativeness. At the level of the firm, radicalness means new processes for established companies, with technology perceived as an enabler of innovation in the data. In contrast to the data, in the reviewed literature technology is portrayed as the driver of radical innovation (Ashford and Hall, 2011; Chandy and Tellis, 2000; Foster, 1986). Some literature singles out individuals as key to overcoming radical innovation in firms (Garcia and Calantone, 2002) and this is supported by some interviews. These interviewees indicate that the individuals can expect opposition during the pursuit of radical innovation activities.

4.4.3 Who pursues radical innovation

The aim of the third interview question was to ensure examples of radical innovation were gathered, and even examples of radical sustainability-oriented innovation. The data shows a diverse picture. Individuals were mentioned more often than firms: individuals 11 times and firms nine times. This was unexpected in the context of the Boston opportunity sample, where innovation activities at the firm level dominated the conference agenda. In both categories, there were expected answers⁹⁹ like Apple, Google, Unilever for companies and Steve Jobs and Elon Musk for individuals.

Less familiar examples were the manufacturing company Natura, composer Johann Sebastian Bach

⁹⁷ Problem solving and its relationship to innovation activities is discussed in section 4.4.5.

⁹⁸ Napster is an online music store.

⁹⁹ Expected answers in the sense that these companies and individuals get a large amount of media exposure. This means that interviewees are likely to have heard of them, therefore easily mention them when put on the spot through an interview.

and MIT Media Lab founder Nicholas Negroponte. Natura was highlighted because the interviewee (16) perceived the firm as radical *“in the sense that they were the first company in the world to extract essences of the Amazon in a sustainable fashion and put together a world class logistics and business model(..). They’re invoicing about (..) \$30 billion a year, (..) it’s not disruptive (..)in that you’re creating a new paradigm. (..) but it’s disruptive in that specific context* (16: p.5, ATLAS.ti line 143). The indications of radicalness for Natura were novelty within the market context and the fact that the firm was the first to commercialize a new approach whilst creating social, environmental and economic value. As shown in the interview quote in the previous chapter section that refers to Nicholas Negroponte, he was perceived by interviewee 4 as radical innovator because he brought together previously separate domains and created new combinations of things (Nooteboom, 2000; Schumpeter, 1934). Finally the interviewee (11) who highlighted Johann Sebastian Bach as radical innovator mentioned this composer because he created a new way of creating Western music that changed the whole of the ‘industry’: *“I think Bach just fundamentally changed music. Music before and after Bach was completely [different] (..) to a certain extend you can boil down all Western music today down to Bach and you would still hear in Bach what you hear today, whereas before Bach it was not like that. (..) I can’t even imagine what it would have been like to only know music pre-Bach.”* (11: p. 2-3, ATLAS.ti line 53). The same interviewee (i.e. 4) associated radical activities with activities that are taking place outside the accepted status quo within the field of the radical innovator. This interview extract suggests that activities outside the status quo might be combined with the inability to provide data and proof derived from the scientific method: *“I think in the science world I think Einstein (..) it’s a little clichéd to say that but he used his brain to figure out things about the universe that we’re just today confirming to be true when he had no way to verify these things. (..) Even though it was leading to conclusions that you couldn’t prove, support or even justify on many intuitive criteria - radical to me”* (11: p. 3, ATLAS.ti line 53). Activities of taking place outside the accepted status quo within an industry were also characteristics of radical innovators suggested by other interviewees (e.g. 17 highlighted the opposition Shawn Fanning faced).

Three interviewees (1, 19, 23) offered entirely unexpected answers to who might have or does pursue radical innovation and these answers were more akin to societal movements: *“Christ as a Saviour and knowing that the gift has already been given to you then you can enjoy and appreciate and give thanks for those blessings. It helps to see the goodness in other people. (..) So you’re valuing each life, radical in the world today I think.”* (23: p.5, ATLAS.ti line 156). The three interviewees offering ‘spiritual’ answers were clearly guided by their personal values and belief system throughout all aspects of their lives, including how they pursued business activities. This suggests that these

interviewees might equally use their personal values to guide their innovation activities.

Some interviewees did not answer the third interview question because the interview did not lead up to this question (19, 21), or previous questions were already rich in data and probing questions led to the exploration of other aspects of the characteristics of radical sustainability-oriented innovation (28, 29).

Key insights: *Who pursues radical innovation*

Interviewees highlighted individuals and firms as almost equal measure, with some interviewees offering societal movements. The data on individuals and firms further confirms new combinations of things as indicator of radicalness, in line with literature arguments (Nooteboom, 2000; Schumpeter, 1934). Individuals and firms were identified as radical because they pursued activities outside the accepted status quo within their domain or industry, where this status quo is context-specific to the innovator.

4.4.4 Input: Sustainability means different things to different people

The operationalization of sustainable development as defined by the WCED (1987) through the triple bottom line definition (Elkington, 1994) was mentioned during the data collection. However, this was a single occurrence: *"I think you mean (...) innovation for the purpose of sustainability. I would take to mean it's innovation that targets the triple bottom line, as in so it's not innovation purely for the sake of making money but for enhancing the social welfare of our community and for the world around us, the environment"* (10: p.2-3, ATLAS.ti line 98). Sustainable development challenges and their impact on innovation activities were coloured by the challenges the interviewee faced directly or by the firm the interviewee worked for. The nested understanding of sustainability as put forward by, for example, Charter et al. (2008), was never explicitly acknowledged, although one interviewee (11) put economic value generation in the context of the finite nature of natural resources: *"(...) ideas or applications exist in the real world and that real world has constraints and that the majority of those constraints really have to do with resource limits. And so this idea of sustainability to me has to do with the fact that the consumable nature of resources means that we can't just do whatever we want for any economic purpose without thinking about the real cost"*¹⁰⁰ (11: p.2, ATLAS.ti line 47).

Two interviewees (13, 14) pointed out the context-dependent nature of sustainable development challenges, for example *"(...) when you start talking sustainability my gosh, it spans across so many different types of people in so many different contexts. (...) I don't know that space very well but that's*

¹⁰⁰ Although the quote might imply this, the interviewee did not offer any explicit information or thoughts on economic theory, specifically negative externalities of business activities that are driven by economic value creation.

what comes to mind" (13: p.6, ATLAS.ti line 51). These two interviewees, however, worked for a consultancy that specialised in empathic research: looking to understand customers through 'walking in their shoes'. It was not therefore surprising for these two interviewees to mention that sustainable development challenges depend on the situation of an individual person or firm. However, their challenge concerning the context-dependency of specific sustainable development challenges (Ashford and Hall, 2011) proved true for the data set. For example, the corporate interviewee (7) who honed in on one resource aspect of sustainable development challenges by talking about a specialised sustainable innovation approach, biomimicry¹⁰¹. This was prompted by a conversation the interviewee had with an employee of a manufacturing firm (carpet company InterfaceFLOR) that used this approach to operationalize sustainable development. This element of sustainable development and how to address it was relatable for interviewee 7 because the interviewee was also based in the manufacturing sector. In contrast, interviewee 20 talked about the food supply chain and the impact of monoculture on biodiversity. His line of work is organic livestock herding. Sustainable development challenges were conceived to be of mainly a social nature by the interviewee who worked with WW2 victims. These interviews suggest that personal circumstance and the relating context influence how sustainable development challenges are perceived. This will influence which sustainable development challenges are perceived as important and, therefore, might have implications for which and how sustainable development challenges are addressed. This aligns with the point made by interviewee 16 about the firm identified as radical innovator: the interviewee identified Natura is a radical innovator within the geographical region and natural environment context.

The interviews were aligned to the assertion made in chapter 3 that sustainable development challenges seem more actionable in the practitioner community when simplified to 'entry concepts'.

Key insights: Sustainability means different things to different people

The data suggests that personal circumstance and the relating context influence how sustainable development challenges (Ashford and Hall, 2011; Charter et al., 2008) are perceived. This will influence which sustainable development challenges are perceived as important and, therefore, might have implications for which and how sustainable development challenges are addressed.

4.4.5 Input: solving problems and setting goals

The key differentiator between 'conventional' radical innovation and radical sustainability-oriented innovation as identified by the interviewees was the problem to be solved through innovation

¹⁰¹ Biomimicry is an innovation concept developed by Janine Benyus. The concept uses designs and processes of the natural world as inspiration for optimising and creating processes, products and services; www.biomimicry.org for full information.

activities. This finding applies across the whole data set and aligns with input to considering business sustainability (Dyllick and Muff, 2015), the aspirations of business to operationalize sustainable development (Adams et al., 2015), and the evaluation framework proposed by Jay and Gerard (2015).

The broadening of business concerns (Dyllick and Muff, 2015) as articulated through the innovation goals ranged from the product level to the whole of humanity's future in the data. At the product level, the problem solving approach to innovation was linked to specific sustainability concerns, in this case the unnecessary use of resources through the creation of objects that customers do not need: *"you can't continue to put things out in the world that don't serve a purpose, (..) if it's just another object, (..), that just ends up in a landfill (..)"* (15: p.1, ATLAS.ti line 29). In contrast, the interviewees who articulated the innovation goal in terms of impacting the whole of humanity (1, 28, 29, 31) spoke more generally about how innovation goals and sustainable development were linked. This went as broad as simply avoiding 'bad' outcomes, illustrated by 29 (p. 2, ATLAS.ti line 71) through the statement *"(..) I just didn't want to work on something that might have a bad outcome"*. This contrast in the data suggests that problem-solving at the product level might be linked to efficiency concerns at the level of the firm. The problem-solving at the macro-level seemed more concerned with effectiveness of innovation activities. This insight from the data suggests that 'conventional' radical innovation might have a 'bad' outcome at the micro or macro level. Radical sustainability-oriented innovation is different to 'conventional' radical innovation because it sets out to explicitly address a sustainable development challenge or it sets out to avoid an innovation outcome that might create or worsen sustainable development challenges.

This argumentation is, however, flawed due to another insight generated through the data analysis. For both entrepreneurs (28, 29) who articulated the innovation goal in terms of impacting the whole of humanity, sustainable development challenges were interesting simply because they posed the biggest problems to be solved: *"I left [research and scientific development firm] because I felt that the challenge facing mankind was not how to make a computer faster but how to provide energy to support our human needs."* (28: p.3, ATLAS.ti line 96). *"Innovation is coming up with new ideas that people thought were not possible and suddenly making them possible (..) we were entering a new age in human innovation. Where instead of needing a new discovery (..) we hadn't even learnt how to use the things we already knew.(..) And so that there was a new thing was to switch the process around from discovery, or 'How can it be useful?' To the first design, 'What do I need to be useful?' (..) So that's what we [refers to co-founder] did. We sat down and said, 'What does the world need?'*

*Decided air capture's what they needed. (...) Because it's the only thing that would close the carbon cycle. There's no other way that can (...) solve the [energy] problem*¹⁰² (28: p.10-11, ATLAS.ti line 241). This text section strongly suggests that macro-level problem solving was the key to the innovation activities of the firm co-led by interviewee 28. The other entrepreneur (29) spelt this implicit point out more bluntly: *"I was trying to figure out things that would most affect the future of humanity"* (29: p.1, ATLAS.ti line 35). *(...) So in College when I was looking at that it wasn't from the starting point of environmental disaster it was more from starting point of 'Well, if we don't have some renewable form of energy generation and consumption, then obviously society is going to collapse'. You know, economic collapse in the World"* (29: p.1, ATLAS.ti line 39). This data insight suggests that for entrepreneurial individuals that are identified by others as radical sustainability-oriented innovators, the problem to be solved was of most interest when creating new business activities. That this problem was associated with sustainable development challenges seemed coincidence. Interviewee 28 touched on values and personal motivation¹⁰³, whereas interviewee 29 did not offer any such information.

The interviewees that were not leading entrepreneurs identified problems as drivers of innovation activities too. These problems might relate to societal issues (e.g. 1, 16, 19, 24), environmental issues (e.g. 20, 28), customer problems (e.g. 8), problems with the corporate culture (e.g. 2), and other factors. Common between all the implicitly and explicitly articulated purposes of innovation was, however, the aim to solve problems, as stated here: *"(...) solving problems in new ways, that's all."* (15: p.1, ATLAS.ti line 23). However, the data did not offer conclusive insights on whether solving a sustainable development challenge is simply interesting because it is a hard problem to solve.

Some interviewees (e.g. 2, 3, 17) articulated how an innovation goal that addresses sustainable development challenges is closely linked to the business model: *"how do we [in business] tie the concept of sustainability and actually reach a goal of say a better planet or a better society, still having it as a revenue generating model?"* (6:p.2, ATLAS.ti line 59). The value creation at the heart of a business model (Osterwalder and Pigneur, 2009; Osterwalder et al., 2014) must be broadened out beyond purely economic value creation (Boons and Lüdeke-Freund, 2013; Schaltegger et al., 2012) according to the literature. This assertion was confirmed by interviewees (e.g. 1, 2, 17, 18, 22, 24, etc), with value creation beyond the economic business case dependent on their individual context. For example, interviewee 22 felt that creating a low price point for scientific books would enable part

¹⁰² The interviewee went on to explain that he had no background in the technical or engineering capabilities needed to address this problem.

¹⁰³ Personal motivation and its role in radical sustainability-oriented innovation activities are discussed in section 4.4.9 of this chapter.

of society to access this knowledge that would otherwise be inaccessible: *“we sold our books, wholesale, for only a dollar and 20 cents; that’s not a lot of money but we wanted our books to be affordable for everyone”* (22: p.5, ATLAS.ti line 62). During the Boston conference, linking economic to social and environmental value to the business model was to be expected because Alex Osterwalder was one of the keynote speakers, therefore conference delegates were primed to think about business models. However, this was equally confirmed by the interviewees that were not so heavily primed to make the connection between new product and service creation goals and business models (e.g. 22).

Key insights: Solving problems and setting goals

The data suggests that radical sustainability-oriented innovation is different to ‘conventional’ radical innovation because it sets out to explicitly address a sustainable development challenge or it sets out to avoid an innovation outcome that might create or worsen sustainable development challenges. Common between the articulated purposes of innovation is the aim to solve problems. The value creation at the heart of a business model (Osterwalder and Pigneur, 2009; Osterwalder et al., 2014) must be broadened out beyond purely economic value creation (Boons and Lüdeke-Freund, 2013; Schaltegger et al., 2012) according to the literature. This assertion was confirmed by interviewees, with value creation beyond the economic business case dependent on individual context.

4.4.6 Radical sustainability-oriented innovation is and takes more than radical innovation

The data confirmed the assertion of Jay and Gerard (2015) that sustainability-oriented innovation includes a larger number of factors than conventional innovation, therefore entailing a higher level of complexity (Maguire et al., 2006).

In the eyes of some interviewees (1, 2, 13, 17), sustainability-oriented innovation was associated with higher cost at the firm level than conventional innovation due to the need to incorporate and address more factors during innovation activities: *“(..) the implications are greater to that radical [sustainability-oriented] innovation, and what it takes to create it and what it takes to sell it in. Seems like the implications are greater to - in terms of costs, and implementing a radical sustainability innovation”* (13: p.2, ATLAS.ti line 47). These costs have an impact on the firm level according to the data. However, Jay and Gerard (2015) only mention ‘higher cost’ in the context of the micro-level of the product cost, with the costs passed on to the customer. The critical success factors articulated by the authors do not mention addressing higher cost at the firm level, or even the mindset that sustainability-oriented innovation costs more. Positive spill over effects of sustainable innovation activities at the macro level are mentioned in the literature (Jay and Gerard, 2015). At the micro level of the firm, some interviewees (e.g. 6, 18) articulated that instead of costing firms more, using sustainability as a way to restructure activities would be beneficial in the longer terms for these

firms, despite difficulties to operationalize sustainable development: *“in 2007/2008 (..) you saw a lot of companies wanting to ask the question (..) ‘What [is] this, how do we reform our business around sustainability?’ (..). And then the economy tanked and 95% of that went away. And so there are a lot less conversations happening, but I noticed the ones that were still happening were the more serious ones (..) that had that sense of urgency. They said, ‘Even though numbers are down. (..) Even though we’re really struggling, we see sustainability as a way to grow the business, or to innovate, or as a lens to make good business decisions.’ And I think those are the ones that have the staying power”* (18: p.7, ATLAS.ti line 154).

Sustainability-oriented innovation and the higher complexity associated with such innovation was acknowledged in the data (28), and one interviewee mentioned that humanity has not evolved fast enough to deal with complex sustainability challenges such as climate change (29). However, at the level of the firm the interviewee most familiar with complexity science and addressing urgent sustainable development challenges through new business activities (28) made the link to experimenting¹⁰⁴ in order to break down the uncertainty of radical innovation outcomes: *“(..) when I (..) did my first experiment (..) doing some measurements. And I got this data that was very surprising (..). And I found that so amazing, and I had the privilege to be the first person to think about what it meant”* (28B:p.2, ATLAS.ti line 29). Other interviewees (17, 31) mentioned the value of pursuing innovation activities with the freedom to experiment during the innovation process to create new product and service offers, without necessarily considering the economic value creation during these experimental learning activities: *“even as we grow, we do more and more things for the first time. (..) we spend a lot of time experimenting with different styles and how to attach it and how to make them modular and all these things”* (31:p.4, ATLAS.ti line 145), *“combining [different technologies] and being willing to take a risk on something that isn’t immediately a profitable idea”* (31:p.2, ATLAS.ti line 64). These extracts from the data suggest two things. Firstly, an experimental learning approach might be suitable to deal with the uncertainty associated with radical innovation outputs because it allows the exploration of ideas that necessitate finding new ways of combining factors (31) or developing new insights to further an innovation idea (28). Secondly, experimental learning should include the freedom to explore value propositions that might not have an immediate economic benefit. The literature argues that a sustainability-oriented innovation process needs more freedom than a conventional innovation process because iterative learning is suitable to address uncertainty (Jay and Gerard, 2015; Paech, 2007). Furthermore, individuals who are given freedom to explore ideas without being subjected to a large amount of evaluation are more likely to engage in

¹⁰⁴ Literature chapter 6 reviews literature on scientific experimentation and business experimentation.

experimentation (Lee et al., 2004). However, at the level of the firm balancing freedom to pursue experimental learning needs to be combined with a way to *“foster that [innovation] culture effectively in that you have runaway creativity without runaway tangents”* (31: p.5, ATLAS.ti line 171). Another interviewee highlighted how successful corporate innovation activities manages to balance the freedom of the individual with economic value creation objectives: *“So the real challenge in innovation is how do you connect up the individual innovators with the people really capable of implementing the innovation in a way that doesn’t kill the individuals spirit and freedom, and is acceptable to the financial and economic imperatives of a large organization”* (28B: p.5, ATLAS.ti line 78). This suggests that experimental learning might be suitable to break down the many factors and decisions associated with a radical sustainability-oriented innovation process. However, balancing the individual freedom needed to experiment during an innovation process with uncertain outcomes is hard. The higher number of factors associated with radical sustainability-oriented innovation suggests that this balancing might be even harder to get right at the level of the firm for these innovation activities.

Nothing in the data indicated that interviewees thought radical innovation activities of any nature would benefit from the application of a detailed theoretical concept. This confirms the literature assertions on the inability of practitioners to apply detailed theoretical concepts by O'Connor and Rice (2013). This suggests that a business response to sustainable development challenges (Dyllick and Muff, 2015) cannot be guided by detailed theory concepts

Key insights: Radical sustainability-oriented innovation is and takes more than radical innovation

The data suggests that radical sustainability-oriented innovation is associated with higher economic costs during development and implementation than conventional radical innovation at the level of the firm. The reviewed literature (Jay and Gerard, 2015) does not mention the need to address higher cost at the firm level, or the mindset that sustainability-oriented innovation costs more. The data also suggests that innovation activities need the freedom to experiment during the innovation process, without necessarily considering the economic value creation during these experimental learning activities. Balancing the individual freedom needed to experiment during an innovation process with uncertain outcomes is hard.

4.4.7 Process: human response time to sustainable development challenges

The urgency of sustainable development challenges was acknowledged in some of the data, with the urgency articulated as a non-negotiable to be addressed through innovation activities (28, 29). However, it was acknowledged that the urgency is unlikely to be acted upon in a timely fashion, with negative consequences: *“(..) we’ve not evolved to deal with this problem. (..) [climate change] is gonna end up being far worse than most people realise”* (29: p.6, ATLAS.ti line 190). However, the

barriers to addressing sustainable development challenges in an adequate timescale were mostly highlighted by others (1, 15, 18): short-term thinking driven by corporate reporting cycles and the human inability to see beyond one's personal lifetime. The inability to see beyond one's personal lifetime might be linked to the interview assertion (29) that humans have not evolved to deal with the challenges of climate change. This quote illustrates how short-term reporting cycles impact firms: *"I was just at a conference where people are lamenting the fact that we think or we're trained to think in such short-term cycles. Especially in business, it's a quarter, at most. And for the most enlightened companies it's maybe a year or two years"* (1: p.1, ATLAS.ti line 37).

The need to consider long-term timescales to include the lifespan of one's children was used to illustrate the urgency of sustainable development challenges (e.g. 14, 17, 19). This is aligned with the most common definition of sustainable development (WCED, 1987).

Going beyond a two-generation timeline, radical innovation implementation time was set in the context of the whole of human existence (11), and it was argued that humans are only able to see the impact of radical innovations 1,000 years after they occurred. The implication of what this means for addressing urgent sustainable development challenges were not offered by this interviewee. The process of radical sustainability-oriented innovation activities was perceived to be longer than conventional radical innovation activities (16), due to the higher complexity of adopting such innovations: *"(..) [radical sustainability-oriented innovation] takes much longer. (..) perhaps the effects are also taking longer. And I think one very good example that we can come up with is the example of biofuels in Brazil"* (16: p.11, ATLAS.ti line 296). The interviewee explained that energy solutions will need to be enabled and supported by government in order to succeed. This macro-level assertion was interesting in the context of the energy sector, another interviewee (9) argued the same. However neither interviewee offered specific suggestions on how firms might link their organizational radical sustainability-oriented innovation activities to the institutional level. In regards to how long radical innovations might take to commercialise, specific commercialisation timelines as suggested in the literature (Goktan and Miles, 2011; Hanna et al., 2015; O'Connor and McDermott, 2004) were not mentioned.

Technology was perceived as a driver of fast change in personal lifestyles: *"(..) anyone who has a smartphone has been dramatically affected by that change of lifestyle that smartphone has brought to them (..). How we receive news, how we, how we entertain ourselves, watching television programmes, seeing new movies (..) it's just so completely radically different than it was 10 to 15*

years ago. And I think that's, that's probably had the biggest tech impact on society at large around the world" (2: p.2, ATLAS.ti line 76). However, technology trajectories (Chandy and Tellis, 2000; Dahlin and Behrens, 2005; Foster, 1986) and technology clusters concentrated in time (Dosi, 1982) were not mentioned in the data, including all academic interviewees. This was an interesting insight generated from the data because the technology dimension of radical innovation is extensively reflected on in the innovation management literature. However, in the data set this was not replicated. This suggests that it might be easier to reflect on the technological innovation dimension from the academic perspective than it might be on the social dimension of innovation¹⁰⁵. However, the social input, process and output challenges and the human element associated with these challenges were dominating the data set. The human element in change and innovation processes has been asserted to lead to 'lumpy' time scales (Poole, 2004). The data suggests that the human elements are, equally, perceived as most challenging by innovation practitioners and academics. Furthermore, the data indicated that people and their desire to further their own interests are at the core of organizational politics (e.g. 31), leading to a slow pace of innovation (e.g. 17). Identifying people as cause for slow organizational timelines aligns with the assertions of Poole (2004) on the perspectives on time.

At the level of the firm, frustration was expressed at the current short-term business thinking and its impact on developing products and services that create triple bottom line value (1, 18, 28): *"(..) I think the more we start thinking longer, and longer could mean different things for different groups of people - I think sustainability gets built into that (..) that's the lens that I'd like to look at sustainability and innovation. Are we, like the American Indians say, planning for 7 generations?"* (1: p.2, ATLAS.ti line 44).

Key insights: Human response time to sustainable development challenges

The data suggests that sustainable development challenges are urgent. However, pursuing radical sustainability-oriented innovation takes longer than pursuing conventional radical innovation activities. The technology dimension of radical innovation is extensively reflected on in the innovation management literature (Dosi, 1982; Foster, 1986; Hanna et al., 2015). However, in the data set this was not replicated. This suggests that it might be easier to reflect on the technological innovation dimension from the academic perspective than it might be on the social dimension of innovation. The human element in change and innovation processes has been asserted to lead to 'lumpy' time scales (Poole, 2004). The data suggests that the human elements are, equally, perceived as most challenging by innovation practitioners and academics.

¹⁰⁵ This thesis is no exception, the technological dimension of radical innovation was easier to research, summarise and write than the section on the social dimension. This section seemed far 'messier'.

4.4.8 Process: Large firms and radical innovation capabilities

The findings of Chandy and Tellis (2000) that more large than small firms were responsible for radical innovation since 1945 was not acknowledged in the data. In contrast, large firms and the corporate structure were perceived to be hindering radical innovation activities. Equally, radical innovation in pursuit of a sustainability goal was deemed difficult as illustrated here: *"We work with so many companies and they can't get (..) to a place where they can offer something more and better, because 'we've got a pipeline we have to fill and we have deadlines we have to hit.'"* (13:p.5, ATLAS.ti line 92)

In an extreme position, corporate structure focused on generating short term economic value was perceived as impacting knowledge generation because there are no immediate rewards to be gained at the personal level: *"people write a lot about (..) how un-innovative big companies are becoming. And how all the innovation is moving to (..) individuals. (..) So the big picture, the way I see it, is knowledge is becoming increasingly powerful. There's a challenge between the people who understand knowledge and the people who control the game for now, who are better at other things, networking, (..) That engagement is creating a reaction of the existing order that's making them more and more against knowledge and resisting some of the notions of that and fighting against some of the social changes of the company"* (28B:p.4, ATLAS.ti line 67). However, other interviewees (1, 2, 7, 9, 17, 22) highlighted how firms are aware of the impact of corporate management structure on radical innovation activities, with many interviewees trying to develop new innovation project management and corporate processes as suggested by the literature (Leifer et al., 2001; O'Connor and Rice, 2013). This was perceived as a hard thing to do: *"It is a personal struggle of mine constantly, because I do work in a corporate structure and I find it... I know where I want to go, but getting there is the hardest thing.(..) I used to think that [colleagues] had to find the same [sustainability] meaning in [the innovation opportunity] that I did, and what I'm finding is that that's not necessarily the case. People could find 10 different things in the same thing to get to the same result. (..) I'm constantly working within a system that resists change, so even for some people what might be a simple thing is sometimes quite hard"* (7: p.1-2, ATLAS.ti line 40). This aligns with other data insights on how individuals in firms are looking to further their own interest (17, 31) and how individual will face opposition to pursuing radical innovation opportunities (17). These data insights also suggest that this research would benefit from exploring the academic literature on innovation goals.

The concept of using entrepreneurial practice was suggested as a desired way to restructure corporate innovation processes (17), with a team as 'internal startup'. This approach would enable to

see through an innovation from the ideation stage to commercialization without losing speed and momentum when the project is handed off to different business functions. The interviewee expressed the view that a restrictive mindset at the individual and firm level is the key barrier to radical innovation in firms: *“I found the critical difference between startups outside the company and entrepreneurs starting their own company versus doing [it] inside a large company, so 1 step is different in the process. And that’s a step I called deconstruction,(..) sort of mentally ripping apart your company and its assets from product development process, supply chain, going to market, branding, all that and saying ‘Is this the right business model? Are these the right skills and capabilities for this new opportunity that we’re going after? (..)’, that deconstruction phase forces you to rethink how you’re going to be successful”* (17:p.4, ATLAS.ti line 96). This practitioner view agrees with the literature argument that corporate mindsets are a key barrier to radical innovation success (Sandberg and Aarikka-Stenroos, 2014). However, perhaps ironically, other interviewees highlighted how new businesses outside large firms experience huge financial pressures (9, 17, 29, 30): *“and the biggest issue is actually fundraising, getting somebody to..(..) (he) was told that there’s no way he can do that because the capital he would have to put together to start up would be huge”* (9:p.13, ATLAS.ti line 161). This means that economic value creation also significantly impacts entrepreneurial startup firms outside large firms. The concept of entrepreneurial practice was not reviewed in the literature and the data pointed towards an interesting avenue to explore further literature on this aspect of businesses pursuing radical sustainability-oriented innovation activities.

Key insights: Large firms and radical innovation capabilities

The data suggests that a corporate mindset (Sandberg and Aarikka-Stenroos, 2014), manifested in management structure and existing processes impacts radical innovation activities. Making the existing structure and processes fit with radical sustainability-oriented innovation is hard for individuals trying to do this. Using entrepreneurial practice was suggested as a desired way to restructure corporate innovation processes. This approach would enable to see through an innovation from the ideation stage to commercialization without losing speed and momentum when the project is handed off to different business functions.

4.4.9 Process: Personal motivation and the leaders of radical innovation activities

The data contained interesting insights as to why people choose to pursue activities that require the acquisition of new capabilities at the individual level. There were many who perceived themselves to be outsiders at their respective firms (e.g. 1, 7, 14, 15) within their profession (e.g. 9), or of the group they perceive as their peers (e.g. 23, 30) and articulated frustration about the existing status quo. This status quo was linked to the slow pace of change in large companies or in the inability of their peers to achieve and push for change. Some interviewees had acted on previous frustration (e.g. 21,

22) and pursued careers and activities that they now perceived as being more meaningful. Some interviewees (e.g. 23) offered their personal belief system as the main driver of all their actions.

Two interviewees (28, 29) were identified by other interviewees as individuals pursuing radical innovation activities. Those individuals did offer that they were motivated by solving problems instead of frustration with their own personal situation. Addressing sustainable development challenges were, in both cases, the result of wanting to address the biggest problem. That the biggest problem related to sustainable development was coincidence. Both also¹⁰⁶ volunteered that they have a higher ability than many people to analyse the effects of combining many factors, here an example: *“I think I have a better memory than most people. I have a very good memory for facts and figures. I wouldn't say I have a particularly good memory for people. I'm not that good at remembering names and faces. But I can remember a large amount of information, especially related to a bit of science. (..) It's very good recall I'd say”* (29: p.5, ATLAS.ti line 146). The skill of basing decisions on many different pieces of information has been asserted to be very challenging for many practitioners (Ashford and Hall, 2011), with simplification of many information factors to a smaller number a long acknowledged fact (Van de Ven, 1986).

The ability of individuals to makes sense of sustainable development goals at the personal level is needed according to Dewberry and de Barros (2009). However, the data indicated that this ‘making sense’ depends on the personal circumstance of the individual. The key conclusions are that values are very personal and were articulated in interviews where trust with the interviewee was quickly established. In contrast, capabilities in the data came across as more clinical and descriptive, purposeful in the way that they were aiming to achieve a specific goal, and achieve this goal fast.

Key insights: Personal motivation and the leaders of radical innovation activities

The data suggests that many individuals act out of personal frustration. However, the entrepreneurial individuals identified by others as radical sustainability-oriented innovators were mainly motivated by solving the biggest problems with their respective innovation activities. Sustainable development challenges are perceived as most important by these two individuals, therefore innovation activities are tailored towards addressing these challenges. Personal values were not offered as motivation. This is in contrast to the reviewed literature so far (Dewberry and de Barros, 2009).

¹⁰⁶ 28 and 29 did meet in person once at the time of the interview, however they have very different career paths and do not regularly engage with each other. So the similarity in these two interviews is not due to the interviewees knowing each other.

4.4.10 Output: affecting others than only the business and technology as enabler

Sustainable innovation should benefit others beyond purely the entity pursuing the innovation (Bocken et al., 2015; Charter et al., 2008; Elkington, 1994), and the data strongly supported this.

Similar to framing the sustainability goal of radical sustainability-oriented innovation activities, the outputs created through such innovation were guided by the background of the interviewees. However, there were three broad levels of output. Firstly, the life of the customer would need to be changed (e.g. 1, 2, 12, 28): *“(..) any product that causes a fundamental change in the end-users lifestyle..and what had previously done that particular task, whatever that product originally would have been done by some other product, the new way of executing that task is now fundamentally different”* (2: p.1, ATLAS.ti line 34). Secondly, at the firm-level new business models would need to be explored (e.g. 6, 7, 17): *“I think [carpet manufacturing company] Interface was fortunate, in the sense that they’ve been able to turn it around fairly quickly internally and see the benefits in a relatively short period of time, from a business model point of view. That’s not always the case; I can tell you from my business experience that it’s more of a longer mission, it’s more of a longer road to travel.”* (7: p.3, ATLAS.ti line 74). And finally, the data indicated that the outputs of radical sustainability-oriented innovation should change society at large for the better (e.g. 6, 30): *“I was lucky enough to go to Japan and (..) the Japanese approach to society and this amazing concept of, “Our role in society,” (..) We all have a part and a responsibility in society, and that we play a part in that, we have to be aware of it. So how do you actually then use data and technology to understand that role and then potentially alter our behaviour in a way that benefits all?”* (6: p.3, ATLAS.ti line 87) Examples include new transport infrastructure (6), technology infrastructure (17), and promoting a sense of financial inclusiveness (22). However, economic value creation would ideally be achieved too (3, 11).

The literature strongly views technology as the key driver of radical innovation (Linton, 2009). In line with technology as an enabler but not the main driver of conventional or sustainability-oriented radical innovation, the outputs of radical sustainability-oriented innovation should first and foremost benefit human beings according to some data. One interviewee articulated how the technology-mindset leads to the notion of *“(..) technology will solve everything and people don’t have to change, which I find terrifying”* (1:p.3, ATLAS.ti line 92).

Finally, the data articulated that innovation activities at any level would ideally need institutional support to pursue radical innovation activities.

Key insights: *Affecting others than only the business and technology as enabler*

The data suggests that the sustainability goal of radical sustainability-oriented innovation activities, and therefore the outputs created through such innovation were guided by the background of the interviewees. The outputs of radical sustainability-oriented innovation should first and foremost benefit human beings. At the same time, human beings need to change for sustainable development challenges to be addressed successfully.

4.5 2013 Data conclusion

The data indicated that lack of individual and firm competencies within large firms lead to unsuccessful innovation activities. This aligns with the findings of Sandberg and Aarikka-Stenroos (2014) on radical innovation barriers in firms. The assertions that radical sustainability-oriented innovation benefits others than just the business (Bocken et al., 2015; Charter et al., 2008) was equally validated, as was the assertion that sustainability-oriented innovation includes more factors and decisions than conventional innovation (Jay and Gerard, 2015). Finally, interviewees suggested that a culture of innovation in firms is needed to encourage ongoing change (Hofstede, 2001).

According to the interviewees, from the perspective of the firm, new processes needed to be learnt in order to pursue radical innovation, with technology perceived as the enabler of this change. Equally, new capabilities need to be learnt to address sustainable development challenges in a timely manner, with some interviewees suggesting an experimental learning approach as a way to improve and the radical sustainability-oriented innovation process. The speed of change and the ambition of response rate of businesses were perceived to be too slow to address the urgent sustainable development challenges. All this strongly indicates that the process perspective on sustainable innovation (Charter et al., 2008) urgently needs to gain a time dimension. That firms must change the operational status quo of solely focusing on economic value creation in order to address sustainable development challenges was not disputed by a single interviewee. However radical sustainability-oriented innovation is associated with higher economic cost at the level of the firm. This creates a tension.

The data highlighted entrepreneurial behaviour and organizational capabilities as being necessary to successfully pursue radical innovation projects. Section 5.1.9. focuses on the individual and goes beyond the literature reviewed in chapter 3. It was instrumental in deepening aspects of the research, leading to the narrowing down of the research's conceptual framework (see Methodology chapter 2). At the same time, the freedom to explore uncertain outcomes at the level of the firm was deemed highly important in the data. This points towards the assertions of Chang et al. (2012) that

the ability to experiment is linked to successful radical innovation activities. The data therefore validated the literature synthesis in chapter 3 and highlighted the need to explore the process challenges of the business response to sustainable development challenges.

This thesis goes on to explore the process of the business response to sustainable development challenges as indicated at the end of chapter 3, whilst focusing on entrepreneurial practices that centre on fast learning. Furthermore, leadership and the need to articulate specific goals are explored in literature chapter 5 and data discussion chapter 6.

5. Exploring the organizational capability of experimentation

This chapter continues the interdisciplinary literature review to explore and link theory from the domains of innovation studies, organizational learning, organizational capabilities, design of experiments and entrepreneurship. How organizations conduct radical innovation is explored in more depths in the organizational capabilities section 5.1., which strongly highlights ‘experimentation’ as key organizational capability for successful radical innovation activities. A short excursion into the design of experiment literature 5.2. provides insights into what the characteristics of ‘experimentation for sustainability’ may be. The entrepreneurship section 5.3. explores who drives radical innovation projects, the research on why some entrepreneurs address sustainable development challenges and the core concepts of the organizational startup culture that has emerged since the 1990s. The leadership section explores and critiques the research on individual and organizational leadership styles in more depth (5.4.).

Section 5.1. to 5.4. end with summaries that build on key arguments and findings in the reviewed literature. The final section 5.5. of this chapter combines the three previous section summaries and offers characteristics of the organizational capability of experimentation. These defining characteristics are the starting point to answer research question (2) and provide the theory foundation for data discussion and analysis of this PhD research.

5.1 Organizational capabilities for radical innovation

It has long been acknowledged that introducing radically new products to any market requires specific organizational capabilities *“embedded in structures, communication channels, and information processing procedures”* (Garcia and Calantone, 2002; p. 122) and that this is a difficult process for established companies (Abernathy and Clark, 1985; Garcia and Calantone, 2002; Leifer et al., 2000). Seebode et al. (2012) set innovation for sustainability in the context of organizational innovation management processes. They argue that the organizational innovation challenge is *“essentially around processes of search (for innovation trigger signals), selection (resource allocation) and implementation”* (Seebode et al., 2012; p.197), therefore concurring with the three organizational innovation activities as articulated by Bessant et al. (2014) and Tidd and Bessant (2013). Hence organizations have to develop a set of capabilities to overcome these challenges (Bessant et al., 2014).

Such organizational capabilities are similar to the five critical process factors referred to and identified in a conference paper by Kennedy et al. (2013):

1. sustainability orientated technology super-scouting,
2. searching for radical sustainability solution,
3. ensuring sustainability performance in product development,
4. captaining emerging sustainability value chain, and
5. harnessing benefits of sustainability strategy through open innovation.

The authors argue that these organizational capabilities are closely linked to the strategic business choice of embedding sustainability into a business. The research findings are based on 19 qualitative interviews, documentary evidence and direct observation based on 12 unique visits to a case study firm¹⁰⁷ in the Netherlands. The five organizational capabilities are linked to the organizational innovation process. The authors stress the capability of 'Sustainability orientated super-scouting' and 'Searching for radical sustainability solution' as the two capabilities for the early stages of radical innovation in established companies. These two capabilities address the assertion of a recent radical innovation literature review that showed that firms pursuing radical innovation activities most commonly lack radical innovation discovery capability (Sandberg and Aarikka-Stenroos, 2014).

Throughout the conference paper, Kennedy et al. (2013) continually highlight that the five critical process factors need to adapt to the individual firm challenges. Furthermore, the CEO of the case study business played a key role in driving radical innovation for sustainability and state: *"His strategic drive to contribute to solving the world's problems permeates the organization and top management team"* (Kennedy et al., 2013; p. 9).

The five critical process success factors identified by Kennedy et al. (2013) are closely related to the organizational capabilities necessary to succeed in radical innovation as explored by Chang et al. (2012). The research by Chang et al. (2012) explored organizational capabilities along the organizational innovation process from product inception to commercialisation. According Chang et al. (2012), overcoming structural inertia to radical innovation in established businesses relies on: the ability to search (i.e. openness capability), to plan (i.e. strategic integration capability), to tolerate (i.e. autonomy capability) and to commercialize (i.e. experimentation capability). The authors explored how organizations implement these four capabilities through a questionnaire survey with 112 respondents from the 'top 500' manufacturing firms in Taiwan.

¹⁰⁷ "A 'new to the world' radical product development allowing plastics to be made from bio-renewable sources and with a substantially improved environmental footprint compared to using petrochemicals." (Kennedy et al., 2013; p. 7)

Chang et al. (2012) explicitly look at established firms, whereas Kennedy et al. (2013) do not say so and use a case study that is placed at the intersection between entrepreneurship and an established business.

5.1.1 *Dynamic capabilities in organizations*

Neither Kennedy et al. (2013) nor Chang et al. (2012) make reference to the dynamic capabilities literature (e.g. Eisenhardt and Martin, 2000; Teece and Pisano, 1998) even though this appears to be the organizational science foundation for their research. The reason for not making the link to the organizational capabilities literature is unclear. Dynamic capabilities enable organizations to address fast changing organizational operational environments beyond a purely resource-based strategy for value creation (Eisenhardt and Martin, 2000; Teece and Pisano, 1998). Eisenhardt and Martin (2000) define dynamic capabilities as implemented by organizational managers to “*integrate, build, and reconfigure internal and external competencies to address rapidly changing environments*” (Teece et al., 1997, in Eisenhardt and Martin, 2000). Teece (2007) argues that organizations with strong dynamic capabilities are highly entrepreneurial: going beyond adapting to fast changing environments and actively shaping them through innovation outputs. Therefore firms with strong dynamic capabilities are able to shape the macro business environment (industry, market) with their innovation outputs: they are able to change the status quo.

The research landscape on dynamic capabilities is split into two main schools of thoughts: dynamic capabilities as ability vs dynamic capabilities as a process (Di Stefano et al., 2014). However recently it has been argued that using dynamic capabilities is a good interdisciplinary framework and useful to stop further fragmentation of the two schools of thoughts and that the splitting into the two schools may be obsolete (Teece, 2014). Furthermore, Teece (2014) goes on to articulate that the individual and how it leads strategy is key to creating and leading dynamic capabilities. Entrepreneurial ability is argued to be a dynamic capability itself according to Teece (2014). Stefano et al. (2014) concur with this position and argue that dynamic capabilities stand and fall with the ability of the individual manager who acts as an entrepreneur when developing dynamic capabilities in order to enable a firm to adapt to a fast changing business environment.

Specifically evaluating “the trade-off between incentives and control” (Chesbrough and Teece, 2002) when developing capabilities for innovation is highlighted as the necessary key skill for individuals to possess. Organizations may choose to develop capabilities in-house or acquire the necessary capabilities through cooperation (Figure 22).

The decision on which this choice is based on the question if the business may pursue the innovation as a stand-alone project (i.e. autonomous) or if other innovations are needed in order to complement this opportunity (i.e. systemic)¹⁰⁸ (Chesbrough and Teece, 2002). The second key choice is to whether the business will acquire the key capabilities or develop them in-house (Chesbrough and Teece, 2002). The authors

conclude that solely large businesses have sufficient “scale and scope to coordinate complementary innovation” (Chesbrough and Teece, 2002; p.134). This mirrors the assertion that large businesses have the scale and scope to address multiple environmental and social issues with their activities through their sustainability management system (Hockerts and Wüstenhagen, 2010).

The lack of ‘discovery’ capability in large businesses has been highlighted as the key barrier for radical innovation success in established businesses by Sandberg and Aarikka-Stenroos (2014). I go on to review the literature on ambidexterity that argues that ‘discovery’ capability has to be developed in conjunction with other innovation capabilities.

5.1.2 Organizational capability of ambidexterity

The economist Schumpeter used the saying “.., in general it is not the owner of stage coaches who builds railways” (Schumpeter, 1934; p. 66) as metaphor to articulate that an existing business is unlikely to be highly innovative. However, since then the thinking has evolved. Exploitation and exploration of innovation opportunities need to take place in parallel for existing businesses if they

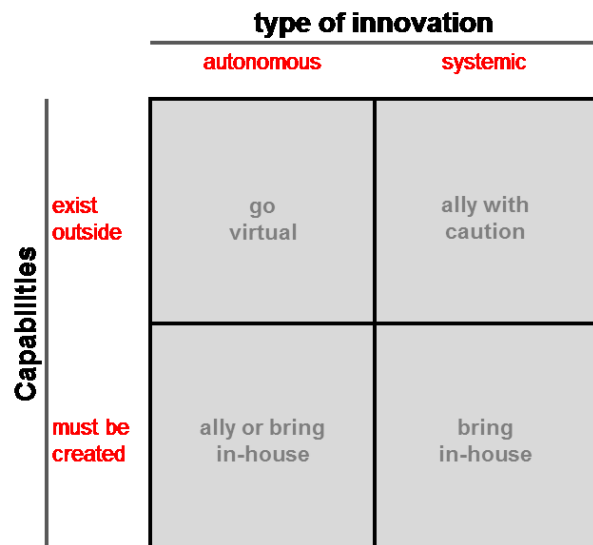


Figure 22: Matching organizations to Innovation (adapted from Chesbrough and Teece, 2002; p.132)

¹⁰⁸ The authors do not define ‘systemic’ in detail.

want to be able to operate in the short term as well as survive in the longer term (Corso and Pellegrini, 2007; O'Reilly and Tushman, 2008; Teece et al., 1997). Exploitative innovation refers to innovation that builds on existing technological and organizational capabilities to serve an existing customers market, explorative innovation refers to innovation that requires developing new such capabilities¹⁰⁹ (Benner and Tushman, 2003; Chanda and Ray, 2015; Jansen et al., 2006; March, 1991). Explorative innovation is linked to the characteristics of radical innovation; exploitative innovation is linked to the characteristics of incremental innovation (Benner and Tushman, 2003; Corso and Pellegrini, 2007). The characteristics of 'explorative' and 'exploitative' have been summarised by March (1991) and are presented in **Table 12**. Innovation falls under 'exploitation' for the author, implying that all innovation is intrinsically linked to an element of the unknown.

Exploration includes these notions	Exploitation includes these notions
Search	Refinement
Variation	Choice
Risk taking	Production
Experimentation	Efficiency
Play	Selection
Flexibility	Implementation
Discovery	Execution
Innovation	

Table 12: What makes for exploration and exploitation (based on March, 1991)

Furthermore, others have linked radical innovation within organization units¹¹⁰ to the notions March (1991) links explicitly to explorative activities: Jansen et al. (2006), Benner and Tushman (2003); Corso and Pellegrini (2007); Güttel et al. (2015).

Process management looks to improve organizational efficiency to maximise economic value of exploiting existing technical capabilities (Benner and Tushman, 2003). Short-term organizational performance pressure based on ease of what can be measured and the demands of existing customers leads to the organizational focus on exploitation (March, 1991). It has been argued that the use of statistical techniques leads to the reduction of variation creation in innovation activities (Benner and Tushman, 2003) – repeatable processes are favoured. Even stand-alone units specifically tasked to pursue radical innovation are affected by organization-wide process optimization aiming at

¹⁰⁹ "(...) radical innovation fundamentally changes the technological trajectory and associated organizational competences." (Benner and Tushman, 2003; p.243). The authors also class 'architectural' innovation and innovation for 'emerging customer sets' as explorative innovation.

¹¹⁰ The authors collected and analysed data from 115 autonomous branches of a European financial services company. In total, 283 organizational units within these 115 branches were used. Each organizational unit has its own management and budget responsibility, including exploratory and exploitative innovation.

lower variation and increased certainty¹¹¹. Despite their explicit mandate these units end up producing innovations that are close to past innovations (Benner and Tushman, 2003).

Ambidexterity has been articulated as an approach to organizational learning, where two parts of learning are achieved through incremental and radical – or exploitative and explorative- innovation activities (Benner and Tushman, 2003; He and Wong, 2004; Jansen et al., 2006; Loorbach et al., 2009). It has been asserted that balancing the exploitation and exploration “*is perhaps the greatest challenge and most important task*” (Nooteboom, 2000; p.8) for people devising business strategy. It has been argued that businesses have to look to balance the learning dimension and the flexibility dimension of ambidexterity: ensuring that management pays attention to balance the innovation dimension (incremental/radical – learning) with the organizational design dimension (alignment/adaptability – flexibility) (Güttel et al., 2015; March, 1991). This articulation of balancing these two dimensions of ambidexterity are the same as the tension between efficiency and flexibility as described by (Eisenhardt et al., 2010). Ensuring that leaders balance efficiency and flexibility in the organizational structure means, perhaps ironically, the “*unbalancing in favour of flexibility*” (Eisenhardt et al., 2010; p. 1270). It has been argued that favouring flexibility is needed for organizational survival in changing –‘dynamic’¹¹²- environments (Eisenhardt et al., 2010; Jansen et al., 2008; Jansen et al., 2006) and ensures that businesses can serve emerging markets and customers (Abernathy and Clark, 1985; Benner and Tushman, 2003).

Things are not as simple as balancing between exploitation and exploration to build ambidextrous organizations though. For example, the organizational ability to manage tensions between differentiation and integration of exploration and exploitation between or within organizational units “*is likely to be an important dynamic capability for creating and sustaining organizational ambidexterity*” (Raisch et al., 2009; p. 687). Other tensions that need to be managed are (1) whether ambidexterity is manifesting itself at the organizational or individual level, (2) the static organizational behaviour ambidexterity research is based on, and (3) how knowledge generated outside organizational boundaries interplays with exploratory and exploitative activities inside of the organizational boundaries (Raisch et al., 2009; p. 686). Therefore, the academic ambidexterity research is, in effect, asserting that individuals within organizations need to be able to create dynamic capabilities to create the dynamic capability of ambidexterity.

¹¹¹ A direct result of process intensity increases throughout the whole of the organization argue Benner and Tushman (2003; p. 246).

¹¹² “*Dynamic environments may be characterized by changes in technology, variations in customer preferences, and fluctuations in product demand or supply of materials. Dynamic environments make current products obsolete (..)*” (Jansen et al., 2006; p. 1664).

However, it has indeed been argued that it is individuals who need to balance conflicting demands of exploitation and exploration at the organizational unit¹¹³ level within a business (Jansen et al., 2012). 2012 research showed that delegating authority to functional unit leaders results in more ambidextrous functional units than units where functional units are under tight control from central business functions (Jansen et al., 2012). However, like March (1991) asserted, Jansen et al. (2012) also found that centralised process management and decision making still impacts the effectiveness of stand-alone organizational units.

5.1.3 Organizational learning

Organizational change is a result from organizational learning. The repeating of the learning cycle results in the change. Different theoretical constructs can be added to this learning cycle, for example sense making; the concept of flexibility; diffusion of innovation; organizational integration and disintegration; and organizational cultural development (Nooteboom, 2000). However, the underlying knowledge cycle (**Figure 23**) remains the same.

Organizational learning and entrepreneurship are closely related through the discovery of knowledge (Nooteboom, 2000) and the author uses the same 'exploration' and 'exploitation' terminology as the organizational ambidexterity literature. Unsurprisingly, March (1991) is drawn upon by Nooteboom (2000). Together with the knowledge cycle, exploitation and exploration of innovation opportunities make up the 'Cycle of discovery' according to (Nooteboom, 2000) (**Figure 24**).

¹¹³ 88 organizational units took part from the same European financial services firm as used by Jansen et al. (2006) for their research.

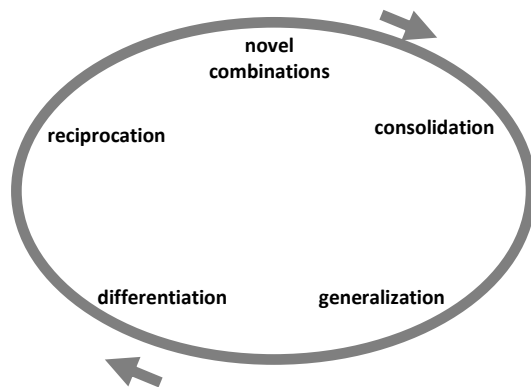


Figure 23: Knowledge cycle (based on Nooteboom, 2000)

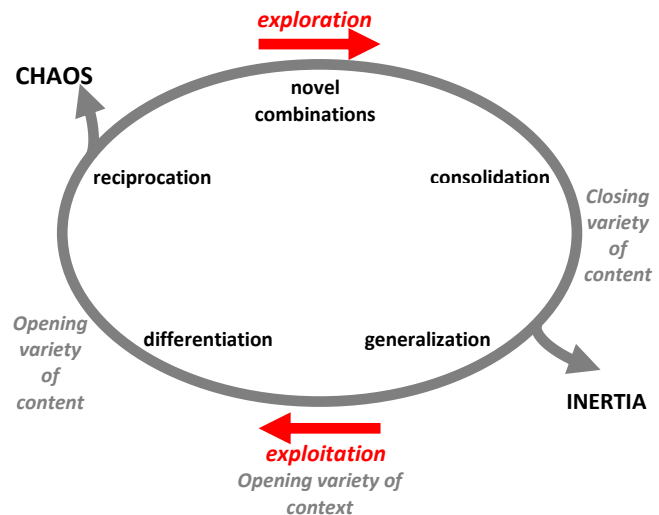


Figure 24: Cycle of exploitation and exploration (Source: Nooteboom, 2000; p. 184)

Recognizing radical innovation opportunities has been linked to the ‘edge of chaos’ by Foster (1986). The cycle of exploitation and exploration proposed by Nooteboom (2000) equally shows how the process of starting to explore new opportunities might lead to chaos or novel combinations. Furthermore, the organizational capability of ambidexterity literature links exploration ability (March, 1991) with radical innovation activities (Jansen et al., 2006). It follows that exploring radical innovation opportunities at the organizational level may result in “*unresolved chaos of trials, errors, and ongoing misfits*” (Nooteboom, 2000; p. 184) or in novel combinations that facilitate new knowledge and contribute to the long-term survival of the business.

A large number of organizational change theories¹¹⁴ look to explain change within organizations. However, it has been argued that these theories overlap and can be combined into four ‘ideal’ theories of organizational change by Poole and Van de Ven (2004). The Cycle of discovery as offered by Nooteboom (2000) is based on theory of intentional change. The intention of the cycle of discovery is to improve organizational innovation capability. In contrast to a life-cycle theory of organizational change, where the final point in the learning cycle symbolises the finite point of a learning process, the teleological process theory defines the goal to be addressed through the organizational change cycle (Poole and Van de Ven, 2004). This implies that such a goal might be the solving of a sustainable development challenge.

¹¹⁴ The theories and approaches looking to explain organizational development and change include “*stage models, evolutionary processes, interaction archetypes, dialectical tensions and contradictions, environmental jolts, institutional analysis, multilevel system models, and complexity theory*” (Poole and Van de Ven, 2004; p.374).

In contrast to Chesbrough and Teece (2002), some have suggested that businesses may be able to be collaborative and autonomous at the same time in order to pursue innovation activities. Collaborations that look to create radical innovation for sustainability can exist in parallel to the pursuit of autonomous innovation activities (Loorbach et al., 2009). Using an ambidexterity conceptual lens, the authors found that *“shadow track”* (Loorbach et al., 2009; p.9) activities enabled the collaboration partners to explore the implications of offering radically new product and services, whilst *“simultaneously maintaining existing business models”* (Loorbach et al., 2009; p.9). This simultaneous ‘experimentation’ in order to explore solutions to sustainable development challenges has been equally asserted by Andries et al. (2013). Neither of these authors allude to an experimentation process. I go on to start exploring the literature for insights on what this process might be.

5.1.4 Organizational experimentation for sustainability: research landscape

“Experimentation is a trial and error process in which each trial generates new insights on a problem” (Lee et al., 2004; p.310). Experimentation as a driver of societal transitions has been researched from the angles of socio-technical experimentation (Schot and Geels, 2008), governance experimentation (Cloutier et al., 2014; Hildén, 2014; Sabel and Zeitlin, 2010) and randomised social experiments (Greenberg and Robins, 2007). Academic research has also started to set experimentation as driver of societal transitions in the context of climate change (INOGOV, 2015). Even though all of these academic research strands are of relevance for the operating environment of firms, none of them are explicitly looking to further radical innovation, innovation, or innovation capabilities with business. However all of these research strands have in common that organizations and society (i.e. relevant to the social dimension of innovation) acknowledge that action-led learning is useful to generate theory that is relevant to practitioners.

Case study research in five businesses on entrepreneurial orientation and the process of exploring and exploiting radical innovation opportunities draws on Schumpeter and asserts that *“a firms tendency to engage in and support”* (Lassen et al., 2006; p. 361) experimentation is an indicator of corporate innovativeness. However, experimentation is solely presented as an indicator for corporate innovativeness and mentioned in conjunction with the firm also engaging in ‘new ideas’, ‘novelty’ and ‘creative processes’. The research by Lassen et al. (2006) intended to start a discussion on the link between the two theoretical constructs of corporate entrepreneurship and radical innovation. ‘Innovativeness’ is a common characteristic of entrepreneurial firms according to the

authors. It is the main dimension of the research conducted and the authors discuss in their work how four other dimensions¹¹⁵ reflect upon the firm dimension of ‘innovativeness’.

In contrast, experimentation is framed as a stand-alone research dimension that impacts corporate radical innovation performance by Chang et al. (2012). The findings of Chang et al. (2012) suggest that four organizational capabilities for radical innovation have a positive effect on increasing radical innovation performance within established firms: openness, autonomy, integration, and experimentation. The four capabilities are all necessary to overcome the organizational status quo, with Chang et al. (2012) referring to ‘structural inertia’ instead of using the term ‘status quo’. The autonomy dimension¹¹⁶ of Chang et al. (2012) is similar in its characteristics to the autonomy dimension¹¹⁷ explored by Lassen et al. (2006) despite drawing on different theory sources: both suggest that allowing staff freedom to pursue innovation activities with uncertain outcomes will benefit firms. This aligns with the assertions of Lee et al. (2004), who researched how conditions at the firm level impact individual experimentation behaviour. Lee et al.’s (2004) findings suggest that *“individuals under less evaluative pressure are more likely to become proactive, optimistic, thoughtful and risk seeking”* (Lee et al., 2004; p.324), therefore these individuals are more likely to engage in experimentation.

At the level of the firm, solely the experimentation capability *“has a significantly positive relationship with the radical innovation performance”* (Chang et al., 2012; p. 448), hence is more important than the other three capabilities to improve organizational radical innovation performance. This means that organizations who have a finely developed ability *“to probe, experiment with, test, and commercialize radical ideas and concepts, across R&D, manufacturing and marketing disciplines”* (Chang et al., 2012; p. 445) are more likely to be able to successfully pursue radical innovation projects. Chang et al. do not allude to sustainability in their research, either as the challenge for radical innovation¹¹⁸ or as organizational strategic choice. However the authors acknowledge that

¹¹⁵ Two dimensions are drawn from characteristics of firm level entrepreneurship and are (1) proactiveness and (2) risk-taking; two dimensions are drawn from entrepreneurial orientation theory and are (3) autonomy and (4) competitive aggressiveness. Firms that emphasise entrepreneurial orientation through (1), (2) and (3) positively stimulate radical innovation, whereas emphasising (4) has a negative effect on stimulating radical innovation according to the research (Lassen et al., 2006).

¹¹⁶ *“The organizational autonomy capability is a firm’s ability to encourage and tolerate risky, ambiguous, unsuccessful radical ideas”* (Chang et al., 2012; p. 445).

¹¹⁷ *“.., in an organizational context autonomy refers to the independent actions of an individual or a team in bringing forth an idea or a vision and carrying it through to completion”* (Lassen et al., 2006; p. 361).

¹¹⁸ Chang et al. (2012) do not settle for a single definition of ‘radical innovation’. However they concur with Leifer et al. (2000) and Linton (2009) that *“A radical innovation should not be a “new-to-the-firm” innovation, but rather a “new-to-the-world” innovation”* (Chang et al., 2012; p. 442). The authors also state that *“.. this paper could easily consider radical innovation, discontinuous innovation and breakthrough innovation as interchangeable concepts”* (Chang et al., 2012; p. 442).

their attempt to measure organizational radical innovation performance is “*far from perfect*” (p. 450).

The need for experimentation at the business strategy level to enable successful innovation is not a new assertion as illustrated by Thomke (2001). However the more recent literature (Andries et al., 2013; Chang et al., 2012; Clegg et al., 2011; Govindarajan and Trimble, 2005) appears far more nuanced in thinking through what experimentation means for organizational capabilities. Whereas Thomke (2001) solely covers concept testing and using new technologies to search for ideas under the term ‘Enlightened Experimentation’, the later literature covers the whole organizational innovation process within the strategy context to provide details on what experimentation means for decision makers in firms at the interface of entrepreneurship and strategy. For example, ten characteristics of strategic experiments¹¹⁹ have been suggested by Govindarajan and Trimble (2005). Others have ‘repackaged’ them as design principles for organizational innovation experiments (Clegg et al., 2011). Both the detailed ten characteristics and the simplified principles assume the departure from the current business status quo. However, neither radical innovation nor sustainable development are explicit dimensions for Clegg et al., (2011) or Govindarajan and Trimble (2005).

The departure from the status quo of organizational practice is, as reviewed earlier, associated with a high degree of uncertainty. Interestingly, research based on six case studies found that experimenting with different business models enables businesses to explore business opportunities and the uncertainty associated with consumer and market reactions (Andries et al., 2013). However, only experimenting with more than one business model at the same time allows long-term survival of the business. In contrast, focus on a single business model experiment is associated with short-term benefits only and not beneficial for the business in the longer-term (Andries et al., 2013).

5.1.5 Summary

The organizational innovation challenge is about search for innovation trigger signals, internal resource allocation, and implementation (Seebode et al., 2012; Tidd and Bessant, 2013). Organizational innovation capabilities are closely linked to the strategic business choice of embedding sustainability into a business (Sandberg and Aarikka-Stenroos, 2014) and the

¹¹⁹ Strategic experiments [1] require departure from assumption about what makes a business successful; i.e. forgetting is required; [2] build on some existing organizational capabilities, hence are different from acquisitions; [3] depart from existing products lines, geographic expansions, or technological improvements; [4] target emerging and poorly defined industries; [5] have no clear formula for making profit; [6] show a high potential for revenue growth; [7] require development of at least some new knowledge and capabilities; [8] are led by managers who face multiple dimensions of uncertainty across multiple functions; [9] are expected to remain unprofitable for several quarters; and [10] are difficult to assess in terms of their success because feedback is delayed and ambiguous.

organizational innovation capabilities need to adapt to the individual firm sustainable development challenges (Kennedy et al., 2013).

Such organizational innovation capabilities are dynamic capabilities. Dynamic capabilities enable organizations to develop and change their competencies to address fast changing environments (Teece et al., 1997). Organizations with strong dynamic capabilities are highly entrepreneurial: going beyond adapting to fast changing environments and actively shaping them through innovation outputs (Teece, 2014). It has been argued that decision makers in businesses must make the choice to develop capabilities in-house or seek collaborations (Chesbrough and Teece, 2002). At the same time, large firms are well placed to tackle systemic/complex innovation and sustainability issues because they have the resources to coordinate activities to address these interwoven and complex issues (Hockerts and Wüstenhagen, 2010).

Large firms benefit in the short and in the long term from being ambidextrous organizations that pursue both explorative and exploitative innovation. Explorative innovation is linked to the characteristics of radical innovation, whereas exploitative innovation is linked to the characteristics of incremental innovation (March, 1991). Experimentation is a characteristic of business exploitation activities (March, 1991). However, even stand-alone units specifically tasked to pursue radical innovation are affected by organization-wide exploitative process optimization aiming at lower variation and increased certainty (Benner and Tushman, 2003). Perhaps unsurprisingly, organizational learning through pursuing explorative – radical- innovation benefits from flexibility (Eisenhardt et al., 2010). This is especially the case in dynamic operating environments with high degrees of uncertainty (Jansen et al., 2006). At the same time, the academic ambidexterity research is, in effect, asserting that individuals within organizations need to be able to create dynamic capabilities to create the dynamic capability of ambidexterity (Raisch et al., 2009).

Still, organizations need to embed learning across central organizational process management and decision making in order to conduct explorative innovation activities (Jansen et al., 2012; March, 1991). Organizational learning is a cyclical process, following an exploitative and explorative pattern (Nooteboom, 2000) and repeating of the organizational learning cycle results in change (Nooteboom, 2000). Seeking radical innovation opportunities –explorative activities- can end in chaos for the business (Nooteboom, 2000) and this is highly undesirable from the perspective of the business. The intention of the organizational learning cycle is to improve organizational innovation capabilities and the cycle can have the overarching goal to solve a sustainable development challenge (Poole and Van

de Ven, 2004). Furthermore, case study research found that experimenting to explore innovation activities with an explicit sustainability goals can take place in parallel to existing business activities (Loorbach et al., 2009).

Action-led learning derived from experimentation is useful to generate theory that is relevant to practitioners. The inertia of the organizational learning cycle (Nooteboom, 2000) and the organizational status quo hindering the success of radical innovation can be overcome through experimentation (Chang et al., 2012; Lee et al., 2004). Moreover, a business benefits from experimenting with more than one business model at the same time (Andries et al., 2013).

All this begs the assertion that all large firms would put high priority on the need to develop the organizational capability of experimentation through their organizational innovation and learning activities. However, the uncertainty and risk of ending in a place of chaos through explorative innovation activities are big barriers.

5.2 Principles of scientific experimentation

The notion of experimentation is based on the desire to empirically learn through the manipulation of controlled situations (Brown and Melamed, 1993) as opposed to through the observation of uncontrolled social situations¹²⁰. Empirical learning means that the investigator subjects a process or system to a set of conditions and draws conclusions from effects these manipulations have on the process or system under investigation (Lewis-Beck, 1993), this is called the scientific method (Savin-Baden and Howell Major, 2013). The empirical learning process should be easily reproducible, therefore resulting in quantification of data to study a process of system (Savin-Baden and Howell Major, 2013).

More specifically, a stated problem or gap in the knowledge is investigated through deductive learning. This means learning is derived by testing a specific hypothesis¹²¹ to explain an observed effect (Fisher, 1960; Lindquist, 1956; Montgomery, 2001; Savin-Baden and Howell Major, 2013). Experimentation is used in the natural sciences¹²² and the social sciences¹²³ (Lewis-Beck, 1993). When

¹²⁰ This approach is used in social sciences. However, key situations or observation intervals to be researched are picked by the researcher. Therefore, this is equally an approach to actively learn. Poole (2004) presents the research approach in the context of the perspective on time and time's role in theory (Table 7).

¹²¹ The comparison hypothesis assumes that nothing will change in the process/system through the experiment (i.e. the null hypothesis).

¹²² Natural sciences refer here to physical, engineering and chemical sciences.

¹²³ Social sciences refer here to studying the behaviour of animals, humans, and social systems.

starting an experiment– i.e. a test or a series of tests- the problem or gap in the knowledge to be investigated is articulated in general terms (Lindquist, 1956). The scientific method follows the same basic steps, shown in **Figure 25**.

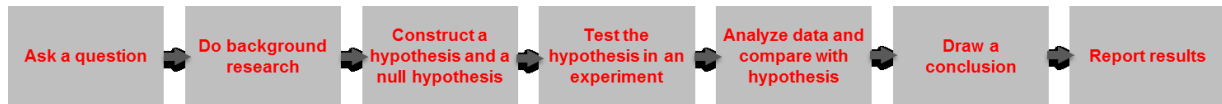


Figure 25: The scientific method (adapted from Savin-Baden and Howell Major, 2013; p.4)

The still fairly general problem or question can be either about (1) characterising or about (2) optimising a process or system (Montgomery, 2001). The first mostly applies when the experimentation is applied to a new process/system; the latter mostly applies to established processes/systems. For both approaches, one large comprehensive experiment is unlikely to answer the key questions that need to be answered to tackle the experiment problem. Rather *“a sequential approach using a series of smaller experiments is a better strategy”* (Montgomery, 2001; p.14).

5.2.1 Basics of experimental planning and design

The planning of the experiment helps to define and narrow down the problem to be investigated in a process or system: *“A careful statement of the problem goes a long way toward its solution”* (Hicks, 1982; p. 3). The researchers ask questions about the general problem to be addressed in order to plan experimental designs which may lead to useful answers through the smallest number of tests (Atkinson and Donev, 1992). Restricting the number of test is desired to enable maximum learning through efficient use of resources: time and money. The final articulation of the problem addressed through the experiment question should include a reference to one or multiple experimentation assessment criterion (Hicks, 1982).

Towards the end of the experiment planning process, the researcher has clarity on the input variable or variables into a process or system. **Figure 26** shows the experiment process. Observing how the manipulation of input variables (x_1 to x_p) effect a system or process, i.e. the output response (y), leads to answers or part answers to the hypothesis to be tested (Montgomery, 2001). In addition, uncontrollable variable may also effect a system or process under observation (z_1 to z_p). For process characterization (i.e. new processes/systems) it is desirable to keep the number of controllable variables low, whereas the region of interest¹²⁴ to be investigated is kept high. In contrast, process

¹²⁴ The region of interest is the area to be investigated through the experiment and is defined by upper and lower variables.

optimisation experiments may include a larger number of variables within a smaller region of interest (Montgomery, 2001; p.15).

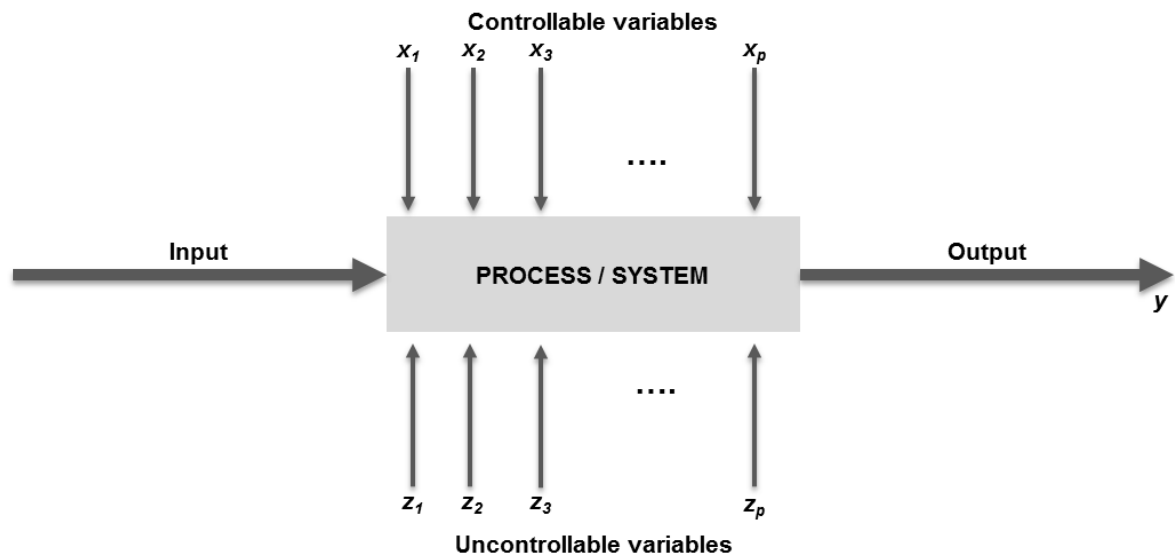


Figure 26: General model of a system or process (adapted from Montgomery, 2001; p.2)

5.2.2 Limited resources, researcher judgement and bias

The design of experiments plans active learning so that appropriate data can be generated and analysed, leading to valid conclusions (Montgomery, 2001). An *“essential characteristic of experimentation [is] that it is carried out with limited resources”* (Fisher, 1960; p. 18) and allocating these limited resources to manipulate controllable variables is the key choice to make during designing an experiment. Therefore, the scientific method of experimentation has human judgement at the core of the planning process. The researcher passing this judgement increases the likelihood of human error in the conducting of the experiments because they choose the controllable input variables. An inappropriate choice of input variables would lead to wrong conclusions about the effect the chosen variables have on a system or process under observation.

In the case of the investigation of a new process/system (i.e. characterization), human judgement is merged with a strong bias of past experience for the researcher (Montgomery, 2001). This is the case because the researcher is looking to apply knowledge on existing processes/systems to the set-up of experiments looking to characterize an unknown process/system.

5.2.3 Addressing human error in the design of experiments

Randomization is used to reduce the likelihood of error due to human judgement in the manipulation of variables. All experiments include controllable variables (x_1 to x_p) that relate to the process or system under investigation. Optimising the process or system might mean either (1) the reduction of the impact of uncontrollable variables (z_1 to z_p) on the process/system or (2) the optimisation of the process/system output (y) - or a combination of both of these improvements (Montgomery, 2001). Controllable variables are used at different levels during experimentation by the researcher. Applying the different levels of controllable variables in a random order leads to the averaging out of uncontrollable variables (Hicks, 1982; Lewis-Beck, 1993; Montgomery, 2001).

When looking to characterize an unknown process/system, the area of interest to be characterized though investigation by the researcher becomes more influenced by judgement of the researcher towards the extremes (i.e. the unknown 'corners') of this area of interest (Box and Draper, 1987). Therefore, the risk of bias is most substantial in this or these points in the area of interest. This bias cannot be addressed through randomization of variables. It is the responsibility of the researcher to source robust sources to inform the decision-making process.

5.2.4 Summary

The notion of experimentation is based on the desire to empirically learn through the manipulation of controlled situations (Lewis-Beck, 1993). Experimentation based on the scientific method is a linear process (Montgomery, 2001; Savin-Baden and Howell Major, 2013).

Experiments look to create maximum learning with minimal time and money spent, with the problem addressed through the experiment question including a reference to one or multiple experimentation assessment criterion (Hicks, 1982). Only then, the manipulation of inputs into the experiment process enables learning to be derived from the output response (Montgomery, 2001). Allocating limited resources to manipulate controllable variables is the key choice to make during designing an experiment (Fisher, 1960). Of course, the design of experiments has human judgement at its core – it is not objective (Montgomery, 2001). For example, researchers look to apply knowledge on existing processes/systems to the set-up of experiments looking to characterize an unknown process/system (Montgomery, 2001). Mechanisms like the introduction of randomness into experiments counteract this and lead to more reliable experiment results (Hicks, 1982).

However, the more unknown a process to be experimented on is, the more guesswork on the part of the researcher is involved in scientific experimentation (Box and Draper, 1987).

5.3 Entrepreneurship approach and sustainable development

It has been argued that radical innovation and entrepreneurship are closely related (Drucker, 1985; Griffin et al., 2014; Stam and Nooteboom, 2011). This section explores this assertion through presenting an overview of the key areas of entrepreneurship research, whilst throughout focusing on literature that has a sustainable development component. The academic domain of entrepreneurship has been argued to be the intersection between business opportunities and individuals (Shane and Venkataraman, 2000; Thompson et al., 2011). However, this intersection can take place within organizations (Schaltegger and Wagner, 2011; Thompson et al., 2011).

The relationship between the academic domains of innovation studies, entrepreneurship and sustainability has previously been explored in a book edited by Marcus Wagner (2012). The book looks at the “*fringes of this nexus*” (Wagner, 2012; p. 5), for example small and medium-sized firms. Large firms are not the focus. This section does, therefore, not draw heavily on this book. Instead, the literature narrative is led by the perspective of the firm (i.e. the organization) and how the people within firms might deal with sustainable development challenges during innovation activities.

5.3.1 Entrepreneurship and the cycle of exploitation and exploration

This research follows Schumpeter’s argument that at the heart of innovation lays the novel combination of production means (Schumpeter, 1934). His argument is based on entrepreneurs who drive these novel combinations and sometimes even destroy stagnant markets through these activities¹²⁵.

This thesis observed earlier that radical innovations do not build on existing social and technical structures (Foster, 1986; Linton, 2009; Nooteboom, 2000). Rather, they are removed from the existing organizational (Goktan and Miles, 2011; Van de Ven and Engleman, 2004), social (Leifer et al., 2001) and technical (O'Connor and DeMartino, 2006) status quo. Hence, the entrepreneurship

¹²⁵ This PhD research follows the assertion of Thompson et al. (2011) that “*while creative destruction may be an outcome of entrepreneurship, the core concept of alertness (to arbitrage opportunities) unites all forms of entrepreneurship (traditional, social, sustainable, and environmental) into the larger scholarly domain*” (Thompson et al., 2011; p.220). Thus, this thesis does not look to divide Schumpeter’s view on the role of entrepreneurs from, for example, Kirzner.

that looks to create novel combinations of productive means is explorative in nature (March, 1991; Nootboom, 2000) and linked to the characteristics of radical innovation (Benner and Tushman, 2003; Corso and Pellegrini, 2007). Figure 27 illustrates how radical innovation activities relate to the knowledge discovery cycle (Figure 24: 'Cycle of exploitation and exploration').

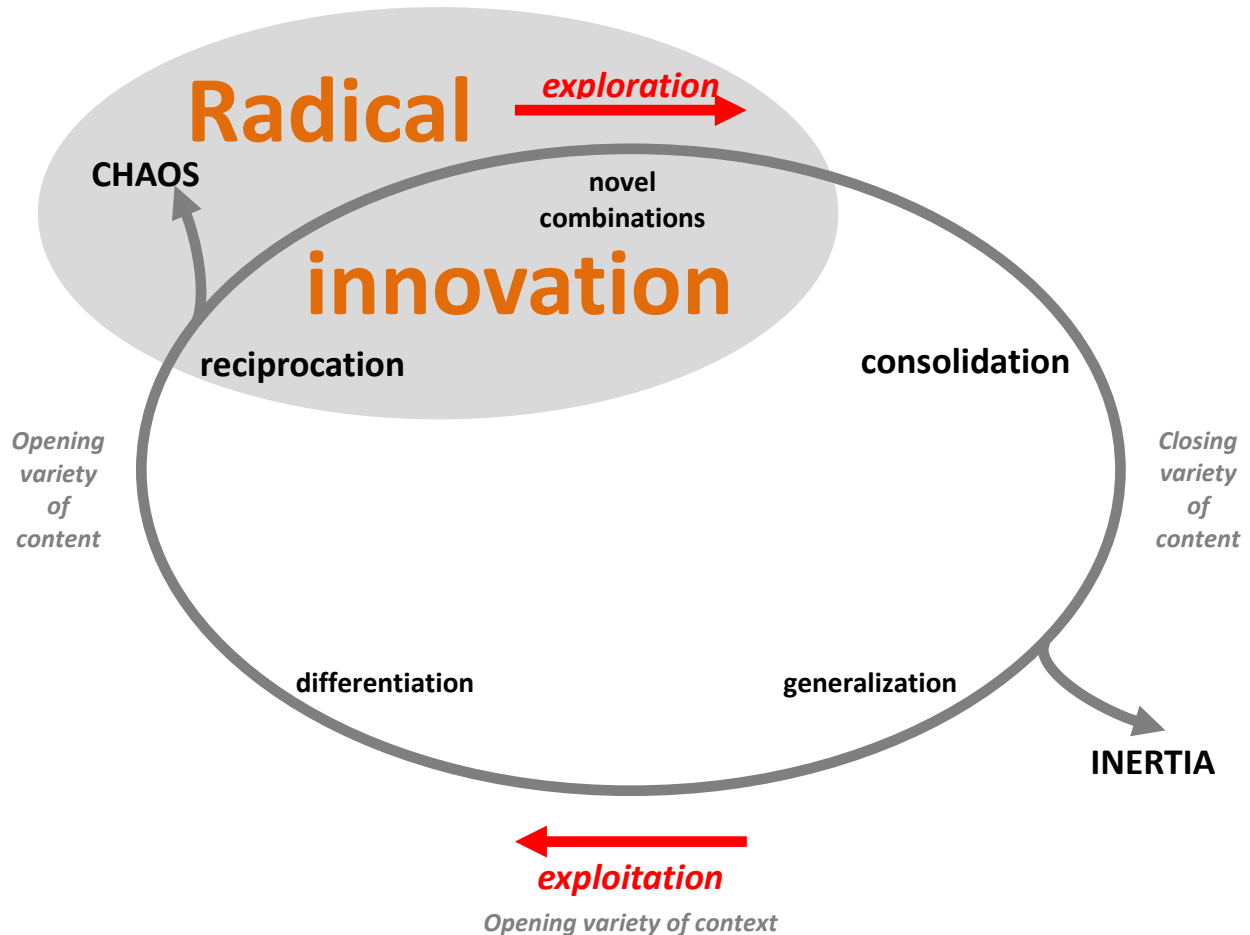


Figure 27: Discovery Cycle: cycle of exploitation and exploration and radical innovation activities (based on Nootboom, 2000)

Of course, all stages of the knowledge 'cycle of discovery'¹²⁶ are relevant to the pursuit and execution of radical innovation. Acquiring knowledge is a cyclical activity. However, it has been argued that different notions¹²⁷ of entrepreneurship "fit different stages in the cycle of discovery" (Nootboom, 2000; p. 258). Schumpeterian entrepreneurship, focused on innovation, fits well with the exploration stage of the cycle of discovery according to Nootboom (2000).

¹²⁶ Nootboom (2000) uses the phrase 'cycle of discovery' interchangeably with 'Cycle of exploitation and exploration'.

¹²⁷ "Different notions of entrepreneurship emphasize different things, in different combinations" (Nootboom, 2000; p. 257). However, radical innovation is removed from the status quo and requires novel organizational practices in order to generate novel combinations as opposed to end in chaos. This is closely aligned with the Schumpeterian view of entrepreneurship.

Technology discontinuities gaps that may lead to disruptive innovation (Christensen, 1997) have been placed on the edge of chaos by Foster (1986). This assertion fits aligns with the Discovery Cycle proposed by Nooteboom (2000). Therefore, I argue that influencing this stage of organizational knowledge creation is of utmost importance for the pursuit of radical innovation activities within the firm.

I go on to review the motivations driving the individuals pursuing entrepreneurship and how sustainable development fits in with these motivations. Entrepreneurship pursued within organizations sets the context for entrepreneurial activities pursued with the goal of gaining maximum learning within a limited timeframe and with few organizational resources.

5.3.2 Entrepreneurial value systems

McGrath et al. (1992) explored a set of entrepreneurial beliefs that build on an individual's value system as proposed by Hofstede (2001)¹²⁸. These values are associated with behaviour that can be the driver for or the result of individual action. **Table 13** shows the values and associated behaviour explored by McGrath et al. through a cross-cultural study, consisting of data from 1217 entrepreneurs and 1206 non-entrepreneurs (i.e. 'career professionals') in nine countries.

Underlying values	Entrepreneurial activities
Power distance ¹²⁹	Entrepreneurs will exhibit high "power distance" scores, reflecting a tolerance for inequality.
Individualism	Entrepreneurs will favour individual rather than collective action.
Uncertainty avoidance	Entrepreneurs will be prepared to take risks and will value their personal time.
Masculinity	Entrepreneurs will tend to have a highly "masculine" orientation; will live to work, and treasure things and money.

Table 13: Array of entrepreneurial beliefs (McGrath et al., 1992)

In effect, each line of **Table 13** represents one of the four hypothesis tested by McGrath et al. (1992), comparing the values of entrepreneur with those of career professionals. Through a questionnaire, the data analysed consisted of 2423 responses. Interestingly, the hypothesis held true across all nine countries, irrespective of the cultural background. Entrepreneurs in Australia exhibited the same four underlying values as entrepreneurs in Portugal, Canada, the U.S., Puerto Rico, Italy, Sweden, Finland and China. However, McGrath et al. (1992) state that it is unclear whether the values shape the life choices of entrepreneurs or if the act of entrepreneurship encourages these underlying values.

¹²⁸ 2nd edition cited here as the 1980 1st edition book as used by McGrath et al. (1992) was not easily accessible.

¹²⁹ The power distance value refers to the income, wealth and 'hierarchy' gap between the most and the least influential members of any society.

In regards to ‘Individualism’, the underlying values as proposed by McGrath et al. (1992) are in stark contrast to more recent literature (Tidd, 2014) and long-term practitioner observations (Graham, 1993-ongoing). They assert that entrepreneurial activities are far more likely to succeed if core capabilities necessary for the enterprise (e.g. technical and commercial) are combined in more than one person, or enterprise ‘founder’. Both Tidd (2014) and Graham (1993-ongoing) state the likelihood of taking an idea to commercialisation benefits from the collaboration between individuals with complementary capabilities. This means that one of the four underlying responses to human problems as proposed by Hofstede (2001) and explored by McGrath et al. (1992) have changed. Alternatively, many entrepreneurs collaborate¹³⁰ when they would prefer to take individual action. However, it has also been argued that personality traits decrease in influence on the entrepreneurial process as this process advances (Frank et al. 2007 in Liñán and Fayolle, 2015).

In contrast, the impact of personal values on the intention to entre entrepreneurial pursuits is a new research area that is becoming more explored (Liñán and Fayolle, 2015). It is argued that personal values are the key differentiator between conventional entrepreneurship and entrepreneurship that looks to address sustainable development challenges (Parish, 2010 in Bocken, 2015). The core motivations to pursue entrepreneurship addressing sustainable development challenges have been contextualised with organizational activities and classified by Schaltegger and Wagner (2011).

I go on to explore the notion of sustainable entrepreneurship and motivation for pursuing this type of entrepreneurship.

5.3.3 Sustainable entrepreneurship

Sustainability-influenced entrepreneurial activities are the starting point for a framework proposed and developed by Schaltegger and Wagner (2011). They analysed individual core motivation and other variables for entrepreneurship that addresses sustainable development challenges. **Table 14** shows the summary of their classification of sustainability-influenced entrepreneurship.

	Ecopreneurship	Social entrepreneurship	Institutional entrepreneurship	Sustainable entrepreneurship
Core motivation	Contribute to solving Environmental problem and create economic value	Contribute to solving societal problem and create value for society	Contribute to changing regulatory, societal and market institutions	Contribute to solving societal and environmental problems through the realization of a successful business

¹³⁰ The benefits of collaboration for building a business are about combining access to knowledge and resources to develop an idea to its commercialization.

	Ecopreneurship	Social entrepreneurship	Institutional entrepreneurship	Sustainable entrepreneurship
Main goal	Earn money by solving environmental problems	Achieve societal goal and secure funding to achieve this	Changing institutions as direct goal	Creating sustainable development through entrepreneurial corporate activities
Role of economic Goals	Ends	Means	Means or ends	Means and ends
Role of non-market goals	Environmental issues as integrated core element	Societal goals as ends	Changing institutions as core element	Core element of integrated end to contribute to sustainable development
Organizational development challenge	From focus on environmental issues to integrating economic issues	From focus on societal issues to integrating economic issues	From changing institutions to integrating sustainability	From small contribution to large contribution to sustainable development

Table 14: Characterization of different kinds of sustainability-oriented entrepreneurship (Schaltegger and Wagner, 2011; p.224)

It is immediately obvious that the goals and motivations as presented by Schaltegger and Wagner (2011) are in stark contrast to the power distance value explored by McGrath et al. (1992). There is a whole category of entrepreneurship summarized by (Schaltegger and Wagner, 2011) that looks to close the gap of between the most and the least influential members of society: social entrepreneurship. According to the findings of the research conducted by McGrath et al. (1992) however, even entrepreneurs from societies with flat hierarchies (i.e. Sweden and Finland) display a high tolerance for inequality. It follows that the entrepreneurs that address sustainable development challenges make up either (1) a third category in addition to the entrepreneurs and career professional proposed by (McGrath et al., 1992) or that (2) the values as proposed by Hofstede (2001) and explored by McGrath et al. (1992) have fundamentally shifted across all societies.

The core motivations as highlighted by Schaltegger and Wagner (2011) were previously explored from the angle of entrepreneurial intentions by Kuckertz and Wagner (2010). Their quantitative research¹³¹ was looking to explore whether a concern about sustainability issues positively influences entrepreneurial intentions. Their research found that there was a positive link between sustainability concerns and entrepreneurial intention. However, this positive link differed according to whether the research participants were from an engineering or from a business background; and to whether the participant had gained experience in working in business. The core finding was that the more

¹³¹ A quantitative survey with statements (e.g. "I think that environmental problems are one of the biggest challenges for our society" Kuckertz and Wagner 2010; p. 531) linked to 5-point scales. The survey was answered by 712 students and alumni of science and engineering degree programmes from a single German university.

business experience an individual had, the less likely sustainability concerns were to drive entrepreneurial intentions.

Others have classified the differences between sustainability-oriented entrepreneurship slightly different (Thompson et al., 2011) and focus on how the broader field of entrepreneurship may embed social, sustainable and environmental entrepreneurship. However, alike to Schaltegger and Wagner (2011), this is not an attempt to create separate research streams or look to differentiate between different types of entrepreneurs addressing sustainable development challenges. Rather, the goal is to look for the links between these entrepreneurs and innovation activities. In the case of Thompson et al. (2011), the authors do assert that sustainable entrepreneurship research is concerned with the “*process¹³² of discovery, evaluation, and exploitation of opportunities*” (Thompson et al., 2011; p. 218) that look to address the environmental, social and economic challenges and market failures at the same time. Sustainable entrepreneurship is positioned as having an effect on whole markets/society whilst sustainability performance is the core business goal by Schaltegger and Wagner (2011).

This thesis follows the classification of Schaltegger and Wagner (2011) and Thompson et al. (2011) and uses ‘sustainable entrepreneurship’ as term to define business individuals that put social, economic and environmental business goals at the core of business activities with the view to impact the market place.

It has been argued that individuals may evoke embedding personal values in the creation of new business product and service offerings or, in other words, business activities with personal meaning that are at the heart of a sustainable enterprise (Tennant, 2015). The mechanism suggested to embed personal values is the reflecting on personal motivation. This argument means that the values as explored by McGrath et al. (1992) may be influenced and changed by individuals themselves – and may even result in entrepreneurial motivations addressing sustainable development goals as proposed by Schaltegger and Wagner (2011), therefore resulting in sustainable entrepreneurship.

Of course, the individuals pursuing entrepreneurial opportunities are unlikely to challenge their personal values through reflection as recommended by Tennant (2015) to do so without a prompt. I go on to explore how organizational innovation activities may be linked to the pursuit of entrepreneurial opportunities with a sustainability goal.

¹³² The process is the same as the radical innovation process as described by Bessant et al. (2014) and Tidd and Bessant (2013).

5.3.4 Corporate entrepreneurship

Individuals pursuing entrepreneurial activities within the organizational boundaries of a large business have been called ‘intrapreneurs’ (Bosma et al., 2011; Ford and Probert, 2009), ‘corporate entrepreneurs’ (Bierwerth et al., 2015; Buckland et al., 2003; Lassen et al., 2006; Van de Ven and Engleman, 2004) and ‘institutional entrepreneurs’¹³³ (Greenwood and Suddaby, 2006).

Some have argued that individuals are intrapreneurs and therefore research explores the behavior and activities of individual employees (Bosma et al., 2011). In contrast, corporate entrepreneurship is related to how a business may encourage these individuals to pursue innovation opportunities (Bosma et al., 2011). However, this distinction is not widely made in the literature.

This research and thesis refers to the individuals pursuing innovation opportunities within businesses as ‘corporate entrepreneurs’. This thesis refers to the activities conducted by these individuals to create novel combinations as ‘corporate entrepreneurship’.

Radical innovations “*lie at the heart*” (Hansen and Große-Dunker, 2013; p.2413) of sustainable entrepreneurship (Hall et al., 2010; Hockerts and Wüstenhagen, 2010; Schaltegger and Wagner, 2011). This is not immediately obvious in the summary table of characteristics (i.e. **Table 14**). However, it is articulated visually in the sustainable entrepreneurship and sustainability classification matrix (**Figure 28**) offered by Schaltegger and Wagner (2011), with sustainable entrepreneurship impacting the whole market and society, i.e. the macro level (Garcia and Calantone, 2002).

¹³³ In this case, ‘institutional’ and ‘organizational’ are used interchangeably because these authors use the term within the boundaries of ‘organizational’ as used by this research, based on Ashford and Hall (2011).

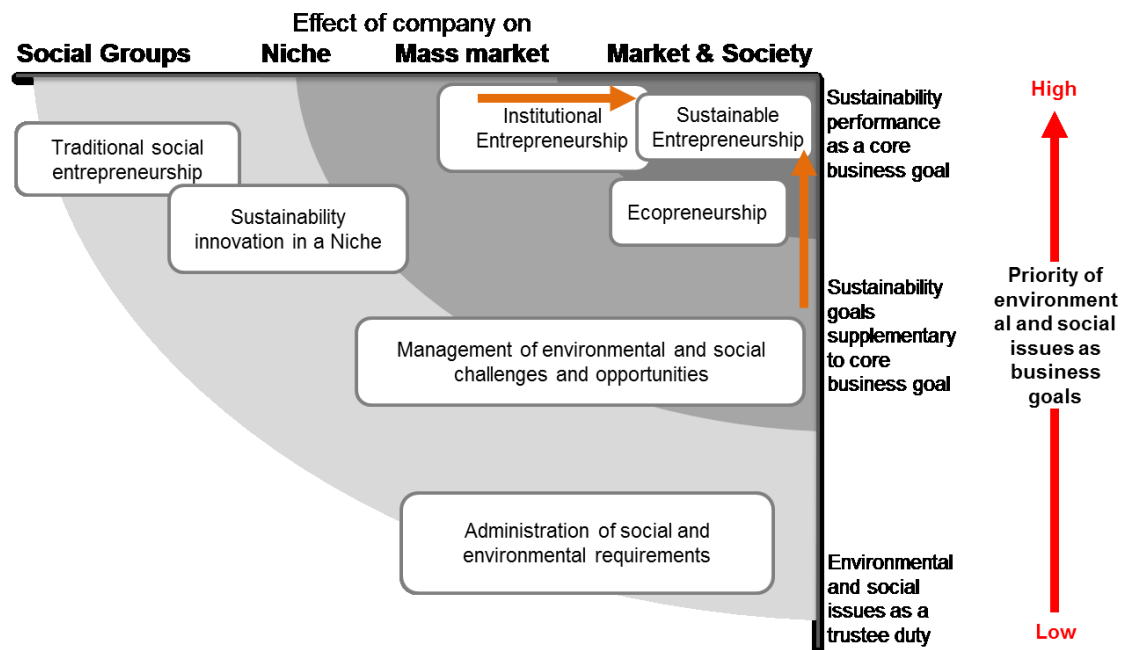


Figure 28: Perspectives and development of sustainable entrepreneurship and sustainable innovation (Schaltegger and Wagner, 2011; p.228)

The qualitative classification matrix developed by Schaltegger and Wagner (2011) suggest that corporate entrepreneurship and sustainable entrepreneurship can share key characteristics. This means that organizations that look to improve their radical innovation performance through encouraging corporate entrepreneurship are in a strong position to nurture sustainable entrepreneurship within their organizational boundaries.

The matrix (**Figure 28**) and characteristics (**Table 7**) offered by Schaltegger and Wagner (2011) echo the notion that the firm is at the core of new business creation and this can take place through the mechanisms of “*internal innovation, strategic alliances, joint ventures, and other network arrangements*” (Van de Ven and Engleman, 2004; p.47). All of these activities look to fundamentally change the existing business and it has been argued that the challenges associated with conducting corporate innovation¹³⁴ (e.g. Van de Ven, 1986) and the challenges encountered by corporate entrepreneurs are very similar (Van de Ven and Engleman, 2004).

The activities associated with corporate entrepreneurship are therefore of importance for the success of innovation activities. These activities follow a path from ideation to commercialization and have been summarized as including perception of opportunity, generating ideas, designing new

¹³⁴ The four challenges centre around four key areas. “(1) A people problem of managing attention, (2) a process problem of pushing new ideas into good currency, (3) a structural problem of managing relationships and (4) a leadership problem of managing the context for innovation” (Van de Ven and Engleman, 2004; p. 48-49).

products and services, building the necessary collaboration networks, securing financial resources, planning and organizing efforts (Bosma et al., 2011). Creating management buy-in to the pursuit of the innovation activities identified is the corporate entrepreneurship activity (Bosma et al., 2011) that is clearly distinct from entrepreneurship pursued outside of business boundaries. However, corporate entrepreneurship activities are otherwise strongly aligned to 'normal' entrepreneurship activities.

The path of entrepreneurial activities to pursue radical innovation is not linear, especially in the early stages of identifying an opportunity to the first wider launch (Griffin et al., 2014; Koen et al., 2001). Rather, there are circular learning cycles necessary to understand and refine the entrepreneurial opportunity for radical innovation, the same goes for taking the opportunity further down the path towards commercialization (Griffin et al., 2014).

The key for entrepreneurial success outside organizational boundaries has been established as, simply put, "Make something people want" (Graham, 1993-ongoing; Livingston, 2007). Learning about and engaging with customers whilst pursuing a business opportunity is, therefore, of utmost importance for corporate entrepreneurs and conventional entrepreneurs.

5.3.5 Customer development

Over the last two decades, how to engage customers in the creation of new services has become a distinct field of management research (Edvardsson et al., 2006; Füller and Matzler, 2007). It has been proposed by business practitioners and grey literature that new products and services should be based on gaps in the markets or as solving customer problems, where filling these gaps and addressing these problems with new customer value offerings should be pursued whilst engaging customers¹³⁵ (Blank, 2013; Debruyne, 2014; Edvardsson et al., 2006). However, this means having to tap into needs that customers might not be able to articulate themselves yet (Füller and Matzler, 2007), otherwise customer-centred innovation will result in incremental innovation (Christensen, 1997; Füller and Matzler, 2007).

Engaging customers leads to a learning cycle that enables the development of a customer value offering that closes a gap in the market. This customer learning cycle has been most refined by Steve

¹³⁵ The exceptions are pharmaceutical and biotechnology businesses because the risk is based in the front-end of product development, not in the back-end of customer acceptance (Blank, 2013). Customer development is nonsensical for businesses that produce products that cure specific illnesses.

Blank who coined the notion of 'Customer development' (Blank, 2013) that is the basis of how practitioners understand the term today. Customer development is a four-step process –customer discovery, customer validation, customer creation, company building- where the customer discovery is almost identical to what Ries (2011) calls 'lean'¹³⁶. **Figure 29** shows the customer development process.

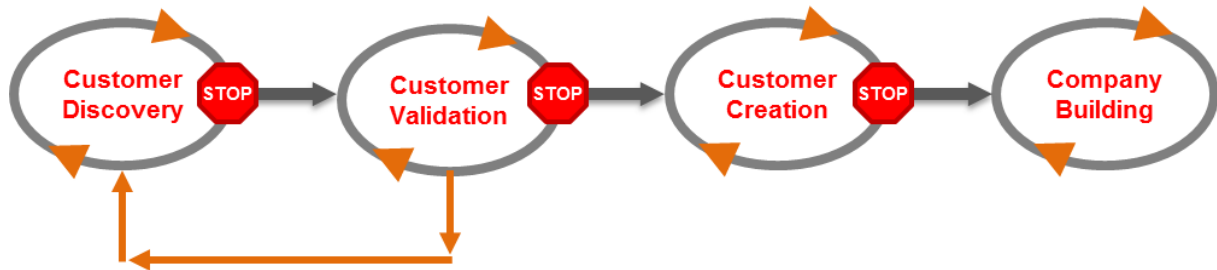


Figure 29: Customer development process (based on Blank, 2013)

Blank's customer discovery phase advocates systematic testing of startup founders hypothesis about the problems and needs of their customers. Customer validation is about creating a model to capture economic value that is replicable, to be aided by driving and creating customer demand (i.e. customer creation). Finally, company building focuses on is less about learning and discovery and more about implementation (Blank, 2013). However, steps one to three need to be pursued by corporate entrepreneurs despite a *"well-oiled machine designed for execution"* (Blank, 2013; p.26) already in place – and especially providing a challenge to pursue exploratory learning and discovery (i.e. the first two steps). All four stages assume the completion of more than one learning cycle. Furthermore, the economic value capture only become apparent in Customer Validation, therefore it might be necessary to revisit Customer Discovery if no one is willing to pay for the new product or service offered in stage two.

Blank (2013) asserts that customer development is a separate process from product development (**Figure 30**), with customer development complementary to the more linear 'stage-gate' model of product development.

¹³⁶ The term was originally coined by Toyota when they introduced lean manufacturing.

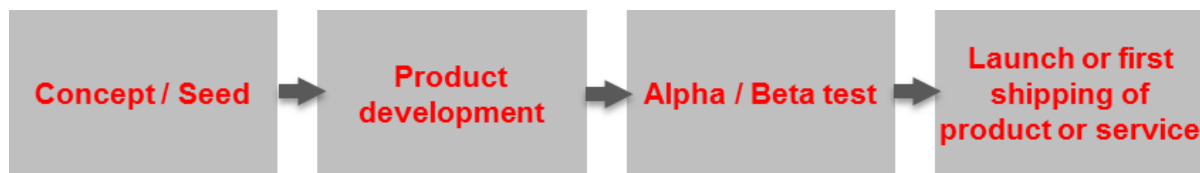


Figure 30: Product development process (based on Blank, 2013)

The whole product development process focuses on execution, whereas customer development *“emphasises learning, discovery, failure, iterations and pivots”* (Blank, 2013; p. 52).

The customer development process as proposed by Blank (2013) underpins the testing of customer value propositions and business models as summarised by Osterwalder et al. (2014). Hence, the work by Osterwalder et al. (2014) brings together Blank’s (2013) customer development work and the business model creation ‘canvas’ as proposed earlier by Osterwalder and Pigneur (2009). The resulting book targets a business practitioner audience through a suite of business tools. However, Blank’s (2013) work is more relevant for creating customer value propositions that address gaps in the market. Blank’s starting point is creating such value afresh, whereas Osterwalder et al. (2014) anchor their customer development tools in the business model canvas, i.e. the business structure. This structural starting point means a more likely re-enforcement of the business status quo because organizational structures known to the person populating the canvas are considered during the customer development process. This is especially disadvantageous if the person populating the canvas has a business school background: *“MBAs approaching a startup typically want only to execute a pre-designed business model, based on standard principles about sales, marketing and customer reaction, which they regard as facts”* (Blank, 2011).

In contrast, startups look to increase customer benefits through fast product or service offer iterations (Blank, 2013; Debruyne, 2014; Eyal, 2014; Ries, 2011). According to learning derived from the most successful seed fund globally, Y Combinator, achieving product/service fit with the market through intensive customer engagement will enable startups to scale to high growth companies (Graham, 1993-ongoing). The people involved in startups, the founders, persevere in the face of uncertainty in order to build products and services that customers will want (Livingston, 2007).

Complete focus makes startups likely to succeed in primary innovation. However large corporates are likely to address multiple environmental and social issues with their activities through their sustainability management system. Hence large corporates *“strengths lies in process innovation”* (Hockerts and Wüstenhagen, 2010; p. 487) that addresses a wider range of sustainability issues. This

argument proposed by the literature illustrates how corporate radical innovation processes may have an advantage over startups when it comes to linking radical innovation processes to sustainable development.

However, large firms are equally likely to commit more resources to launch a new value offering to a new market (Blank, 2013). Overcommitting resources without sufficiently testing whether customers have an appetite for the new offering can be “*catastrophic*” (Blank, 2013; p.11) for the survival of the large firm. This mirrors the assertion that explorative innovation activities may end in chaos for established businesses (Nooteboom, 2000). In contrast, small businesses can quickly change direction and product and service development because they don’t have so many established internal processes (Blank, 2013).

However, grey literature¹³⁷ has exposed many practitioner to the principles of customer development and Ries (2011) brought the term ‘pivoting’ into many business conversations. A pivot refers to a change of direction often as a result of learning from business experiments. According to Ries (2011) a pivot is only useful if data establishes where a company is at present through a Minimum Viable Product (MVP) and many experiments have been run to close the gap between the performance of the MVP and the ideal level of product/service performance. Only then a startup should consider pivoting. Ries (2011) views each experiment as product iteration and with each such iteration a startup must ensure to test existing or future business prospects. This process is called validated learning and according to Ries, validated learning includes both qualitative and quantitative learning: “(..) *poor quantitative results force us to declare failure and create the motivation, context, and space for more qualitative research. These investigations produce new ideas - new hypotheses- to be tested, leading to a possible pivot. Each pivot unlocks new opportunities for further experimentation, and the cycle repeat*” (Ries, 2011; p. 125). **Figure 31** shows the circular learning concepts developed by Blank (2013) and Ries (2011) are linked.

¹³⁷ Eric Ries was a student of Steve Blank.

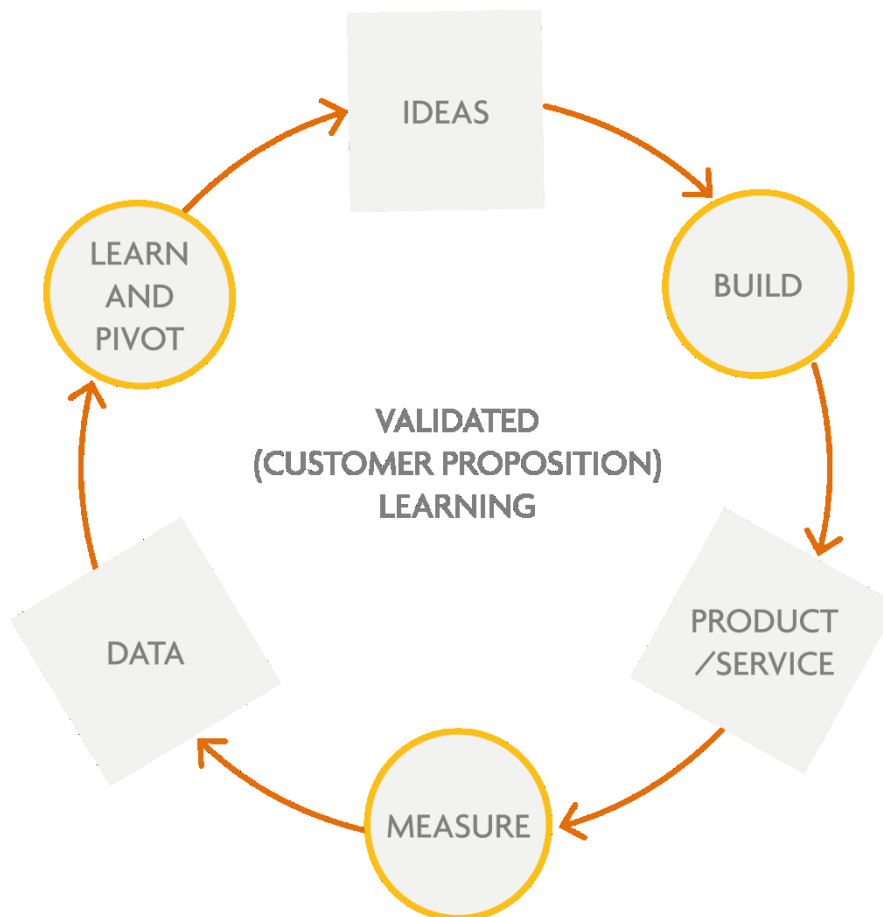


Figure 31: Learn startup approach, adapted from Ries (2011) and Blank (2013)

5.3.6 Summary

Entrepreneurship can take place within organizational boundaries (Schaltegger and Wagner, 2011; Thompson et al., 2011). Entrepreneurship focused on innovation can be mapped on the organizational knowledge creation cycle: especially to the ‘exploration’ phase of the cycle (Linton, 2009; Nooteboom, 2000). Radical innovation, technology discontinuities and the organizational ambidexterity all link the same stage of knowledge discovery and creation of radical innovation too.

The basic underlying values that drive how entrepreneurs solve problems are the same across different cultural backgrounds (Hofstede, 2001; McGrath et al., 1992). Individualism is a core value associated with entrepreneurship but doesn’t breed success (Graham, 1993-ongoing; Tidd, 2014). Personal values are the key differentiator between conventional entrepreneurship and entrepreneurship that looks to address sustainable development challenges (Bocken, 2015): the motivations for sustainable entrepreneurship (Schaltegger and Wagner, 2011) are at odds with the core values of conventional entrepreneurship identified by others (McGrath et al., 1992).

Furthermore, the more business experience an individual has, the less likely the person is to pursue sustainable entrepreneurship (Kuckertz and Wagner, 2010). This means that people with business expertise are unlikely to pursue entrepreneurial activities that look to capture economic value whilst creating social and environmental value (Schaltegger and Wagner, 2011; Thompson et al., 2011). However, the values of conventional entrepreneurship may be actively challenged and influenced with the outcome of pursuing sustainable entrepreneurship (Tennant, 2015).

Corporate entrepreneurship requires for the majority the same activities as entrepreneurship pursued outside of firms (Bosma et al., 2011) and overlaps with sustainable entrepreneurship in regards to impacting the whole market place and the ambition of the sustainability goal articulated for business activities (Schaltegger and Wagner, 2011). Organizations that encourage corporate entrepreneurship encourage the pursuit of radical innovation activities at the same time (Van de Ven and Engleman, 2004). Circular learning cycles are necessary to understand and refine the entrepreneurial opportunity for radical innovation and for taking the opportunity towards commercialization (Griffin et al., 2014; Koen et al., 2001). Specifically, learning about and engaging with customers whilst pursuing a business opportunity is a must (Blank, 2013; Graham, 1993-ongoing; Livingston, 2007).

This means that new products and services should be based on gaps in the markets or solve customer problems to enable any capture of economic value (Christensen, 1997; Füller and Matzler, 2007). Customer discovery and customer validation are key to learn about the economic value capture viability of new products and services (Blank, 2013), they are part of the constant learning cycle that is customer development, enabling the establishing of products and services that people want. Using the business model (Osterwalder and Pigneur, 2009) as the starting point to pursue radical product and service innovation is likely to enforce the organizational status quo due to the previous experience of the person creating a new business model (Blank, 2011). In contrast, persevering in the face of uncertainty is needed to pursue cyclical learning in customer discovery and validation (Livingston, 2007).

Finally, it has been asserted that large businesses can address more sustainability challenges than small businesses due to more resources and activities (Hockerts and Wüstenhagen, 2010). However, overcommitting resources without sufficiently testing whether customers have an appetite for the new offering can add in chaos for the large firms (Blank, 2013; Nooteboom, 2000). Lean startup

principles and customer development enable and promote the constant learning required that can enable the change of direction for entrepreneurial business opportunities (Blank, 2013; Ries, 2011).

5.4 Leadership for sustainable development

This section explores how individuals engage in and influence the organizational development and change associated with pursuing radical innovation. The organizational strategy literature explores how individuals drive radical change for sustainability through the leadership literature.

The innovation opportunity space is located at the interface of entrepreneurship and organizational strategy (Drucker, 1985; O'Connor and McDermott, 2004). It has been argued that dealing with the complexities of today's society has to be led by the people sitting at the interface of entrepreneurship and business strategy (Spender, 2014). Spender (2014) asserts that the complex challenges require these individuals to go beyond simple decision making processes towards a willingness to engage with the more interconnected and complex world around them.

Furthermore, in order to create and lead value-creating companies fit for a complex world, the role of individuals sitting at the interface between entrepreneurship and strategy is to "*persuade collaboration into existence*" (Spender, 2014; p. 290). Without collaborating with others, individuals won't be able to fill their own knowledge gaps about their companies operating environment.

I go on to explore the tension between individualism and leadership in complex business operating environments. This is followed by establishing links to the literatures on sustainability goals.

5.4.1 The individual hero narrative

There are multiple levels of complexity involved in the process of embedding sustainability into organizations: of understanding sustainability challenges, of complex problem solving and of leadership (Metcalf and Benn, 2012). In order to address these three layers of complexity, "*leaders of extraordinary ability*" (Metcalf and Benn, 2012; p.369) are required. The abilities of these leaders has to be extraordinary indeed according to the authors and they assert that such leaders "*can read and predict through complexity, can think through complex problems, engage groups in dynamic adaptive organizational change and can manage emotion appropriately*" (Metcalf and Benn, 2012; p. 381).

It has long been argued that entrepreneurs have superior skills and this is associated with their ability to be able to deal with uncertainty. At the same time, the individuals pursuing business activities in the face of uncertainty are by no means always successful: *“Where the boundaries of routine stop, many people can go no further, and the rest can only do so in a highly variable manner”* (Schumpeter, 1934; p.80). Perseverance in the face of uncertainty and continuing to develop a business opportunity where others stop has been highlighted as the key commonality of entrepreneurial individuals (Livingston, 2007).

The perseverance required by entrepreneurial leaders has been associated with strong physical, almost fighting qualities in the literature. There is ‘entrepreneurial judo’ (Drucker, 1985), ‘business athletes’ skills¹³⁸ (Kanter, 1989) and the ‘Maverick’¹³⁹ (Ford and Probert, 2011; O’Connor and McDermott, 2004). O’Connor and McDermott (2004) assert that entrepreneurial individuals are the key drivers of radical innovation, inside and outside of established organizations. Ford and Probert (2009) assert that tolerance for ‘hero innovators’ within organizations is needed for radical innovation to succeed, however the authors do not offer suggestions on how this tolerance might be created.

However within organizations merely tolerating the individual who pursues opportunities in a different manner to established organizational processes (Ford and Probert, 2009) might not be sufficient. For example, it has been argued that entrepreneurial skills should be pursued by more than one single ‘hero’ entrepreneur, therefore becoming a social function within healthy organizations (Schumpeter, 1942). Interestingly, this arguments is articulated in Schumpeter’s later (i.e. 1949) work, indicating a shift from his earlier position of the entrepreneurial individual towards an entrepreneurial function (Hagedoorn, 1996; p.891). Furthermore, entrepreneurial skills as a ‘social function’ are closely related to organizational capabilities of enabling the explorative innovation capabilities (Graham, 1993-ongoing).

Spender (2014) argues that the individuals sitting at the interface between entrepreneurship and strategy make decisions (Spender uses the term ‘strategizing’) and that academic research *“actually*

¹³⁸ The seven skills and ‘sensibilities’ proposed are [1] learn to operate without the might of the hierarchy behind them, [2] know how to “compete” in a way that enhances rather than undercuts operation, [3] operate with the highest ethical standards, [4] have a dose of humility, [5] develop a process focus, [6] be multifaceted and ambidextrous, and [7] gain satisfaction from results. The skill of being ambidextrous (i.e. 6) simply acknowledges that ‘business athletes’ have to be able to work across functions and business units, ambidexterity is not related to the organizational capability of ambidexterity as reviewed in section 5.1.2.

¹³⁹ No reference to Lieutenant Pete “Maverick” Mitchell is made though.

denies the ancient meaning of strategizing for it is a reflection of our believing we have choices whose choosing requires judgement and whose ultimate consequences can only be imagined” (Spender, 2014; p. 280). He goes on to conclude that *“strategizing is no more, or less, than the practice of reflecting on how we think about ourselves and our doings”* (Spender, 2014; p. 280). This activity of actively influencing and challenging oneself with reflection to make business choices that may result in desirable outcomes agrees with the assertions of Tennant (2015). It follows that the strategizing as described by (Spender, 2014) can lead to the examining of personal motivations and the addressing of sustainable development challenges.

Others have also argued that business leaders need to change their leadership to an explicitly entrepreneurial approach (Greenberg et al., 2013). Executing highly ambitious resource productivity goals within limited timeframes through business value creation is linked to high levels of uncertainty for a business, because many challenges encountered in this process are new (Greenberg et al., 2013). Therefore past business performance data are not suitable to determine a suitable path of action forward – business leaders have to be comfortable with uncertainty and adopt ‘entrepreneurial leadership’ (Greenberg et al., 2013). At the heart of such leadership is taking action in the face of uncertainty, and each action provides more insight into a problem: *“This snowball of intentional iteration is the foundation of being an entrepreneurial leader”* (Greenberg et al., 2013; p.60). This iterative learning aligns with the experimentation definition of Lee et al. (2004) and the iterative customer learning approaches proposed by the startup literature (Blank, 2013; Ries, 2011). This position concurs with the assertions of Spender (2014) that individuals in the position to devise organizational strategy continually adapt their judgement through unexpected learning devised from practice.

More recently, Spender has contributed to work that has called for the complete abolishment of any ‘leadership science’(Chabault et al., 2016). The reasoning offered is that individual leaders who are able to create a business out of opportunities with extreme uncertainty will succeed not through applying *“scientific ways of thinking”* (Chabault et al., 2016; p. 58). Rather, these individuals practice a creative art-form which is constantly changing and shaped by the specific context of the organization and wider socio-technical environment (Chabault et al., 2016).

Decision making in highly uncertain situation is linked to sustainable development challenges through the setting of goals for innovation activities.

5.4.2 Innovation goals

Goal orientation depends on the motivations of any team in the pursuit of achievements. The goal orientations influence the goals of the achievements and the actions in pursuit of these goals (Alexander and van Knippenberg, 2014). Goal orientations are very important for radical innovation teams because radical innovation activities are complex and require conflicting tasks when conducted in established large businesses (Alexander and van Knippenberg, 2014; Nooteboom, 2000). Furthermore, it is the role of the team leader to adapt the goals of radical innovation projects to unpredictable changes in the organizational and wider environment according to Alexander and van Knippenberg (2014).

Others have also argued that interpreting a complex situation and communicating well within a team is a key element to help achieve goals (Guarana and Hernandez, 2014; Metcalf and Benn, 2012). Guarana and Hernandez (2014) acknowledge that leaders who encourage “*learning and positive team member interactions*” (Guarana and Hernandez, 2014; p.17) are likely to succeed in creating the exchange of ideas and decision-making processes with their followers that are needed for interpretation and decision-making in complex situations. This notion is based on research on empowering leadership (Lorinkova, Pearsall, & Sims, 2013 in Guarana and Hernandez, 2014). The uncertainty of discontinuity gaps between technologies than can enable radical innovations have been described as chaos (Foster, 1986). It has been argued that making decisions in complex situations “*near the edge of chaos*” (Guarana and Hernandez, 2014; p.2) benefit from leaders and followers influencing each other through collective goals (Guarana and Hernandez, 2014).

Others have come to similar conclusions. For example, Alexander and van Knippenberg (2014) concluded it is necessary to define and adapt collective goals when dealing with the uncertainty and unanticipated challenges of radical innovation projects. Their analysis takes the research perspective of large organizations that recognize the importance of innovating products but encounter challenges with their development and commercialisation. Hence, the necessity to establish clear goals for innovation activities in the face of uncertainty is a good thing according to both Guarana and Hernandez (2014) and Alexander and van Knippenberg (2014).

Kennedy et al. (2013) highlighted the importance of sustainability as a strategic choice to conduct radical innovation for sustainability projects, with the end point of creating environmental, social and economic value. They also highlight that the vision of the CEO was essential to embed this strategic choice within the case study they analysed. Other case study research conducted came to the same

conclusion: Larson (2000) explored how sustainable development consideration were embedded into the business strategy of a digital startup. She asserts that the case study analysis shows “*the necessity of visionary leadership and goal setting at the helm*” (Larson, 2000; p.314). However, the author takes her conclusion somehow further than Kennedy et al. (2013) and observed that such leadership needs to take place in combination with “*careful attention to detail and relationships*” (Larson, 2000p.314). Larson (2000) recommends that more case study research would usefully benefit from applying an entrepreneurship lens to the relationship between business activities and sustainable innovation, simply because innovation and entrepreneurship are so close related.

Metcalf and Benn (2012) link leadership styles to how sustainability might be successfully implemented into organizations. They argue that organizational leaders who devise strategy to address sustainable development challenges through innovation need to be able to do manage their emotions. This ‘inner management’ is deemed essential by Metcalf and Benn (2012) to be able to interpret sustainable development challenges and translate them into organizational strategy and lead people within organizations during the strategy implementation.

The Alexander and van Knippenberg (2014) research identified ambidextrous leadership¹⁴⁰ and the importance of learning and reflection within the whole project team as important for the success of radical innovation projects. Leaders that are able to display flexible leadership styles according to different stages of radical innovation projects are likely to be able to lead their teams through changes of the collective goals during the innovation process. Alexander and van Knippenberg highlight that “*challenges in (radical innovation) idea development require learning goals; challenges in (radical innovation) idea promotion require performance prove goals*” (Alexander and van Knippenberg, 2014; p. 433). This call for flexibility is aligned for the call for organizational flexibility in order to survive in the longer term in in changing operating environments (Eisenhardt et al., 2010).

5.4.3 Summary

In contrast to less entrepreneurial people, entrepreneurial leaders persevere when in the face of uncertainty (Livingston, 2007; Schumpeter, 1934). Within organizations, the tolerance of entrepreneurial individuals is necessary to let them achieve entrepreneurial success (Ford and Probert, 2009). Furthermore, entrepreneurial skills must shift from individuals to become an

¹⁴⁰ This leadership “*balances opposing demands by alternating between behaviours that are conducive to one of the demands*” (Alexander and van Knippenberg, 2014; p.433). In regards to radical innovation activities ambidextrous leadership is, therefore, the individual leader equivalent to organizational ambidexterity as explored by Benner and Tushman (2003), Jansen et al., (2006) and others.

organizational capability (Graham, 1993-ongoing; Schumpeter, 1942), mirroring the assertion in chapter 2 that corporate entrepreneurship is an organizational activity and responsibility.

Entrepreneurial business leaders take action in the face of uncertainty and change business strategy based on the learning they get from these actions (Greenberg et al., 2013; Spender, 2014). Such action based learning defies management science.

However, goals have the ability to provide direction for innovation activities. The motivations to pursue any achievement shape goal orientations within teams (Alexander and van Knippenberg, 2014). Team leaders must ensure that goal orientations adapt to unforeseeable changes. It has been shown that decisions made at the edge of chaos benefit from collective goals (Guarana and Hernandez, 2014). Therefore, it is necessary to establish clear goals for radical organizational innovation activities to develop and commercialise such innovations (Alexander and van Knippenberg, 2014; Guarana and Hernandez, 2014).

It is the role of organizational leaders to shape the innovation goal itself whilst paying close attention to relationships within and outside teams (Larson, 2000). However, organizational leaders of sustainable innovation projects need to manage their emotions in order to not appear overwhelmed by complexity of sustainable development challenges (Metcalf and Benn, 2012). Therefore, perhaps unsurprisingly, flexibility in leadership style is required throughout radical innovation processes (Alexander and van Knippenberg, 2014). This is necessary at the individual and organizational level (Eisenhardt, 1989b).

5.5 The concept of experimentation for sustainability

The literature review Chapter 3 offered characteristics of radical sustainability-oriented innovation: what are the inputs, basic process features and outputs associated with such innovation activities. Based on the literature conclusion in chapter 3 and the data discussion in chapter 4, this chapter explored in more depth how established firms may pursue radical sustainability-oriented innovation. This section synthesises what the characteristics of the organizational capability of experimentation for sustainability are from the perspective of the established firm.

5.5.1 Synthesis: characteristics of the organizational capability of experimentation

Discovering and searching for innovation opportunities are most challenging for established firms: creating, recognizing, elaborating and articulating are all part to this (O'Connor and DeMartino, 2006; Sandberg and Aarikka-Stenroos, 2014). In order to pursue radical sustainability-oriented innovations, firms need to develop new social and technical abilities. This section offers details on these new abilities and is structured along three key areas: learning approach, entrepreneurial behaviour, and project leadership. It has been argued that *“process theories provide explanations in terms of patterns in events, activities, and choices over time”* (Langley, 2009; p. 409). This section is the starting point to develop a descriptive process theory of the organizational capability of experimentation in order to pursue radical sustainability-oriented innovation.

Experimentation learning approach

- Aims to overcome the inertia of the organizational learning cycle (Nooteboom, 2000) and the organizational status quo hindering the success of radical innovation (Chang et al., 2012).
- Aims to enable to go beyond adapting to fast changing environments and actively shaping them through innovation outputs (Teece, 2014).
- Recognizes that circular learning cycles are necessary to understand and refine the entrepreneurial opportunity for radical innovation and for taking the opportunity towards commercialization (Griffin et al., 2014; Koen et al., 2001).
- Aims to create maximum learning with minimal time and money spent, with clear learning objectives and one or multiple experimentation assessment criterion (Hicks, 1982).
- Adapts to the sustainable development challenges (Kennedy et al., 2013) to be addressed by the firm.
- Can be developed in-house or through collaborations (Chesbrough and Teece, 2002).
- Is part of explorative innovation activities (March, 1991).
- Has human judgement at its core (Montgomery, 2001), with ‘guesswork’ increasing the more unknown a new process, product or service is (Box and Draper, 1987).
- Requires a flexible organizational structure to encourage fast adaptation (Eisenhardt et al., 2010), especially in operating environments with high degrees of uncertainty (Jansen et al., 2006).
- Needs to be linked to central organizational process management and decision making in order to embed learning (Jansen et al., 2012; March, 1991).

- Perseveres in the face of uncertainty to pursue cyclical learning in customer discovery and validation (Livingston, 2007).
- Can take place in parallel to status quo business activities (Loorbach et al., 2009).
- May end in chaos for the business (Nooteboom, 2000) if learning is not fast enough or specific enough to aid the development of new social and technical capabilities.
- Benefits from lack of knowledge and experience about the new product or service to be developed (Montgomery, 2001).
- Learns about and engages with customers whilst pursuing a business opportunity (Graham, 1993-ongoing; Livingston, 2007).

Experimentation entrepreneurial behaviour

- Recognizes that radical innovation, technology discontinuities and organizational ambidexterity all link to the same stage of knowledge discovery.
- Recognizes that the basic underlying values that drive how entrepreneurs solve problems are the same across different cultural backgrounds (Hofstede, 2001; McGrath et al., 1992).
- Recognizes that the motivations for sustainable entrepreneurship (Schaltegger and Wagner, 2011) are at odds with the core values of conventional entrepreneurship (McGrath et al., 1992).
- Recognizes that people with business expertise are unlikely to pursue entrepreneurial activities that look to capture economic value whilst creating social and environmental value (Kuckertz and Wagner, 2010; Schaltegger and Wagner, 2011; Thompson et al., 2011).
- Bases new products and services on gaps in the markets or solve customer problems to enable any capture of economic value (Christensen, 1997; Füller and Matzler, 2007).
- Investigates the economic value capture viability of new products and services through customer discovery and customer validation (Blank, 2013).
- Recognizes that overcommitting resources without sufficiently testing whether customers have an appetite for the new offering can add in chaos for the large firms (Blank, 2013; Nooteboom, 2000).

Experimentation project leadership

- Tolerates entrepreneurial individuals to let them achieve entrepreneurial success (Ford and Probert, 2009).
- Takes action in the face of uncertainty and change business strategy based on the learning from these actions (Greenberg et al., 2013; Spender, 2014).

- Recognizes that scientific thinking does not work in decision-making situations with a high degree of uncertainty (Chabault et al., 2016).
- Articulates sustainable development project goals because decisions made at the edge of chaos benefit from collective goals (Guarana and Hernandez, 2014).
- Establishes clear goals for radical organizational innovation activities to develop and commercialise such innovations (Alexander and van Knippenberg, 2014; Guarana and Hernandez, 2014).
- Shapes the innovation goal whilst paying close attention to relationships within and outside teams (Larson, 2000).
- Manages emotions in order to not appear overwhelmed by complexity of sustainable development challenges (Metcalf and Benn, 2012).
- Is able to be flexible in leadership style (Alexander and van Knippenberg, 2014) at the individual level (Eisenhardt, 1989b).

6. Data discussion 2: characteristics of the organizational capability of experimentation

This chapter presents the second round of data collected and analysed in research phase one. The data analysed in this chapter comprises of the nine interviews conducted in 2014¹⁴¹ with a view to deepening the understanding of experimentation in the corporate innovation process, building on insights generated through the 2013 data and the innovation process literature reviewed in chapter 5. **Figure 32** shows how these interviews fall within the conceptual framework of this research. The data was collected to explore how experimental learning might further radical sustainability-oriented innovation in firms.

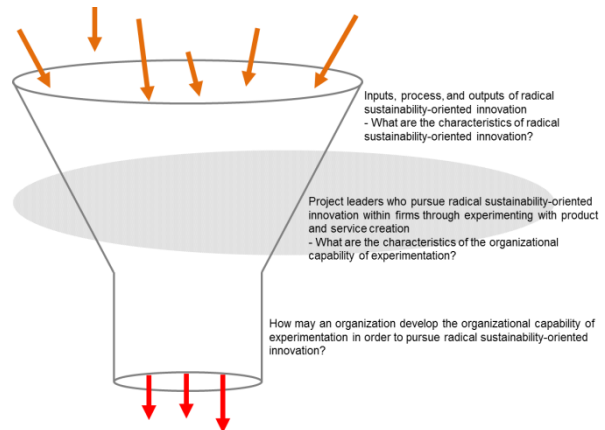


Figure 32: Experimentation interviews in the conceptual framework

Chang et al. (2012) state that *“the main determinants of radical innovation still may be unidentified. Other factors [than experimentation,] such as leadership or resource commitment may need to be considered in future studies”* (Chang et al., 2012; p. 448). This chapter begins exploring leadership factors through data, highlighted as important for enabling radical innovation processes in the 2013 data and covered in the literature in chapter 5.

6.1 Data sources, types and use

The cross-sectoral interviews formed the main basis of the data analysis, with the 2013 Reflection Diary and interview notes used to support the data collection and analysis process. **Table 15** presents the data sources, details on data type and the use in the data analysis during this research phase.

Data Sources	Type of Data	Use in the Analysis
Semi-structured interviews (100 pages)	Interviews with practitioners located within a corporate structure (8 in total)	Gather information on conducting experiments within firms
	Interview with startup incubator senior manager (1 in total)	Corroborate understanding of experimentation driven through entrepreneurial behaviour
Interview notes	Written at the end of 9 interview transcripts.	Track and examine interaction and immediate

¹⁴¹ One interview was conducted in March 2015

Data Sources	Type of Data	Use in the Analysis
(part of 100 pages)		data stand-out points of interviews.
Reflection Diary (12 pages)	Reflections written every day during the data collection in 2013.	Corroborate understanding of challenges from action-based learning through self-experiment. Track and examine researcher thoughts.

Table 15: Capability of experimentation data sources, types and use

6.2 Reflecting on data collection and analysis

The learning on the research process obtained through the 2013 interviews was applied during the data collection conducted during this second round of data collection. As a result of the 2013 data collection, the 2014 interviews were conducted in formal settings; all interviews took place at the firms of the interviewees, at the Sustainable Development Advocacy Organization (SDAO), or in Skype and phone calls.

During the data analysis process, the 2013 Reflection Diary enabled me to relate to the challenges of conducting activities with an uncertain outcome and a clearly stated goal within a limited timeframe. The Reflection Diary was written during a 3-week journey across the U.S. and I knew my destination. However, I did not plan a detailed route, secure accommodation, or had any prior experience about solo motorcycling across a continent before starting the journey. The journey therefore included a high degree of uncertainty and required problem solving on a daily basis whilst trying to secure learning¹⁴².

Similar to the interviews conducted in 2013, a data narrative emerged from the 2014 interviews and enabled some contrasting of data with the additional transdisciplinary literature reviewed in chapter 5. Some 2013 data insights seemed aligned with or in contrast to the insights generated through the 2014 cross-sectoral interview data. These similarities and differences are included in the discussion sections of this chapter.

However, this second part of research phase one indicated that interviews alone would not be sufficient to explore the challenges of experimenting in order to pursue radical sustainability-oriented innovation at the level of the firm in more depth. The process challenges were snapshots in time provided through the personal context lens of each 2014 interviewee, as it was the case in the 2013 data set. Exploring a set of innovation process challenges over a longer period of time was needed to enable the exploration of the process challenges associated with developing the

¹⁴² Learning with the objective to further the PhD research.

organizational capability of experimentation to pursue radical sustainability-oriented innovation activities within a firm. This led to the decision to conduct a case study during the second research phase and, ideally, collect data over a period of time to research the process of developing the organizational capability of experimentation. This longer term process research would enable the exploration of the ‘lumpy’ timescale in change and innovation processes (Poole, 2004).

6.3 Data analysis overview

The 100 pages of interview transcripts and the 12 pages of the Reflection Diary were coded in ATLAS.ti and resulted in 50 1st-order codes: 48 content codes and two research process code. As in the data analysis conducted with the 2013 interviews, the literature enabled initial auto coding and the ATLAS.ti co-occurrence function was the basis for grouping the 1st-order codes into 11 conceptual 2nd-order codes.

6.3.1 1st-order and 2nd-order codes

Table 16 shows the 1st-order and 2nd-order codes that resulted from the data analysis of the nine interviews. Three 2nd-order codes have the same name¹⁴³ as 2nd-order codes from the 2013 data analysis: time, innovation goal, and personal motivation. Having an overlap of 2nd-order codes between 2013 and 2014 data was not a goal of the 2014 data analysis. However, the overlap in data narrative was helpful to narrow the focus of this research and aid the establishment of an overall narrative.

1 st -order codes		2 nd -order codes
• Future thinking • Urgency	• Present day challenges to make sustainability tangible	Time
• Competition as business driver • Economic value creation dominates • Incremental innovation takes priority	• Innovation not sustainable innovation • Profitability	Economic value creation dominates
• Business case for triple bottom line value creation • Firm culture – sustainability • Business case for SD evolving	• Triple bottom line value creation not goal • Social impacts • Sustainability into core business	Innovation goal
• Ambidexterity • Corporate entrepreneurship • Firm innovation structure	• Spin out venture • Technology as process	Corporate innovation structure
• Cross-functionality • Fast staff turnover	• Firm culture – flexibility • No freedom	Corporate innovation

¹⁴³ The 2nd-order codes had overlap in meaning too. However the interviewees had different circumstances, were asked different questions, and all were operating within large firms or led spin out ventures. Therefore the overlapping 2nd-order codes from the 2013 and 2014 data sets cannot be compared directly. A part comparison was attempted with the five entrepreneurs and the eight innovation practitioners in large firms from the 2013 data set. However, this approach did not allow for all salient data insights from the 2013 data set to be captured because the four academic interviewees were excluded during this attempt to compare similar types of data.

1 st -order codes		2 nd -order codes
• Firm culture - innovation		challenges
• Business leading consumers • Iterative learning • Mirroring startup approach	• Need for experimentation culture and tools • Experimentation success	Drivers for experimentation
• Leading to chaos • Exploring uncertainty • Failure without learning	• Parallel experiments • Uncertain innovation outcome	Fears and concerns
• Breaking business-as-usual – external experts • Collaboration need	• Collaboration to get technologies • Complexity • Sustainability expertise - external	Collaboration is needed
• Breaking business-as-usual mindset	• Breaking business-as-usual off site	Breaking business-as-usual
• Visual engagement • Personal appetite for learning	• Personal value • Sustainability – right thing to do	Personal motivation
• Executive reporting • Internal leadership	• Sustainability as innovation challenge	Leading experimental projects
• Illustrative quote	• Leading question	Research process

Table 16: 1st - and 2nd - order codes derived from semi-structured interviews conducted in 2013 (+1 in 2014)

6.4 Data discussion

This section offers a discussion of the data collected to explore the process of the business response to sustainable development challenges (Dyllick and Muff, 2015) and specifically how the characteristics of the organizational capability of experimentation as synthesised in chapter 5 might further radical innovation with a sustainability goal. The discussion narrative is based on the 2nd-order codes in table 16, with text extracts from 1st-order codes used to illustrate the narrative. The discussion broadly follows the narrative of the experimentation learning approach, entrepreneurial behaviour and project leadership in large firms as synthesised at the end of chapter 5. It starts with a discussion of the element of time in the context of economic value creation within the firm.

6.4.1 Economic value creation vs the urgency of sustainable development challenges

This section presents insights from the 2nd-order codes ‘Time’ and ‘Economic value creation dominates’.

Some data (37, 39, 43) suggested that experimental learning to further radical sustainability-oriented innovation ideas does not allow for making an economic business case early on in the organizational innovation process. As indicated by some 2013 interviews, sustainability-driven innovation is perceived to be associated with higher cost for the business. This interviewee ensured that radical ideas with a sustainability dimension were considered in parts of the firm where they might be developed further: “(..) sometimes the [sustainability] idea just stops at the doorstep because there is

a lack of education, a lack of engagement, there is no one to bring them to the right people in the business because it's just unfamiliar territory. That would be the difference with other innovation ideas, is that people are not really familiar with what this is and what it can do and have lots of preconceived ideas of, 'It [innovation with sustainability component] will always be more expensive'. One of my roles is to make sure that I see these ideas and I bring them to the right place in the business and we can nurture them and then develop them internally" (37: p.1, ATLAS.ti line 33). Furthermore, some data (37, 39, 41) indicated that successful experimentation to further the exploration of completely new value proposition ideas cannot require a clear economic business case. For example, one interviewee argued that if the firm had focused on the market introduction of a product that required new capabilities at the level of the firm and *"...the short term profit, we would never [have] got there"* (39:p.9, ATLAS.ti line 347). This aligns with the literature on exploitative innovation activities, which includes the notions of 'play', 'risk taking', and 'discovery' as opposed to 'production' or 'efficiency' (March, 1991). One interviewee spelt out the tension between these two approaches to innovation: *"Clearly, there is a level of challenge around the fact that proper innovation¹⁴⁴ is very much around creativity, taking risk, understanding risk, breaking barriers, and often quality can be seen as around maintaining norms, status quo specifications. There is a bit of a dilemma"* (43: p.2, ATLAS.ti line 51). The interviewee went on to explain that maintaining the norm is perceived to be associated with economic value creation at the level of the firm. The 2013 interviews equally generated insights about the need to allow freedom during experimental learning activities to further innovation activities that necessitate the exploration of new processes and combination of previously unconnected domains, technologies, or skills. The data collected suggests that the tension between efficiency and a clear economic business case vs. longer-term and uncertain innovation outcomes are similar for radical innovation (e.g. 43) and sustainability-oriented innovation (e.g. 37, 39).

Some interviewees (37, 39, 41, 46) argued that the innovation activities of their respective firms were primarily driven by addressing sustainable development challenges such as resource shortages, creating an equitable society, or climate change mitigation and adaptation. However, these assertions might have been influenced by the fact that the interviews were facilitated by the SDAO because the interviewees were expecting to talk about the sustainability activities of their respective firms. This is corroborated by interviewee 42, working for the same organization as one of the interviewees who articulated that business activities were driven by the need to address important

¹⁴⁴ The interviewee viewed 'proper innovation' as innovation that went beyond improving existing products and services and used language that indicated that 'proper innovation' was more akin to radical than to incremental innovation.

sustainable development challenges. Interviewee 42's take on what drove the firm to pursue innovation in response to sustainable development challenges was rather different. The interviewee explained how the firm started working on a radical sustainability-oriented innovation project and that "[it] *didn't come out of a rational process where people changed their perception of risk because of new climate or resource data. The reason [the project] came off the ground was because of a PR communication scare*" (42:p.3, ATLAS.ti line 116). This suggests that addressing sustainable development challenges was driven by a business case of keeping a positive reputation in the view of customers, suppliers and investors, therefore securing legitimacy (Schaltegger and Hörisch, 2015). As opposed to the need to address important and urgent sustainable development challenges as expressed by the other interviewee from the same firm.

Some (e.g. 39, 41) acknowledged that the speed of change to innovation processes in their firms was not fast enough to address sustainable development challenges in a timely fashion: "(..) *there is no doubt about the direction. It's just the speed (..), one of our feelings is the speed is not enough (..). So really we want to accelerate because we feel if the current speed, if we continue, would not be enough to be sustainable by 2050.*" (39:p.11, ATLAS.ti line 464). However, information on how the concern about the lack of speed of corporate innovation activities might be addressed was not given.

Economic value creation was shown to be highly important in the data (e.g. 37, 38, 43, 57). Triple bottom line value creation was highlighted as a desirable concept by some (39, 41), however economic value creation was the motivation to pursuing innovation activities at the level of firm. This is in contrast with the literature on sustainable entrepreneurship that asserts that the motivations for pursuing sustainable entrepreneurship has to go beyond economic value creation (Schaltegger and Wagner, 2011).

Key insights: Economic value creation vs the urgency of sustainable development challenges

The data suggests that the tension between efficiency and a clear economic business case with longer-term and uncertain innovation outcomes are similar for radical innovation and sustainability-oriented innovation. Some data indicates that the speed of change to innovation processes in firms is not suitable to address sustainable development challenges in a timely fashion. Triple bottom line value creation was acknowledged as desirable; however economic value creation was the motivation to the pursuit of all innovation activities at the level of firm.

6.4.2 Challenges of the corporate innovation management process and culture

The 2nd-order codes 'Innovation goal', 'Corporate innovation structure', and 'Corporate innovation challenges' are the basis for this chapter section.

Innovation management processes need to support experimental learning or, at least, not significantly hinder it (Lee et al., 2004). Without innovation management processes that enable experimental learning, it is unlikely that the freedom needed to explore radically new value propositions exists within a firm. That such freedom is needed was argued by the 2013 interviewees.

In the 2014 data, one firm was looking to encourage this freedom to giving all employees the mandate to pursue radical innovation. The firm changed their organizational design to move their radical innovation function from being solely anchored under the R&D department to the business development department: *"The reason for that was to make it less of a technical, radical innovation, and make it more business focused. It's not that we don't do radical innovation anymore, we certainly still do, but just to emphasise for the company that now radical innovation is business innovation "* (40; p. 1, ATLAS.ti line 22). However interviewee 40 explained that the mandate to pursue radical innovation activities was not successfully embedded in the firm at the time of the interview. Nonetheless, the mechanism of broadening out radical innovation activities across the whole business might be suitable to overcome the economic value creation dilemma mentioned by interviewees 37 and 43 earlier: explicitly stating that everybody in the business has the mandate to pursue radical innovation activities might encourage individuals and teams to explore completely new value propositions. Broadening out the innovation function beyond a single corporate function is pushed through another mechanism in the firm of interviewee 40: all firm functions have been asked to establish an innovation team to accelerate the development of new value propositions within all established business units.

The data showed that others (37, 41, 43, 46) were working equally actively to increase innovation capability across the whole organization. One interviewee argued that current corporate structures need to embed new technologies into their innovation learning processes in order to build radical innovation capabilities: *"I think organizational structures of large companies, whether they're manufacturers or retailers, they are simply out-of-date. The organizational structures that we all operate on, [whether] chief executive or chairman (..), and all the rest of the hierarchy, they're based on the models of the Industrial Revolution; they're not based on the information revolution that we have just entered. We are at the very early stages, in my opinion, of something really radical when it comes to how we innovate"* (43;p. 8, ATLAS.ti line 294). This suggests that organizational structures need to be made more flexible (Eisenhardt et al., 2010) in order to be able to discover and implement new business opportunities.

The data acknowledged that a greater degree of flexibility is needed for long-term resilience of a company (e.g. 43, 40, 46). This requires changing core strategy to adapt to the changing business environment due to sustainable development challenges (39): *“What we can do I think is to prepare the organization that the organization is open and flexible to anticipate future change. We need to put systems and processes in place to earlier identify, monitor and, if required, adapt our strategy”* (39: p.2, ATLAS.ti line 61). The interviewee argued that futures techniques¹⁴⁵ were part of these ‘systems and processes’. However, these futures techniques were disconnected from taking action and testing new value propositions in the present day: *“So it’s not that we one-to-one translate long term scenarios into short term action because the [infrastructure] is too complex to do this”* (39: p.4, ATLAS.ti line 120).

Complementary to exploratory innovation learning activities is setting sustainability standards for existing products: a space that is more easily controlled because there is no uncertainty associated with these products. This is different to the high level uncertainty associated with radical innovation opportunities that are *“new to the world, the market, or an industry”* (Garcia and Calantone, 2002; p. 118). However, some data (39, 41, 43) indicated that setting sustainability standards for existing products and exploring future opportunities through completely new value propositions with uncertain impacts on sustainability are not mutually exclusive, despite the contradictions that might be the result of a dual-purpose approach: *“It is absolutely fine to be working rigidly around setting sustainability standards for your existing products and product improvements. But it is equally okay to be looking at exploring new opportunities for what the products of tomorrow might be. Even if these products might fall outside of the constraints of the standards you are setting today”* (43:p.2, ATLAS.ti line 52). None of the interviewees expressed the view that their respective organizations have succeeded in having an organizational innovation culture that is flexible enough to set sustainable development standards for existing products as well as exploring radically new value propositions, with or without sustainability considerations.

No interviewee mentioned the concept of ambidexterity (Loorbach et al., 2009), the dual-purpose approach of pursuing exploitative and explorative innovation activities within the same firm. However, some interviewees (37, 41, 43) acknowledged the need to pursue exploitative and exploratory innovation activities (41, 43) (Benner and Tushman, 2003) and learning approaches (37)

¹⁴⁵ This interview was conducted with an MSc student researching the application of futures techniques to encourage long-term thinking for the SDAO. The interviewee was, therefore, primed to offer future thinking and techniques as a way to link firm innovation activities with sustainable development challenges.

(March, 1991; Raisch et al., 2009) in parallel. The constraints to pursue exploratory activities were mentioned, with one interviewee arguing that is the responsibility of the corporate innovation lead to make the case for pursuing exploratory learning to further radical sustainability-oriented innovation: *“So I always say, innovation, inspiration, education [about the benefits of including a sustainability dimension] are the three pillars of what I’m doing”* (37: p. 2, ATLAS.ti line 52). The interviewees 37 and 40 articulated that they see it as their responsibility that their respective firm succeed in the pursuit of radical innovation (40) and radical sustainability-oriented innovation (37).

Key insights: Challenges of the corporate innovation management process and culture

The data suggests that firms try different approaches to encourage the pursuit of radical innovation activities within their respective firms. However, embedding sustainability considerations into value propositions that are new to the firm is perceived as challenging.

6.4.3 Experimental learning in large firms during the innovation process & learning from failure

‘Drivers for experimentation’ and ‘Fears and concerns’ are the two 2nd-order codes from which insights are presented in this section.

The cyclical learning approach as proposed by Nooteboom (2000) and its link to pursue radical innovation activities were not acknowledged. Rather, innovation challenges at the firm level were driven by challenges in the operating environment. However, Schumpeterian entrepreneurship and its focus on innovation was associated with exploring new business opportunities (37, 39, 41). I go on to present how interviewees were seeking to enable the exploration of new business value propositions at the level of the firm.

It was acknowledged that the current business environment holds unknown challenges that might end in disaster for firms looking to radically innovate with the view to addressing sustainable development challenges. The word ‘chaos’ (Foster, 1986; Nooteboom, 2000) was not mentioned in the data in terms of the uncertainty associated with explorative innovation activities. However, this text section expresses how innovation activities might end in chaos at the level of the firm: *“(..) it’s a very turbulent time, I think, over the next year or two, for a whole number of reasons between a past paradigm of business, which is starting to look a bit tired, and a future business. And I think you’ve got mind-set changes, innovation skill set changes, leadership changes, that will have to take place, and that’s very turbulent, bumpy, rough. That’s not to say that we’re sailing off into a beautiful sunset. I sometimes feel we’ve got one foot on the job, and the other foot on a banana skin”* (41: p.8, ATLAS.ti line 230). This suggests that for firms and individuals within firms, pursuing new business

opportunities needs to happen. However, pursuing these new business opportunities will be challenging for firms without any current indication which processes and changes will lead to future success or will end in chaos for the business.

Another two interviewees (37, 43) were in senior positions and enabled their respective organizations to search for, develop, and prototype ideas with the potential to make existing business ventures obsolete. For both interviewees, action led learning was perceived to be the key component of experimental learning. Both these interviewees drew on the approaches of startup businesses to illustrate how structures and processes should be structured to deliver radical innovation successfully. This quote illustrates the point: *"The challenge for all of businesses (..) in my opinion, is how can you look at your existing corporate structure, your existing processes - and job roles, actually - to actually deliver innovation (..) which is equivalent to, if not better than, what's happening in the small startup world."* (43: p.8, ATLAS.ti line 282) The lean startup approach (Blank, 2013; Ries, 2011) was mentioned by interviewees (37, 41, 57) as a way to learn action-led and fast about aspects or new value propositions: *"(..) if you can do the iterative learning thing fairly quickly then you can get to where you want to be much faster"* (57: p.5, ATLAS.ti line 186). However the need to engage customers early in the development of radically new products and services, viewed as crucial to this approach (Blank, 2013) was only mentioned by two interviewee. This interviewee, working for a large clothing retailer, argued that his firm does not have problems in learning about the customer when developing new products and services (Blank, 2013; Ries, 2011) because the retail environment allows for constant testing of what the customer approves of (i.e. buys) and what does not work: *"(..) consumer insights are not a big issue for us. It's not like we're sat here going, 'I wish I knew what they wanted.' We have a website with customer reviews; we have over half a million reviews about products on there, so it's not like we haven't got any data from our customers. (..) The customer is in our face every minute of every day; we've got, I don't know, [XX] million people going through our doors every day"* (43:p.5,ATLAS.ti line 175). This suggests that the interviewee deems the current customer value proposition testing as adequate in the firm. However, another interviewee articulated that engaging the existing customer base is not appropriate to test new value propositions outside the current firm offers: *"It's actually counter-productive for this [radical sustainability-oriented innovation] space obviously because she or they don't always know what's the right thing to do. But actually through that (..) the consumer is boss thing, our CEO (..) would say, "It doesn't really mean follow blindly what people are saying, it means make sure that the insights that you are using are true"* (37: p. 4, ATLAS.ti line 144). This suggests that existing customers are useful to test incremental innovation activities, whereas radically new value propositions need to be tested

more cautiously because the existing customer base might not be able to react yet to a completely new value proposition.

In contrast to engaging the customer to generate and extract the learning needed to develop new products and services, other interviewees highlighted other aspects of experimental learning. How principles of scientific experimentation might aid the exploration of radically new products and services was mentioned by the interviewees that worked in pharmaceutical and biotechnology firms (40, 42, 57). Interestingly, one of these interviewees (57) articulated the link between the lean startup approach (Blank, 2013; Ries, 2011) and experimental learning (Lewis-Beck, 1993; Montgomery, 2001) whilst reflecting on the innovation process of the firm: “(..) if [names different processes] *all came together, that would be implemented as a fast iterative process, as opposed to the fast serial (experimentation) process at present, and that would be truly revolutionary (..) much more revolutionary in that it’s a very different way of doing stuff. (..) I guess our processes of what we were doing (..) were a bit lean startup. Yes, we would test things and feed back, test things and feed back, but (..) I’m not sure that we necessarily did the pivoting*” (57: p.8, ATLAS.ti line 188). The interviewee considers the scientific experimentation approach (Montgomery, 2001) as not ideal to learn quickly even in a natural science driven experimentation environment because learning is gained through sequential iterations.

Two interviewees (41, 42) led innovation project from the idea stage towards corporate spin-out ventures. In both cases, the existing organizational and technical capabilities in the firm were not able to accommodate taking an idea to implementation within the existing firm. Both interviewees articulated that the spin-out ventures were perceived as disconnected to the core business activities by senior management. Furthermore, the learning generated through trial and error learning during the implementation of the idea that led to a spin out venture was not brought into the existing firm. One spin out venture had just closed down at the point of the interview. The interviewee (42) who had the idea and implemented the idea in the spin-out venture explained that taking the learning generated through the failure of the spin-out venture would only take place if an NGO¹⁴⁶ would apply pressure to the firm to share why the sustainability-oriented spin-out venture failed. Currently, senior management was not interested in extracting learning from the closing of the (multimillion dollar) spin out venture: “*One of the big bosses has voiced during a party, casually suggested [that] we should have a big ‘talk about what happened and learn from it’ session, but there’s a long way from him saying that to there being a full process*” (42: p.11, ATLAS.ti line 454). The interviewee

¹⁴⁶ Non-governmental organization

explained that he is in the process of setting up an entrepreneurial incubator to make the most of the learning derived from the failure of the corporate spin-out venture: *"I'm also starting up an incubator on the side right now (..), to basically learn from everything I've done here and convert that into an intelligent impact venture incubator. My job (..), and my access, and my rolodex, and everything that I have here is (..) instrumental to building the incubator, and it has been necessary to fund my little business¹⁴⁷ on the side. I have absolutely no interest in being anyone's employee anymore. So rather than just leave [my firm], and get a job somewhere else, I'm using [the firm] to launch into entrepreneurship of some kind"* (42: p.11, ATLAS.ti line 467). This suggests that capturing learning from the failed radical sustainability-oriented innovation project is not a priority for the firm of the interviewee.

Key insights: *Experimental learning in large firms during the innovation process & learning from failure*

The data suggests that pursuing new business opportunities is challenging for firms because there is little indication which processes and changes will lead to future success or will end in chaos for the business. Action led learning was perceived to be the key component of experimental learning, used to address innovation uncertainty. Some interviewees suggested that structures and processes of startups are suitable to pursue action led learning. However, existing firms face the challenge of engaging their existing customer base in the testing of radically new value propositions.

6.4.4 Collaboration ambition and reality

The 2nd-order code 'Collaboration is needed' and the respective 1st-order codes are presented here.

Interview data (37, 38, 39, 40, 41, 43) indicated that sustainability challenges cannot be tackled by a single organization and require collaboration outside a single sector. One interviewee put this issue succinctly in the context of sustainable development challenges: *"The future is very much around an issue-based platform: access to events and access to education or energy, nutrition, water. These are systemic issues"* (41:p.7, ATLAS.ti line 210). The issue-based approach to address sustainable development challenges proposed by this interviewee is in contrast to the insights from the 2013 data set: which and how sustainable development challenges were addressed were dependent on the context of each individual and firm. The 2014 acknowledgement that sustainable development challenges are unlikely to be addressed effectively by a single firm that needs to change existing value propositions did, however, not mean that all 2014 interviewees pursued innovation activities

¹⁴⁷ The interviewee refers to a different venture than the incubator here, a technology startup.

to address sustainable development challenges through collaborations. Rather, collaborations were a part of specific project. This indicates a tension between the knowledge of what should be done to address sustainable development challenges and what is currently done at the level of the firm. The remainder of this section explores this tension.

Some firms also use collaboration with businesses and organizations outside the firm as a way to deal with the complexity of sustainable development challenges according to the respective interviewees (37, 38, 39, 43). Hearing how smaller businesses address sustainable development challenges enabled the team of interviewee 37 to engage with these challenges: *"We had the CEO of [firm] for instance, who is hugely charismatic. As a result, we've been doing things (..) because he showed that it can be done. It's both inspiration that leads to innovation and very complete business ideas"* (37:p.3, ATLAS.ti line 90). Interviewee 38 was interesting because the interviewee argued that collaborating with others is a way to address the uncertainty of corporate innovation activities (Chesbrough and Teece, 2002) to address sustainable development challenges because it enables the sharing of knowledge. This goes beyond the inspirational element of collaboration highlighted by interviewee 37.

Starting and enabling collaboration has been highlighted by Spender (2014) as the necessary individual capability of individuals sitting at the interface between entrepreneurship and business strategy to enable organizations to deal with a complex environment. Interestingly, all interviewees highlighted their own personal role and benefits as well as the organizational efforts. This aligns with the argument of interviewee 31 from the 2013 data set, who highlighted how collaboration is most interesting if it furthers one's own advancement in the firm. However, apart from one interview (38), all interviewees mentioned that they were the ones choosing collaboration partners for furthering radical innovation and/or sustainable development within their personal project or organizational division decision-making space. It was not the organizations that were 'enforcing' collaborations at the firm level within the interviews conducted. This data finding seems to agree with the argument of Spender (2014) that, in order to create and lead value-creating companies fit for a complex world, the role of the individuals sitting at the interface of entrepreneurship and strategy is to *"persuade collaboration into existence"* (Spender, 2014; p. 290). However, this is somewhat at tension with the assertions on collaboration efforts to further innovation activities as proposed by Chesbrough and Teece (2002), who assert that firms have to decide appropriate collaboration approaches to increase innovation capabilities (virtual, ally, and bring in-house) at the strategy level of the firm. The data set suggests that decisions about collaborations are made on a project basis and motivated by personal

interest as opposed to being mainly driven by the desire to achieve a stated project goal. This implies that the approach to collaboration taken within a radical sustainability-oriented innovation project is highly dependent in the preferences and knowledge of the innovation project lead.

Key insights: Collaboration ambition and reality

The data suggests that there is tension between the knowledge of what should be done to address sustainable development challenges and what is currently done at the level of the firm. Collaboration to share knowledge is a mechanism used to break down the uncertainty associated with addressing sustainable development challenges. The interviewees suggested that they were the ones to choose how and when collaborations are used to further an innovation process, address sustainable development challenges, or both at the same time through radical sustainability-oriented innovation.

6.4.5 Breaking the business-as-usual innovation mindset

This section is based on the two 2nd-order codes 'Breaking business-as-usual' and 'Personal motivation'.

The data indicated that innovation leads within firms can make sustainable development challenges relevant to the corporate innovation process when people are confronted with them outside the business-as-usual context. Facilitating off-site inspiration resulted in four product and service ideas for one firm: *"We took a full week away in [Country]. We wanted to show [staff] how their technology could actually have a lot greater impact than we can imagine, social and environmental"* (37:p.2, ATLAS.ti line 88). *"But it can also be taking the team to a landfill, so less sexy but as effective in terms of: 'is this the legacy we want to have?'"* (37:p.3, ATLAS.ti line 111). This suggests that breaking business-as-usual mindset within an innovation team can be linked to sustainable development problem. This interviewee linked the activities to 'inspiration', however explained that making sustainable development challenges tangible to staff was the reason for the off-site activities. This 'inspiration' was looking to enable the team to create new product and services that would improve or avoid the negative environmental and social impacts of products and services. This problem solving approach aligns with the approach of the two individuals identified by 2013 interviewees as radical sustainability-oriented innovators to address the most pressing problems. At the same time it aligns to the 2013 data insights that sustainable development challenges are context-specific. The two off-site locations chosen by interviewee 37 were associated with sustainable development challenges that are associated with current products and services of the interviewee's firm. This approach suggests that such 'inspiration' activities might enable to break the business-as-usual innovation process during the ideation stage of creating new value propositions.

Problem solving has been shown to be at the heart of entrepreneurship in the 2013 data and in the literature (Livingston, 2007; Schaltegger and Wagner, 2011).

During the development and implementation of value propositions outside the current firm innovation status quo, interviewee 40 explained how the following approach might help to break business-as-usual during the innovation process. Encouraging cross-cultural and cross-functional teams might enable individuals to break a business-as-usual mindset and to create shared goals focused on sustainability challenges. Taking people physically away is a substantial time and resource commitment (37, 40, 41). One interviewee (40) argued that a similar result can be embedded in ongoing project activities by asking people to work together who do not usually do so and consider relevant sustainability challenges: *“Innovation is all about creating opportunities and then seeing opportunities where there are none to be seen today. To have that creative approach to things I think you need a different atmosphere, a different culture”* (40: p.4, ATLAS.ti line 102). The interviewee went on to explain that placing people with different nationalities and different cultural backgrounds in a radical innovation project team can help to gain perspectives that would be impossible to generate from a single-nationality team only. This data insight is interesting because it shows how this innovation lead was able to use a flexible organizational structure (Eisenhardt et al., 2010) whilst paying close attention to the relationships in the project team (Larson, 2000). The insight also suggests that business-as-usual mindset within a firm might be challenged through cross-cultural teams.

Some literature asserts that personal values are they key differentiator between choosing to pursue conventional entrepreneurship or sustainable entrepreneurship (Bocken, 2015; Tennant, 2015) and this is a new research area (Liñán and Fayolle, 2015). Others argue that the core motivations to pursue sustainability-oriented entrepreneurship are to solve problems related to social and/or environmental problems (Schaltegger and Wagner, 2011). The 2013 data asserted that the entrepreneurs (28, 29) identified as radical sustainability-oriented innovators were solely concerned with addressing the biggest problem. The 2014 data set, however, mirrors the 2013 data insights from the other 2013 interviewees who mentioned that their personal values, shaped through their personal experiences, was driving their desire to pursue innovation and business activities that go beyond the objective of economic value creation (i.e. go beyond business-as-usual activities). The 2014 data (e.g. 39, 41, 43) suggests that addressing sustainable development challenges through organizational innovation projects allows interviewees to align their personal values with their work activities. For example, a sense of encouraging an individual sense of purpose pervades the work

undertaken by, and the business case for setting up a spin-out venture, with business benefits being stated as deeper staff engagement and retention (e.g. 41, 43). Aligning personal values with work activities seems to be easily done where the job is addressing sustainable development challenges: *“I think by ignoring so many non-financial values in the past, we have already created a world where we have to repair a lot of damage now to have that nice planet also for future generations”* (38: p.11, ATLAS.ti line 368). It seems that sustainable development challenges and individual purpose are viewed as a chance to move forward with one’s career in a purposeful manner: *“A belief that something is missing in your career, or that you want to do something you feel passionate about but haven’t been able to express”* (41: p.2, ATLAS.ti line 58). However, the sense of individual purpose was closely related to the acknowledgement that change is not easy at the personal level. Sustainable development challenges require the ability to take action in the face of uncertainty (Greenberg et al., 2013) and that can feel uncomfortable (e.g. 38, 39, 41, 57). It has been acknowledged that the organizational changes required when addressing sustainable development challenges can give rise to a tension with the individual sense of purpose: *“Truly meeting sustainability challenges will require many changes - including job roles. Really it’s turkeys voting for Christmas, isn’t it”* (43: p.10, ATLAS.ti line 314). This tension was equally acknowledged in the Reflection Diary: *“I find it hard to look at the Pioneers properly because I constantly think that they and their values were going against my personal values, especially when it comes to engaging with nature”* (0A: p.4, ATLAS.ti line 79).

Key insights: Breaking the business-as-usual innovation mindset

The data suggests a mechanism and confirms one insight from the 2013 data. The mechanism is as follows: firms trying to break a business-as-usual mindset during innovation activities might benefit from taking staff outside their familiar work environment, with the locations chosen to highlight social and/or environmental problems associated with firm activities. The insight confirmed from the 2013 data set is that personal values, shaped through personal experiences, drive the pursuit of innovation and business activities that go beyond the objective of economic value creation (i.e. go beyond business-as-usual activities).

6.4.6 The role of corporate leadership in supporting innovation activities with uncertain outcomes

‘Leading experimental projects’ is the 2nd-order code that provides the insights for this chapter section.

The importance of senior management to encourage and enable radical innovation with a sustainable development goal was mentioned by all interviewees. This support is important because

it allows innovation teams to explore value propositions that have no immediate economic benefit. A change of the senior leadership had significant impact on the innovation activities of some (42, 57): *“(..) that simply has to do with pipeline stages, budgets and finances of big things (..) So, a change of the attitude of the person that is in charge. We had a guy before (..) he was very positive about trying to incorporate technology development stuff and be at the forefront, and saw the vision of how these sorts of things might implement and give the company a competitive edge down the line. I guess budgets were somewhat freer, but then when the new Chair of R&D came in he set a slightly different agenda. And the freedom was gone.”* (57: p.3, ATLAS.ti line 105) The need to have freedom at the individual and team level in order to explore radically new products and processes is asserted in the literature (March, 1991; Nooteboom, 2000) and, equally, in the 2013 data (chapter 4).

At the time of the interview, one interviewee (37) was in the middle of an experiment that emerged after taking a team outside their known business context and into a social setting that highlighted social sustainability challenges¹⁴⁸. One of the team’s ideas was approved for further development with executive understanding that profitability did not have to be an explicit consideration in the early stages of bringing the idea closer to commercialization. The innovation team was granted the freedom to explore the idea without a clear economic business case by the CEO and this has been the key factor in the team’s ability to push the idea forward: *“He said, “It’s a pilot, we’re going to try it. I’m not expecting a return. I just don’t want to lose too much money” [...] so that was helpful because it’s very - totally new territory”* (37: p.5, ATLAS.ti line 185). This final data point illustrates that the firm’s leadership was flexible in style (Alexander and van Knippenberg, 2014) because in other innovation projects, the same leadership favoured economic value creation. This suggests that giving the explicit mandate to pursue explorative innovation activities without providing an immediate financial business case is needed.

Key insights: *The role of corporate leadership in supporting innovation activities with uncertain outcomes*

The data suggests that senior management can encourage and enable radical innovation with a sustainable development goal through making explicit that radical sustainability-oriented innovation activities can be explored without an immediately obvious economic business case.

¹⁴⁸ The previous section contains the details of how this was done.

6.5 2014 data conclusion

The data showed strongly that developing new capabilities to pursue radical innovation activities benefit from collaboration with individuals and organization outside the firm's boundary. The need for collaboration was more strongly articulated than the literature synthesis in section 5.5.1 of chapter 5 indicates.

The challenges of pursuing radical innovation in large firms were acknowledged in the data. Equally, the challenges of pursuing triple bottom line value creation and personal values driven entrepreneurial activities were acknowledged. The data enabled a cross-sectoral snapshot of these challenges and aspects of the literature synthesis in chapter 5 could be set in the context of the data. However, in order to explore the synthesis in more depth and draw on the synthesis in chapter 3, a longer-term research approach is necessary.

7. Data discussion 3¹⁴⁹: developing the organizational capability of experimentation

This chapter presents the data analysis of a case study that took place over a total period of 22 months and had the purpose to explore how a large firm might develop the organizational capability of experimentation. **Figure 33** acts as a reminder of how these interviews fall within the conceptual framework of this research.

The 2013 and 2014 data highlighted the need for collaboration to enable the development of new organizational capabilities. Furthermore, some literature reviewed in chapter 5 highlights that it is a choice of firms to pursue innovation activities as a stand-alone project or through collaboration activities (Chesbrough and Teece, 2002). The case study firm chose to pursue radical sustainability-oriented innovation activities in collaboration with a university. The collaboration itself is not the research focus of the case study. Instead, the research aim was to explore how a large firm might develop the

organizational capability of experimentation in order to pursue radical sustainability-oriented innovation. However, the collaboration had an impact on developing the organizational capability of experimentation and this is discussed in this chapter.

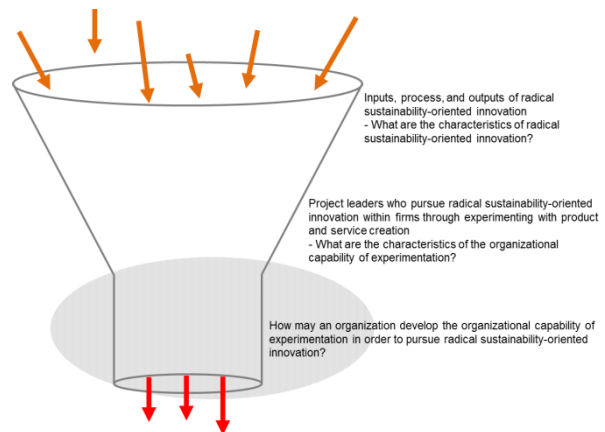


Figure 33: Case study research in the conceptual framework

7.1 Data sources, types and use

The case study used the “*big three*” (Langley, 2009; p. 411) data sources used in qualitative research: interviews, observation, and archival documents. The project brief, residential workshop observation protocol, interview transcripts, meetings, and workshop transcripts were interpreted (Savin-Baden and Howell Major, 2013; Thomas, 2011a) with the recordings of three workshops (62 Research meeting; 63A-B and 64A-D Data burst sessions) supplementing the text files. The data sources and associated types of data fulfilled different purposes during data analysis, as shown in **Table 17**.

¹⁴⁹ Parts of this chapter are included in a paper accepted for publication in the Journal of Cleaner Production: Weissbrod and Bocken (2017) ‘Developing sustainable business experimentation capability – a case study’.

Data Sources	Type of Data	Use in the Analysis
Project proposal (7 pages)	Document written through collaboration between representatives of the retailer and the university (1 in total)	- Gather information on whether the case study project is suitable to answer the research question - Gather information on project ambition and process
Observation protocol (13 pages)	Structured observation protocol of 2-day project ideation workshop (1 in total)	Increase understanding of the project goals and proposed process to achieve project goals
Workshops and meetings (433 pages)	Meeting transcripts (3 in total): - Internal sign-off meetings with senior firm staff (2) - Progress meeting with government funding representatives (1)	- Gain understanding of how senior management views project goals and processes to achieve project goals - Corroborate understanding of project progress derived from semi-structured interviews and project team workshops and meetings
	Workshop transcripts (4 in total): - Experiment planning workshops (3) - Experiment review workshop (1)	- Gather information on process of developing the organizational capability of experimentation - Gather information on how project team views progress on project experimentation
Semi-structured interviews (101 pages)	Interviews with academics (3 in total)	Corroborate understanding of developing organizational capability of experimentation from workshops and meetings
	Interviews with firm employees (6 in total)	Corroborate understanding of developing organizational capability of experimentation from workshops and meetings
	Interviews with funding monitoring representative (1)	Support accounts from other semi-structured interviews
Meetings (14h and 15min)	Meeting recordings (3 in total): - Research meeting for a single experiment content with external contractor (1) - Fact finding sessions to research market data for experiments (2)	- Examine whether details of experiment planning add value to accounts from semi-structured interviews - Corroborate 1st-order codes on how the project team endeavours to adopt lean startup principles
Private project website	Website hosted by the clothing retailer containing project documents, experiment details, team calendar	Integrate and crosscheck project process details and timelines from workshops, meetings and interviews
Interview notes (part of 101 pages)	Short paragraph written at the end of 10 interview transcripts	Track and examine interaction between researcher and interviewee, capture immediate stand-out points of interviews

Table 17: Case study data sources and use

7.2 Data analysis overview

As for the 2013 and 2014 data sets, the transcripts were analysed with the qualitative data analysis software program ATLAS.ti. The academic literature presented earlier in this thesis provided the content prompts for highlighting text in the reviewed documents. As a starting point to identifying interesting text sections, the ATLAS.ti auto coding function was used to find sentences that include key words (e.g. 'lean', 'radical', 'value') from the reviewed literature. In addition to the literature prompts, the data analysis strategies 'organizing principles' and 'oppositional talk' were applied¹⁵⁰. All transcripts were read in full to enable the coding of the full data corpus (Friese, 2012).

¹⁵⁰ Full details on the data analysis are presented in the methodology chapter 2 of this thesis.

This chapter does not make the links to the data analysis conducted in research phase one. This is done in the meta discussion and conclusion chapter 8.

7.2.1 1st and 2nd-order codes

The coded text sections received descriptive labels consisting of nouns and adjectives: these were the 121 1st-order codes. Once the first coding cycle was completed, the ATLAS.ti co-occurrence¹⁵¹ tool was used to reveal associations between 1st-order –lower level- codes, their intensity and meaning (Contreras, 2011; Friese, 2012). Revisiting the transcripts and paying close attention to text sections with co-occurring codes (example shown in **Appendix 1**) aided the grouping of the 1st-order codes into 2nd-order –conceptual- codes through developing “a sense of categorical, thematic, conceptual, and/or theoretical organization” (Saldaña, 2009; p.149). **Table 18** presents the 1st-order and 2nd-order codes that resulted from the inductive data analysis.

1 st -order codes		2 nd -order codes
• Ambidexterity • Antibusiness • Business model • Decision-making toolkit as output • Decision at the edge of chaos • Desire to plan and control • Design of Experiment principles in project experiments • Embedding innovation in firm • Experiment planning inhibits action • Experiment vs pilot • Explore new business model • Extending organizational capability	• Generating radical innovation ideas • History as innovation inspiration • Ideation • Innovation vs Business model innovation • Limits of technology • Merger and Acquisition • Need for corporate innovation • Open innovation • Reinforcing firm's innovation process status quo • Spin out company • Technical capability • Technology as process enabler	Organizational innovation process
• Board engagement • Business leadership • Collective goal • Corporate structure hindering radical innovation • Executive innovation input • Innovation culture • Internal relationship network	• Influencing tactic to enable organizational change • Leadership • Organizational values • Project is too comfortable to be radical • Project leader • Senior firm staff pushing some experiments • Senior leadership • Strategy to engage senior staff	Creating internal buy-in
• Value proposition • 4 key themes • 11 experiments • Aim to increase resource efficiency • Complexity in project • Decision making in complex situation • Economic value creation	• Environmental value creation • Experiment learning • Fibre recovery rate • Goal • Other firms used as decision guidance • Social value creation • Struggling to keep experiment scope small • Sustainable development goal	Increase of ambition and complexity of sustainability goals
• Academic rigour hampers action	• Freedom to explore innovation	Embedding

¹⁵¹ To remind the reader what this means: co-occurrence of codes refers to the enclosing or overlapping of different codes in the same data text section.

1 st -order codes		2 nd -order codes
• Acting like entrepreneurs • Action • Applying lean startup approach • Consumer engagement • Customer discovery • Customer focus • Customer validation • Digital customer testing • Entrepreneurial experience • Experimentation action	- opportunities • Gauging demand for new product • Identify gaps in market • Lean startup in corporate • Misunderstanding entrepreneurial mindset • No entrepreneurial experience • Reluctance to engage customer • Startup finance • Technical lead as 'agile coach' of team • User acquisition cost • Whole team engaged in market testing	entrepreneurial principles
• Deadline driving project action • Innovation changes whole industry • New team member • Project delay	• Project team communication • Slow organizational timeline • Speed • Time to commercialise innovation	Time
• Collaboration benefit • Collaboration challenges • Emotions not managed • Fragmentation	• Outsourcing organizational innovation Capabilities • Past business experience bias • Staff serving multiple roles	Multiple roles
• Incognito customer testing • Experimentation = quick learning • Innovating outside status quo • Personal experiments	• Personal values • Sustainable development values driving innovation • Unplanned learning	Unplanned, action-based learning
• Carbon emissions • Circular economy • Economic value creation is highest priority • Experienced business person • Finance to bear risk • Hunger for templates to apply • Innovation accountability • Link experiments to status quo firm events • Process confusion	• Project experiment reason • Public funder input • Resource use • Statistical robustness • Throwing toys out of pram • Triple bottom line value embedded • University asked to drive radical innovation • Using familiar project management tools	Tension between environmental, social, economic value creation
• Academic input • Discard experiment not leading to project goal	• Experiment completed	Discarding experiments
• Researcher displays bias • Illustrative quotes		Research process

Table 18: 1st-order codes and 2nd-order codes

The 2nd-order codes formed the basis of the case study discussion presented in this chapter. The data provided a rich picture of the project team efforts to develop products/services outside the organizational status quo, the process of developing, planning, and implementing the project experiments, and the challenges associated with linking a sustainability dimension to radical innovation activities within the boundaries of the firm.

7.3 Findings and discussion

The narrative is presented in the order of the 2nd-order codes shown in table 4, with a selection of quotes from 1st-order coded text sections used to illustrate the narrative.

7.3.1 Exploring developing the capability of experimentation through the case study

The case study firm (FIRM) started a 2-year project (PROJECT) to explore approaches for reducing all of its clothing fibre going to landfill through applying an experimental learning approach. The following proposal extracts¹⁵² illustrate how and what PROJECT set out to achieve:

- *“We will conduct experiments to prove key concepts (..)”* (0:p.2, ATLAS.ti line 1265).
- *“This project will develop new models of engaging with the customer to encourage recovery of high value material at volume (...). In 2012, 4 million items (1,700 tonnes) were returned successfully, which might otherwise have been lost to low value waste streams. 1,700 tonnes is around 1% of the total garments sold each year by FIRM, with a fibre input value of £5m”* (0:p.2, ATLAS.ti line 2518).
- *“The 120KT of material that FIRM sells [per year] represents approx £500 million of raw material input and 10% of the UK market. [A FIRM] program was designed to address the return and re-use of garments. While the program has been copied by other UK retailers it is only achieving a 1% recovery success rate [in 2014 and of FIRM fibre input]. This project will innovate the recovery system and supply chain to determine what conditions are required to meet our objective of scaling the 1% to 50%”* (0:p.3, ATLAS.ti line 2116)
- *“(..) a radical change in business logic is required. 8 out of 10 such transformations fail”¹⁵³. This project seeks to mitigate the change risk by trialling separate elements then exploiting a new model startup”* (0:p.4, ATLAS.ti line 4952).

This proposal extract illustrates three things. Firstly, the current resources flow of the retailer is largely linear: it starts with clothing materials sourcing, continues with clothing manufacturing and ends with the sale to customers. The retailer has little to no control over the sold clothing after the sale to the customer. Secondly, the project at the heart of this case study requires radical innovation of products and services from the clothing retailer. This product and service innovation will result in the retailer having to experiment with new innovation activities and business models. Thirdly, the increase in clothing recovery has been very low and improvement is insufficient for the trajectory of change needed to address sustainable development challenges (Martin et al., 2010; Tegart et al., 2014).

PROJECT looks to create triple bottom line value. The environmental and social benefits associated with increasing the garment recovery rate are argued to be as follows in the project proposal:

¹⁵² The proposal extracts included many spelling mistakes. These spelling mistakes have been corrected without highlighting the changes in the text extract to enable ease of reading. No grammar or words were changed.

¹⁵³ There is no information in the proposal on whether this argument is based on insights from FIRM activities or other sources.

“Recycling and repair strategies use significantly less energy, resource and material than virgin production strategies (1 tonne cotton t-shirts rescued saves 12 tonnes CO₂, if recycled saves 1 tonne CO₂). Positive social implications in the UK based supply chain come from new recovery and re-use supply chains. The reduction in demand for virgin feedstock would be offset by growing demand in emerging markets. The economic benefits of 100% fibre recovery would be to potentially take £500 million out of the supply chain cost base annually, which will be transformed into new value for those involved in the circular (remanufacturing) supply chain. The value through garment recovery and re-use and recycling will be significantly higher than currently achieved as each thread is given greater use. The consumer would gain greater utilisation and free up wardrobe space. The increased recovery and return may allow the secondary market (currently through [charitable organization]) to become more systematic with a better range of quality items and an increase in volume of lower quality items potentially bringing in resource income (£300-550k rag trade) and delivering social benefits through the donation of worn but useable clothing” (0:p.3, ATLAS.ti line 4769). This extract suggests that the social and economic value creation associated with PROJECT would positively impact FIRM and its suppliers, the industry within the country, and industry in less developed countries. Furthermore, the environmental value creation would positively impact the whole world, because the benefits associated with fewer carbon emissions are global.

The submitted project proposal was reviewed to determine project goals and the suitability of the case study to answer the research question. The proposal indicated that the retailer would be required to pursue, at the very least, new to the firm innovation activities. Furthermore, the project proposal explicitly acknowledged the need for the retailer to experiment with unknown product and service propositions in order to achieve the goal of reducing clothing fibre going to landfill by 100% at a much higher speed than the increase in recovery rate achieved between 2012 and 2014.

The project proposal was written in cooperation between FIRM and the collaborating university. This was consciously done by FIRM, because previous collaborative projects, where the collaboration partner was mainly writing the funding proposal, were perceived to not reach their full potential in terms of benefits for FIRM (49). This interviewee explains why FIRM engaged in PROJECT and the motivation to co-write the proposal: *“(..) it was one of the topics that ever since [corporate sustainability strategy and action plan] has launched we’ve never really cracked in terms of thinking about how we deal with end of life clothes and customer behaviour change, so that was attractive. (..) The university were very willing to take ownership of the bid and it was almost like, ‘Oh, you don’t really need to worry about it, you can just sign your name and just be supportive in principle.’ We*

disagree with that approach because we've done too many things like that where, unless we actually get involved and think about how it's going to run and actually play a part, it isn't as useful to our business as it could be" (49:p.1, ATLAS.ti line 1732). This suggests that FIRM was shaping the project content, goals and approaches from the outset of PROJECT.

The data collected for this case study started with the creation of PROJECT and ended when some experiments were in the implementation stage in. During the course of PROJECT, the ideas generated during the two-day ideation workshop and the follow-up workshop were grouped into four themes, with each theme containing approximately three ideas to be explored through experiments: *"We have four key themes, [service offer] being one, [product/service offer], [extending clothing life offer], and then making [recycling offer] better. So there are four key themes that came out of the [two] ideation workshops"* (47A: p.2, ATLAS.ti line 2092). In total, there were above 100 initial ideas, however the exact number and nature of the ideas was not clear to project team members, even six months (i.e. in April 2015) after the ideation workshops: *"(..) those 200 or 100 crazy or not so crazy ideas that we had at the beginning"* (54:p.1, ATLAS.ti line 863). The theme that was looking to make the existing FIRM recycling offer better was replaced by a service offer that was new to FIRM and the UK industry in the autumn of 2015. This replacement was driven by a senior member of staff in FIRM, a member of PROJECT steering group (and data number 43). All this suggests that pursuing radical sustainability-oriented innovation was associated with high degree of change and confusion within PROJECT.

I go on to discuss particular project challenges. The content of the experiments is not discussed; the focus of the discussion is on process challenges because this research phase two seeks to explore how a firm might develop the organizational capability of experimentation in order to pursue radical sustainability-oriented innovation.

7.3.2 Reinforcing the organizational innovation status quo

From the project proposal (0), the PROJECT steering group meeting on 3 September 2014 presentation¹⁵⁴, and the detailed observation protocol (55) is it undisputable that PROJECT was intended to explore products and services with the potential to destroy the existing business model of FIRM. This aligns with the sustainable business model literature (Bocken et al., 2014; Boons and Lüdeke-Freund, 2013). At the same time, the need to create new technical and process capabilities

¹⁵⁴ Accessed through the PROJECT website; a summary of key points from the presentation deck is provided in the methodology chapter.

was clearly acknowledged (0,55), again aligning with the literature (Abernathy and Clark, 1985; Garcia and Calantone, 2002). The retailer was comfortable to pursue innovation activities with strategies that went beyond purely resource-based strategies for economic value creation (Eisenhardt and Martin, 2000; Teece and Pisano, 1998).

The initial idea generation process of searching for radical ideas was flawed in creation value proposition ideas fit to meet the project goals. This is indicated in the observation protocol, which was prepared to answer the research question of 'Does the 2 day workshop succeed in searching for and possibly even generate the radical innovation ideas PROJECT aims for?': *"The workshop observations and the outputs observed for this document indicate that the answer to the research question is 'No'. The pre-workshop materials seemed suitable to enable participants to search for such ideas, so were elements of the information provided during the workshop. The setting was well chosen but the possibilities of the setting seemed underused. The ideas generated and communicated during the workshop through team presentations did not seem of the radical nature the PROJECT aims articulate"*¹⁵⁵ (55:p.2, ATLAS.ti line 1926). This failure of generating ideas fit to meet the project aims was acknowledged even during the ideation workshop: *"(..) the ideas were an accumulation of team discussions (..) it was communicated that the ideas articulated in participant notebooks and on team displays would be taken forward into the next phases of the project"* (55: p.2, ATLAS.ti line 1151¹⁵⁶). The follow-up workshop was not attended or recorded, therefore how the ideas captured in participant workshops and on team displays were taken forward was impossible to assess. However, the value proposition ideas presented in the first experiment planning workshop (47A-D) included more and different ideas than the ones presented at the end of the residential ideation workshop (55).

The project started to encounter major barriers after the project ideation workshops. The team was keen to apply familiar innovation process tools. Workshops (47A-D, 51A-B, 52A-B) illustrated the strong desire by the majority of project team to plan PROJECT using tools such as road mapping, developing decision matrices, or linking the project to planned corporate activities. This exchange between two participants provides an illustration: *"I think it'd be good to have a general chat about what works and what doesn't work in experimenting. So taking 2 or 3 sentences from 'The Lean Startup', (..) what works and what doesn't work in experimenting."* – *"Does that then give us the matrix that we devise during the session to work to?"* (47A: p.9, ATLAS.ti line 2596). Ironically, a

¹⁵⁵ This text extract is taken from the executive summary of the observation protocol.

¹⁵⁶ The ATLAS.ti line numbers are much higher than in data chapter 4 and 6 because the documents are mainly loaded as Portable Document Files (pdf) files as opposed to Rich Text Format (rtf) files into the data analysis programme.

senior FIRM person had previously expressed in an interview¹⁵⁷ that the application of decision frameworks is not suitable for the exploration of radically new value proposition ideas: *“No, we [refers to FIRM] don’t and I don’t believe in a kind of formalisation of the assessment matrix at that stage [refers to ideation and exploration stage of current FIRM innovation activities]. This is an emotional business, so the people that make the decision are the [garment] design, commercial, buying people. (..) It’s not an analytical process; it’s a group of people and if that group of people think, ‘You know what? That’s a winner,’ then nine times out of ten they’ll get it right”* (43:p.7, ATLAS.ti line 236). However in the workshop, the interviewee was not present. Furthermore, the representatives of FIRM present in the workshop did not express any dislike for applying decision making frameworks during the exploration of ideas either: *“Some time someone will invent a nice methodology for all this stuff and we won’t have to keep inventing dialogues every time we have a meeting”* (47D:p.13, ATLAS.ti line 807). Therefore, within FIRM there is no shared understanding of how value propositions should be explored that are *“a bit more radical, a bit more mad”* (43:p.7, ATLAS.ti line 230).

The desire to apply known project process tools reinforced the innovation status quo of the retailer. The literature suggested that the pursuit of radical innovation requires the creation of new approaches to project management and corporate processes (Leifer et al., 2001; O'Connor and Rice, 2013). Project activities that would have required the development or implementation of ‘uncomfortable’ (i.e. new) capabilities at the individual or firm unit level were discussed. However, the responsibility for conducting these activities was established to be outside the project scope: the establishment of a spin out business and personal limits of technological skills are two examples articulated where it was deemed unfeasible to develop new capabilities.

The term ‘experimentation’ invoked language based on the scientific design of experiment literature in the team: ‘testing variables’ (56A), ‘hypotheses to prove’ (60B), and ‘control group’ (61B) are examples. However, solely the technical team member articulated how FIRM used statistical design of experiment principles (Montgomery, 2001) during implementation of customer discovery (Blank, 2013) and customer validation activities (51A-B). When scientific design of experiment language was used in workshops, the participants tried to narrow down content details of the experiments to be conducted in order to pursue radical sustainability-oriented innovation activities. In contrast, the technical team member who made the link between scientific design of experiments and customer

¹⁵⁷ This interview was part of the 2014 experimentation interviews data set. This interview led to the research engagement with the case study. My PhD funding is associated with the collaborating university, however Imperial College London was no official or unofficial partner in PROJECT.

testing was advocating testing specific customer aspects of radically new value propositions. This suggests that the customer discover and validation aspects of experimental learning activities and the language of scientific experimentation were linked to the pursuit new value propositions by only the PROJECT team member who had previous experience with testing new value propositions. For the other team members, 'experimental learning' was associated with needing clarity on experiment inputs before starting experiments to explore the uncertainty associated with new value propositions.

Key insights: Reinforcing the organizational innovation status quo

The data suggests that the desire to use familiar processes reinforces a firm's innovation status quo. Defining key PROJECT terms (i.e. experiment) will enable teams in pursuit of radical sustainability-oriented innovation to minimise confusion in meetings and workshops.

7.3.3 Creating internal buy-in

The need to engage in iterative processes to explore how product and service propositions might be linked to customer value propositions has been highlighted as a key component of the lean startup approach (Blank, 2013; Ries, 2011). The data shows that the project team was keenly aware of the need to create buy-in from decision-makers and corporate budget holders in order to test customer value propositions: *"(..) if it something a bit more radical, a bit more mad, then it needs to go into this mechanism and be supported or not supported, (..). You need to kill things quickly or support things quickly to get them through"* (43: p. 7, ATLAS.ti line 1110).

From the beginning of the project, FIRM engaged staff members across all business functions, a characteristic of experimentation for the pursuit of radical innovation highlighted in the definition by Chang et al. (2012). However, the data also indicates a lack of clarity about the internal buy-in process and project team accountability regarding (1) how experiments were to be planned and (2) how experiments were to be executed for this purpose. During project meetings the need for creation of buy-in from senior members of clothing retailer staff was articulated. In particular, the need to 'internally sell' product/service innovations that are new to the retailer customer base was perceived as high risk due to the uncertainty of how consumers might engage in or react to new products or services. *"That [consumer reaction], of course, is the big unknown at the moment and we probably won't even really know at the end but we might have a half decent idea"* (66: p.4, ATLAS.ti line 1612).

During year one of the project, a limited number of senior staff of the clothing retailer were exposed to the project. While this initial non-exposure was done intentionally to nurture the project, once positive results started emerging, buy-in was required from senior staff: *“We talked about the tactics all the time, we talked about how we’d have to bring it up on different board meetings, how we’d have to key it into strategy reviews, and then working back from that who would do that and who would get time with the different sponsors at board level to share the knowledge and share the findings and convince them”* (49: p.3, ATLAS.ti line 4592). This suggests two things. Firstly, involving the senior staff at the right moment is a real balancing act. Involving too many senior staff too early might lead to the cancellation of product and service innovation experiment plans because they are deemed too risky, whereas involving key staff too late might mean experiment content will not gain traction in the wider organization. Secondly, consistent with the arguments of the radical innovation capabilities literature (Chang et al., 2012) and entrepreneurial goals literature (Guarana and Hernandez, 2014), staff need to be ‘allowed’ by senior management to experiment and engage in uncertain innovation activity outcomes. This indicates the tension between engaging senior leaders at an appropriate time and the need to gain senior sign-off to conduct experiments.

Key insights: Creating internal buy-in

The data suggests that creating internal buy-in across all levels of seniority is necessary. The timing with which senior staff is engaged is important: too early will result in the killing of projects with high uncertainty, too late will result in lack of senior ownership. This mirrors the literature assertion about the need to create buy-in to the customer development process (Blank, 2013).

7.3.4 Balancing multiple roles and freedom to experiment

None of the project team members worked fulltime on the project, which is different to people developing products and services in a startup business (Graham, 1993-ongoing; Livingston, 2007). Senior members of the project team were leading content development in workshops. However, two new team members were introduced to the project and the project ambitions. Participants of the workshop varied widely before and after their introduction: in some meetings participants were mainly from FIRM (e.g.65), in some numbers were evenly split between FIRM and the university (e.g. 63A-B) and in some academic participants dominated (e.g. 52A-B). In effect, workshops were led by different team members (i.e. either from FIRM or the university) throughout year one. In addition to shifts in team membership, team members from FIRM and the university had to combine different mandates. During the meetings and workshops where FIRM participants were in equal or higher numbers, actions and next steps for experiments were agreed. In contrast, the meetings and workshops where academics were in the majority, the conversations were dominated with

reflections on specific sustainable development challenges and how they might be addressed through experiment, the pros and cons of conducting experiments in a specific way, and process details of workshops¹⁵⁸. This suggests that the project team struggled to have a clear common understanding on how to proceed with PROJECT. Furthermore, there was no single team member that was mainly focused on delivering PROJECT.

Towards the end of year one of the project, this case study challenge was addressed by FIRM. A project team member was freed up from other commitments to dedicate 50 per cent of their working time to the planning and execution of experiments. Almost immediately, this resulted in more frequent communication between members of the project team - and frequent communication was stated as an explicit project need by interviewees (49, 56, 58). The literature equally argues that interpreting a complex situation and communicating well within a team is a key element to help achieve entrepreneurial goals (Alexander and van Knippenberg, 2014; Guarana and Hernandez, 2014). The data suggests that allowing a member of staff to spend 50 per cent of their time on a radical innovation project might be a suitable mechanism to avoid the 'processification' of corporate innovation, manifesting itself as corporate mind-set and identified as a key barrier to radical innovation success in large corporates (Sandberg and Aarikka-Stenroos, 2014). Combining staff freedom to pursue innovation goals and the ability to monitor corporate innovation processes was highlighted as a key challenge: *"It's a fine balance about trying to create a process that doesn't feel like a process, because obviously if you think people are just going through a machine then it doesn't create the serendipity that creates innovation"* (43: p.5, ATLAS.ti line 628). This suggests that FIRM staff recognize the need to allow freedom in radical innovation processes. However, in PROJECT this freedom led to uncertainty about how to best generate learning to pursue ideas that require radical sustainability-oriented innovation.

Key insights: Balancing multiple roles and freedom to experiment

The data suggests that despite the corporate practice of multi-project working, enabling key team members to significantly focus on a radical innovation project will enable entrepreneurial focus (Katz and Shepherd, 2004; Livingston, 2007). It is important to have clarity on how to use freedom to experiment and clarity on who leads areas of decision making during radical sustainability-oriented innovation activities.

¹⁵⁸ This is an example of an academic trying to broaden out the scope of a meeting to consider different perspectives in an upcoming workshop *"I think the best way to run through any material is to run through it in the way that it would be used in a workshop because then you're testing two things. You're improving the material but you're also trying to understand how other people will interact with the same material. I think it's really important to emulate what we think the workshop would look like and who would be attending, and try to imagine their reactions so that we go, 'These are the right words and the right pictures but it's got to be in green' or, 'It's got to be bigger' or, 'Careful, because if you swamp people with too much information will they be able to absorb it during the workshop and do you have to give people pre-reading?' and all that sort of stuff"* (47A:p.2, ATLAS.ti line 4251).

7.3.5 The project collaboration

The previous section indicates that FIRM and university members of the project team had different interests during the development of new value propositions in PROJECT. However, FIRM interviewees repeatedly cited the involvement of the university as a suitable mechanism to enable the project team to reflect on project risks and challenges. This reflection was viewed as a useful means by which to think through how to communicate the innovation activities outside the organizational status quo within the clothing retailer. However, the uncertainty relating to customer reaction inhibited customer engagement in the project experimentation until month eight of the project. This late customer engagement is in stark contrast to the lean startup literature (Blank, 2013; Ries, 2011) that argues that engaging customers is essential to develop new value propositions.

The second key role of the academic collaborators was to challenge the ambitions of the experiments in terms of novelty to the company, stretching sustainability goals, and securing the most learning (47A, 43A, 60B). The involvement of the university was deemed essential to secure learning from the experiments that might not have an immediate economic business case. However, this argument was only offered six months after the main data collection phase did stop: *“if we run an experiment and the numbers don’t help in any way but you still get a lot of learning and so from a project perspective it wouldn’t be a failed experiment because you get a lot of information from it - if you looked at it strictly from a numbers perspective then (..) ‘This was a disaster. Just stop it, kill it.’ Whereas, if you’re doing it as part of PROJECT with the academic eye on it you go, ‘Alright, okay. We’ve learnt this, this and this therefore we can take it like that and try again.’”* (60B:p.2, ATLAS.ti line 2188).

For developing the experimentation content of the project, the academic collaborators were perceived as normal project team members by the practitioners: *“I think there were people (academics) observing the process, and then there were people who were contributing to the project. So the people who were observing were just there to observe (..) and the people who were contributing were as good as everybody else there”* (58: p.7, ATLAS.ti line 880). The case study data did not indicate whether PROJECT encountered challenges that were mainly due to the fact that the retailer engaged a university as collaboration partner. However, the project proposal included the project ambition to engage an entrepreneur after completion of the project: *“The project results will be exploited by a spin out company¹⁵⁹, using a business model designed and selected by the project team, and a collaborating entrepreneur”* (0:p.3, ATLAS.ti line 3596). The challenges encountered to

¹⁵⁹ In the other data collected during this PhD research there was no indication that PROJECT experiments might result in the creation of a spin-out company created by the end of PROJECT.

pursue action-led and iterative learning during PROJECT suggests that it might have been beneficial for PROJECT to include entrepreneurs as collaboration partners during the development of the PROJECT value propositions too.

Key insights: The project collaboration

The data suggests that academic collaboration partners are useful to capture learning during a radical sustainability-oriented innovation process. However, it might be beneficial to include entrepreneurs as collaboration partners during the development of radically new value propositions to encourage action-based and practical learning.

7.3.6 Ambition and complexity of sustainability goals

In relation to the content of the planned experiments, the data indicated that the ambition was to gradually build up in ambition and resources, which is in line with the iterative ‘lean startup approach’ (Blank, 2013; Ries, 2011): developing a large number of smaller scale experiments. However, the data indicates that up to the final month of the main data collection (i.e. September 2015), the ultimate ambition of the experiments to be completed was new to the clothing retailer and some was novel for the industry, but none was new to the world. The sustainability project goal was not articulated on an ongoing basis during the planning of the project experiments This contrasts the assertions of the literature (Alexander and van Knippenberg, 2014; Guarana and Hernandez, 2014) that interpreting a complex situation and communicating well within a team is a key element to help achieve entrepreneurial goals. The task orientation of project team has been highlighted as not unusual: “(...) there’s always a danger of people becoming just transfixed about achieving a project but not actually really achieving the goal of the project” (43A: p.3, ATLAS.ti line 387).

In the project, the failure to articulate the project goal (to reduce clothing going to landfill and to achieve this reduction fast) on an ongoing basis resulted in uncertainty about what the experiment parameters might be with regards to sustainability ambition. Academic team members were keen to have clarity on input detail of the experiments, whereas FIRM team members were comfortable to start action-led learning through project experiments. However, it was a challenge to agree goals and details for each experiment. In this planning workshop a FIRM team member gets impatient with academics who discuss experiment process detail and potential negative sustainability feedback loops associated with amending the experiment goal: “What I’m saying is that [specific part of one clothing retrieval experiment] is happening anyway [in FIRM]. So as long as we agree what we’re trying to get out of it [one experiment] I can just get on with it. Do you know what I mean? We can make that happen without you guys necessarily agreeing on details” (47D:p.11, ATLAS.ti line 3066). This mirrors the literature on sustainable entrepreneurship which advocates that corporate process

innovation may address a wider range of environmental and social issues at the same time because of better corporate processes than sustainable entrepreneurs, who have a narrower focus due to more limited available resources (Hockerts and Wüstenhagen, 2010). In general, this may be viewed as a positive assertion; however, during PROJECT the broadening of sustainability scope seemed to hinder action. Considering potential negative feedback loops of new value propositions seemed overwhelming, especially to academic team members. Towards the end of year one of PROJECT in October 2015, the sustainability benefits of project activities associated with each of the project experiments were framed in relation to the project fibre goal as well as wider social and environmental benefits. This approach was driven by FIRM and executed by the team member who spent 50 per cent of their time on PROJECT. The resulting 2-page documents were used within FIRM according to a FIRM team member¹⁶⁰.

Key insights: Ambition and complexity of sustainability goals

The data suggests that a sustainability project goal might quickly broaden out to other sustainability issues, such as social sustainability, as suggested in the literature (Hockerts and Wüstenhagen, 2010). Articulating the value creation goal on an ongoing basis (Alexander and van Knippenberg, 2014; Guarana and Hernandez, 2014) helps to maintain and increase the project ambitions.

7.3.7 Embedding entrepreneurial principles

Despite a stated desire for exploring product and service innovation outside the organizational status quo in order to address a highly ambitious sustainability goal (0), breaking out of a corporate mindset through acting like a member of the startup community was challenging for the team. This was an aspiration that was clearly articulated in workshops, meetings, and interviews, as illustrated through this quote: *“Big is best has become big is bad, because actually today being big makes you less nimble and it makes you less able to do the stuff that can happen in a small startup environment. The challenge for all of businesses (..), in my opinion, is how (..) to actually deliver innovation at a business model level which is equivalent to, if not better than, what’s happening in the small startup world”* (43: p.8, ATLAS.ti line 1791). The interviewee expressed the hope that PROJECT and the process innovation learnings from PROJECT would enable FIRM to explore business model innovations.

However, acting like a member of the startup community proved challenging for the project team members because customer discovery and customer validation was perceived as hard to do within FIRM because of the risk of making existing customers unhappy: *“Not to over exaggerate it but FIRM*

¹⁶⁰ This was articulated during an informal conversation with a FIRM team member during a chance encounter in August 2015.

is this British institution more so than others. (...) Therefore our customers and the public are so much more unforgiving of us compared to our competitors, so whenever we do something it needs to work well. We found those two examples recently like [details on two initiatives]. You look at the timescale and you go, 'Holy cow that is a bit...' (...) But the business was brave and kind of went, 'Let's just launch.' Both occasions we have been somewhat punished for it. I think it was still the right thing to do, but god we have taken a hit. If you are going to go above the radar, in FIRM it has to be the chief exec pushing it over the radar (...). If we were a different company, if I was in a different business I would definitely be doing more above the radar and I wouldn't be so worried" (49A:p.7, ATLAS.ti line 2796). The fear of engaging customers with uncertain outcomes was at tension with the desire to engage customers to explore value propositions new to FIRM. The project team meetings and workshop repeatedly articulated that the project was looking to employ a learning approach with fast iterations. The following workshop quote is an example of this: *"We are very much aware that we need to take a lean startup approach (...) we need to learn, and then set up new experiments based on that learning"* (51A: p.1, ATLAS.ti line 1059). However, the fear to engage customers got in the way of this ambition.

The ambition to embed quick iterative learning, except for some informal unplanned learning referred to in section 7.3.8, was not met up until the execution of the first experiment in June 2015. The project proposal did class customer engagement into new value propositions as high risk: *"Consumer engagement is needed for successful new models, if scale cannot be achieved then the benefits of circular models will not be fully captured. Acceptance of new models is therefore high risk and is tackled as a distinct work package which seeks to understand motivations and leverage points which might encourage committed uptake of new service provision."*(0:p.4, ATLAS.ti line 4308). Lean startup thinking also explicitly fed into the early stages of PROJECT through team presentations. However, only one project team member from FIRM had prior experience in executing the lean startup approach. The team members who had not previously applied the lean startup approach struggled with how to address the uncertainty of the radical innovation process and outcomes through (1) setting experiment learning goals and (2) agreeing which actions should be taken first to generate iterative learning.

Project team members highlighted the need for action to gain validated learning during the semi-structured interview (43A, 48, 49, 50, 58, 60A-B). However, for the interviewees the process of how to gain such validated learning varied: in the expected number of action-learning cycles; in the process of establishing assumptions to be tested; in the amount of time to be spent on each

assumption; to what degree retail customers would need to be involved; what the ultimate learning success for project experiments would look like. The planning workshops did not seem to fully remedy the disparate understanding of how to gain validated learning (e.g. 52A-B). The need for action in order to learn (Blank, 2013) was acknowledged by corporate and academic project team members – but ironically not acted upon until almost a year into the project, mainly due to (1) the confusion within the project team about the goals and content of each experiment theme and each experiment and (2) the reluctance to engage customers in new value propositions.

Key insights: Embedding entrepreneurial principles

That data suggests that a project that introduces lean startup principles will benefit from highlighting the new social and technological capabilities that are needed to implement this approach. Engaging customers is a must in radical innovation projects that look to apply a lean startup approach. The need for new organizational capabilities for radical innovation has been suggested by the literature (Chang et al., 2012; Garcia and Calantone, 2002) as has the need to create team-wide understanding of the specifics of conducting customer development (Blank, 2013).

7.3.8 Time

The pace of progress for the project experiments was perceived as slow by the retailer interviewees (43, 58, 60), even in comparison to standard corporate product and service innovation. The project delays on starting with action-based learning were perceived to reduce the possible amount of learning that could be extracted from the experiments: *“Everything is really delayed. As in, apart from [experiment event linked to other FIRM sustainability activities] which was a fixed date, (...) everything is so much later than we thought it was going to be. (...) So potentially the middle of August to actually start the [service] experiment per se. (...) So it just feels to me like we’re sleeping and it’s getting really late. (...) So the window to experiment is getting smaller and smaller. (...) you might end up having run an experiment for two weeks and I’m not sure if that’s necessarily going to be relevant. [The experiments] that need to take the longest are the [service experiments] because you need to run it for at least two months to see if people are willing to [engage over a longer period of time]”* (60B:p.5, ATLAS.ti line 2192). Academic project partners equally acknowledged the slow pace: *“(.) in an ideal way we would have started with some smaller experiments already and learned from that and set up some other small experiments and learn from that again but the pace is a bit slower than everyone might be hoping”* (48: p.5, ATLAS.ti line 1310).

The project was expected to exceed the envisaged two-year timeline, a fact openly discussed with the government funder towards the end of data collection (65). Multiple roles, creating internal buy-in and other business priorities were articulated and accepted as the reasons. The project delays and

the implication for the urgency of implementing sustainable development (Ashford and Hall, 2011; Boons et al., 2012; Martin et al., 2010) however, were not discussed. It seemed like agreeing PROJECT goals and experiment details already was too big a challenge for the team, making it impossible for PROJECT to be completed within the 2-year timeline.

The corporate timeline and slow pace of change were acknowledged, but the implications for the corresponding slow increase in fibre recovery rates were not mentioned in the data collected. In one of the early planning workshops, the importance to map project activities and actions against a timeline without imposing too much detail was proposed: *“So (..) [FIRM team member] and I met two weeks ago and we were discussing (..) using road mapping techniques. Because road mapping is something where you get people together in a room and you have a timeline, you have activities that you plot and stuff that needs to happen. (..) I think in this case it might need to be quite different from the normal road mapping technique. But it needs to be something with a timeline, so I think that’s why this is very important and already trying to map some of these activities (..)”* (47A:p.3, ATLAS.ti line 1323). However, the completion of the envisaged timeline was not achieved in this workshop. This was due to addressing the need to agree more basic details, such as how many ideas are to be explored in the four experimentation themes. This exchange illustrates the differences in the understanding of basic PROJECT facts during a planning workshop (47A-D):

“Participant 1: It seems to me that we’ve got 11 ideas.

Participant 2: Why do you keep saying 11? I thought it was 12.

Participant 1: Has it become 12 again?

Participant 2: I think [senior FIRM staff member] wanted 3 in each but a lot of the [ideas in clothing recycling theme] were similar weren’t they?

Participant 3: Yes, with the [service theme] some of them could be combined.

Participant 1: So what is the number I should be saying?

Participant 4: Yesterday we had this conversation, [Participant 5], how many of them are actually distinct ideas and how many are the ramping up of existing [FIRM efforts].

Participant 3: I think we have 3 per theme.

Participant 4: But are they?

Participant 5: More or less.

Participant 1: So for the purpose of my point let’s say 12, given that we might alter that. It seems to me that each of the 12 is worthy of a large piece of paper, an A4, which says what it is, as a reminder and, ‘This is our timeline for running this experiment.’

Participant 2: We don’t have a timeline at the moment.” (47A:p.12, ATLAS.ti line 1261)

Testing new value propositions online and without FIRM branding was seen as a way to reduce the reputational risk of FIRM. However, most team members did not have the technical skills to develop and conduct web-based customer engagement. In terms of developing new capabilities (Chang et al., 2012; Eisenhardt and Martin, 2000; Teece and Pisano, 1998) within the project and the retailer, it was clear that the technical lead- the experienced lean startup member of the team- was very stretched for time. The recruitment of a technical contractor to run an experiment relying on technical capabilities remedied this in the late summer of 2015 (61A-C): *“(..) all his knowledge gets retained and his sense of ownership; it’s just that the work is going to have to be done by another coder rather than him. It took us probably two or three weeks longer than we would have liked”* (65: p.18, ATLAS.ti line 514). However, the project team did not see the need to develop basic technical skills to be able to run small ‘incognito’ experiments for any of the four experiment themes or to further any of the individual (11 or 12..) experiments. Technical capabilities from other parts of FIRM were drawn into other project activities too, indicating that the retailer indeed found it easy to free up extra resources to pursue a triple bottom line value creation goal (Hockerts and Wüstenhagen, 2010). However, this still was not sufficient to substantially speed up the experiments needed to generate learning to further the development of radically new value propositions. Finally, project deadlines pushed action towards the later stage of the data collection, with two project sessions scheduled to address gaps in the project knowledge (63A-B, 64A-D).

Key insights: Time

The data suggests that the urgency of operationalising sustainable development (Ashford and Hall, 2011; Boons et al., 2012) is easily forgotten when trying to meet short-term project goals and other commitments in the firm. In the case study, new technical capabilities would have helped to speed up the experimental learning needed to further radical sustainability-oriented innovation activities because these technical capabilities would have enabled incognito customer engagement. However, the data did not indicate an appetite of the project team to acquire these new capabilities. Instead, new team members were added to fill the skill gaps, however this did not significantly speed up the learning.

7.3.9 Unplanned, action-based learning

The data highlighted two project mechanisms that furthered project learning. Both of these mechanisms developed without longer-term advanced planning and were action-led.

Firstly, members of the project team started to run experiments related to the resource productivity goal ‘on the side’ or in their own time outside of work. The ‘on the side’ experiments were closely

related to personal activities, and hence had personal meaning for the project team members. This mirrors the literature assertions that valuing sustainability from personal knowledge helps to build triple bottom line creating enterprises (Schaltegger and Wagner, 2011; Tennant, 2015). The learning from these ‘on the side’ experiments was not captured formally. However, the meeting and workshop recordings as well as the interviews show that the learning was fed into the project process: *“(..) those are probably pre-experiment I guess, and we need to do something more deliberate at work”* (48: p.6, ATLAS.ti line 601).

The project team also drew on learning from general observations made during life outside of work during the planning and early implementation stage of the PROJECT experiments. This learning was freely shared in workshops and meetings, for example during the discussion of clothes-sharing business models: *“(..), I have friends who have between them a bag with clothes that they share, between a group of five, and that’s their pregnancy bag”* (47B: p.26, ATLAS.ti line 2276). Hence, the organizational capability of experimentation for the project was built significantly outside of the organizational boundaries of the clothing retailer.

Secondly, the project team systematically tested customer and market assumptions for the project experiments in August 2015 (63A-B, 64A-D). In total, over thirteen hours were spent determining the commercial and environmental impacts for each of the experiments through populating Excel spreadsheets with information on market size, competitors, etc. The sessions were informal, and were attended by team members from the retailer and the university. These sessions were closely linked to overcoming the challenge of creating a wider corporate buy-in to the uncertainty associated with the experiments. In effect, the project team is now able to demonstrate to senior staff –the internal investors - that the uncertainties, risks, and potential benefits associated with the experiments have been thought about in detail: the corporate project team members gain the mandate to lead high risk activities (63A-B, 64A-D).

Key insights: Unplanned, action-based learning

The data suggests that personal motivation drives action-based learning outside of project boundaries. This is desirable and useful to happen in addition to more deliberate learning. Unplanned action-based learning will enable project members to become more confident negotiating experiments with uncertain outcomes.

7.3.10 Tension between economic, social, and environmental value creation

The project team did acknowledge sustainability feedback loops of each experiment in meetings and workshop discussions. Equally, the worry about potential negative feedback loops associated with

conducting project experiments within narrow parameters was articulated. The fear of ‘running off in the wrong direction’ due to running the wrong experiments was a strong theme in the earlier experiment planning meetings and workshops. A wrong experiment would not lead to the learning needed to further the development of the PROJECT ideas.

Rebound effects such as those explored by Figge et al. (2014) were discussed, and on some occasions led to heated discussions¹⁶¹. However, the revolutionary change needed to pursue sustainable development (Ashford and Hall, 2011) -and how the project was aiming towards such change both internal and external to FIRM (Garcia and Calantone, 2002; Linton, 2009)- was not discussed. Overall, experiments with clear economic benefits were favoured over experiments with uncertain economic benefits. This was irrespective of the potential social and environmental benefits: *“(..) there was as much tension between customer needs and profitability as there was between the other dimensions [of environmental and social value]. The lean startup says don’t worry too much about making money from day one, focus on what the customer needs and the money will come. [Whereas in a large company] you are forced to at least have an estimate of what the value might be business-wise”* (49A: p.8, ATLAS.ti line 3598).

The retailer has a strong track record of operationalising sustainable development, beneficial for a project like this according to Christensen et al. (2016). However, even so the risk associated with uncertainty of project outputs necessitated the seeking of outside funding (0, 48, 49, 50, 56A-B, 66). It seemed that this mechanism of reducing the risk for the retailer did not overcome one of the key barriers (Sandberg and Aarikka-Stenroos, 2014) to radical innovation in established companies: restrictive mindset and lack of competences, especially affecting the ideation stage of radical innovation opportunities (O’Connor and DeMartino, 2006). Financial viability of experiments was a major factor impacting how the team viewed the exploration of new products and services. Triple bottom line value creation as articulated by the literature (Dyllick and Hockerts, 2002; Schaltegger et al., 2012) was, therefore, not achieved.

Key insights: Tension between economic, social, and environmental value creation

The data suggests that the corporate mindset (Sandberg and Aarikka-Stenroos, 2014) dominated by economic value creation can block experimentation activities with high output uncertainty, even if highly promising from a social and environmental value creation perspective.

¹⁶¹ An example is shown in the section titled ‘Ambition and complexity of sustainability goals’.

7.3.11 Discarding experiments

The tensions between social, economic and environmental value creation was openly discussed after some experiments were started. The first experiment in June 2015 helped to create internal awareness of the project. However, it was acknowledged that the social and environmental value creation was not fit to meet the PROJECT ambitions. Conducting this 'non-PROJECT' experiment enabled the project team to get comfortable with engaging customers in new product and service propositions, essential for successful new business activities (Blank, 2013; Ries, 2011). The experiment was duplicated in other locations without drawing on project funding, although using the learning derived from the initial store experiment in June 2015.

Other experiments were outright rejected due to missing out one aspect of triple bottom line value creation, in this case environmental value creation in line with the project goal: *"I'm really confident that we can do that. Or at least, build a proper trial (..) if we were doing it in real life. But that doesn't prove anything. As in, that proves that this model is nice. It makes money (..) It has social value. It has community value. But it doesn't prove that less clothes go to landfill"* (61B: p.13, ATLAS.ti line 1479). In PROJECT, however, the tensions as articulated in the previous section were still dominating the majority of decisions when it came to innovation activities. The involvement of the university did allow for justification of creating learning without an immediate economic business case. However, overall the experiments conducted and planned by the October 2015 did indicate that economic value creation was priority when looking to generate learning through experiments in order to pursue the PROJECT goals.

Key insights: Discarding experiments

Some data suggested that experiments that prove unfit to meet firm specific triple bottom line value creation goals should be discarded. At the same time, process learning lessons can be useful and influence wider corporate sustainability and innovation practice.

7.4 Case study data conclusion

Key lessons were drawn from the case study narrative, as shown at the end of each discussion section. These lessons are discussed in the context of the data discussion in research phase one in the following chapter.

However, there are some 'stand-alone' findings from PROJECT case study and analysis. Firstly, PROJECT failed to ideate for and start exploring radical sustainability-oriented innovation opportunities that were fit to meet the project aims as articulated in the proposal. Secondly, the project was slowed down through the inability of the project team to have a common understanding of how the uncertainty associated with radical sustainability-oriented innovation might be addressed. Thirdly, the FIRM was reluctant to engage customers in radically new product and service propositions. Incognito customer discovery and development was done in some experiments, however the project team lacked technical capabilities, even after additional resources were freed up to increase technical capabilities within the team. Fourthly, the academic project partner was suitable to help extract learning from experiments. However, for action-based learning other project collaborators such as entrepreneurial individuals or startups might have been more suitable. Fifthly, and finally, FIRM failed to develop an organizational capability of experimentation during the search and discovery phase of PROJECT because all project team members looked to apply their existing skill set instead of developing new skills and FIRM did not allow the team the freedom needed to explore action-based learning within the boundaries of FIRM innovation process.

8. Concluding discussion

This PhD set out to research how large firms might pursue innovation activities at the speed and scale required to meet the urgency of sustainable development challenges. This final chapter offers a concluding discussion of the three previous data results, analysis and discussion chapters (4, 6, and 7).

The first literature review (chapter 3) and cross-sectoral data insights (chapter 4) led to a more detailed exploration of the process of the business response to sustainable development challenges. In particular, how individuals and firms might experiment to address uncertainty and complexity was a promising avenue for research. This promising avenue led to the review of a second set of literature (chapter 5) and the analysis and discussion of cross-sectoral data (chapter 6). At the end of this research it was clear that, in order to generate in-depth insights on how a firm might develop value propositions fit to meet the urgency of sustainable development challenges, it was necessary to follow an innovation processes over a period of time. An in-depth case study followed a project that set out to develop new value propositions with a specific and ambitious sustainability goal, with the explicit component of achieving this goal at a much higher speed than the firms track record indicated (chapter 7).

During conventional radical innovation, the key barriers to success in large firms have been identified as restrictive mindset and lack of competences (Sandberg and Aarikka-Stenroos, 2014). The competence most lacking is the 'Search' or 'Discovery' competence (Sandberg and Aarikka-Stenroos, 2014), encompassing firm activities *"that create, recognize, elaborate, and articulate radical innovation opportunities"* (O'Connor and DeMartino, 2006; p.489). Commercialisation of radical innovations takes more than 20 years for conventional radical innovation and radical sustainability-oriented innovation (Goktan and Miles, 2011; Hanna et al., 2015). This timeline is unfit to meet the urgency of sustainable development challenges that need to be comprehensively addressed by 2025 (Tegart et al., 2014).

This research links two insights from the literature to address this lack of radical innovation competence in large firms.

Firstly, the organizational capability of experimentation has been proposed by Chang et al. (2012) as the most important ability at the level of firm to succeed in radical innovation to overcome the structural inertia hindering radical innovation success in large firms. They define experimentation as

the ability “to probe, experiment with, test, and commercialize radical ideas and concepts, across R&D, manufacturing and marketing disciplines” (Chang et al., 2012; p. 445) at the level of the firm. However what this means is unclear.

Secondly, it is argued that small firms can react quicker to change than large firms, therefore address sustainable development challenges quickly (Chesbrough, 2010; Hockerts and Wüstenhagen, 2010). However large firms are likely to address multiple environmental and social issues with their activities through their sustainability management system. Hence large corporates “*strengths lies in process innovation*” (Hockerts and Wüstenhagen, 2010; p. 487) that addresses a wider range of sustainability issues.

The literature review on radical sustainability-oriented innovation (chapter 3) and the 2013 data (chapter 4) indicated that the human factor within the innovation process is the key to slowing down the innovation process. This aligns with the argument of Poole (2004) that time the human factors is the cause for time scales that go beyond the existence interval. However, sustainable development challenges are absolute and need to be addressed within a finite existence interval. People have difficulties with making decisions in complex situations (Van de Ven, 1986). The key differences between conventional radical innovation and radical sustainability-oriented innovation were that the latter includes more input and process factors, therefore increasing complexity. The uncertainty of innovation outputs is high for conventional radical innovation. The 2013 data suggests that the uncertainty is even higher for radical-sustainability oriented innovation because the number of factors in the process is increased through the aim to address sustainable development challenges. It follows that radical sustainability-oriented innovation might be slower than conventional radical innovation. All three data sets (chapter 4, 6, and 7) indicate that entrepreneurial behaviour is suitable to speed up innovation processes because it encourages fast learning cycles in order to solve problems, both at the individual and firm level. The iterative learning suggested by the lean startup approach (Ries, 2011) and the need to validate and test new value propositions with customers (Blank, 2013) seems promising to speed up the organizational innovation learning cycle (Nooteboom, 2000).

I go on to discuss the above assertions through linking the key insights¹⁶² from the three data chapters, leading to the proposition of a new descriptive firm innovation framework. The five discussion sections are written as ‘guidance’ to large firms looking to pursue radical sustainability-oriented innovation.

8.1 1: Encourage action-based learning driven by personal values

The three data sets suggest that ideation and development of radical innovation activities benefits from allowing staff freedom to pursue action-based learning. Two radical sustainability-oriented entrepreneurs (28, 29) indicated that they were most motivated by addressing the biggest problems that humanity faces. That these problems were linked to sustainable development challenges was purely because sustainable development challenges were perceived as the most important problems for humanity by these two entrepreneurs. However, all other data indicated that the desire to pursue meaningful work activities through aligning the pursuit of new business opportunities (and, therefore, innovation) with personal values was the driver of radical sustainability-oriented innovation activities. In the case of one firm in the 2014 data set, sustainable development problems were made tangible for innovation team members through personal experiences. In the research case study (chapter 7), off-site learning and learning generated through personal initiative outside the project boundaries was gained through small learning experiments team members conducted within their own time. This was essential to help the team members to make decisions and take action in order to explore novel value propositions. These personal experiments significantly built up the firm capability to explore triple bottom line value propositions outside the firm’s status quo, therefore increasing the ‘Discovery’ competence in the firm. However, in the case study the project goal of reducing the amount of clothing fibres going to landfill at a much faster and higher rate through new value propositions was not often articulated throughout the project. This means that the personal experiments were driven by personal context, indicating that the case study data aligned with the 2013 and the 2014 data set where personal context shaped which elements of sustainable development challenges were perceived as important.

¹⁶² All insights from both research phases are presented as an overview in **Appendix 7**.

8.2 2: New innovation processes are required

The personal experiments conducted by team members during the case study confirmed the 2013 data suggesting that pursuing radical sustainability-oriented innovation activities is hard for individuals in firms. However, the urgency of sustainable development challenges means that all firms in all sectors will need to explore new value propositions. Corporate innovation processes with long development times are unfit to meet the urgency of sustainable development challenges through novel combinations. The 2013 interview data is more closely related to the aspirations of the radical innovation, sustainable entrepreneurship and lean startup literature reviewed. In contrast, the case study data illustrated the desire to reinforce the corporate innovation process status: the team was looking to apply known tools and frameworks in order to deal with uncertainty. Furthermore, the team did not develop the technical capabilities at the scale needed to test new value propositions. I conclude that the case study ideation and development of innovation activities through project experiments were not fit to meet the characteristics of radical sustainability-oriented innovation synthesised in chapter 3.

8.3 3: Economic value creation as Trojan horse to pursue radical sustainability-oriented innovation

All three data sets suggested that sustainability-oriented innovation activities are perceived to be of higher economic cost than conventional innovation, irrespective of whether the innovation is radical or incremental. However, the data equally suggests that senior management in a firm must allow staff, who look to address sustainable development challenges with new value propositions, the freedom to explore these propositions - without the need to articulate the immediate economic business case. In the case study, some experiments were outright blocked by senior staff because the economic value of possible innovation outputs was not obvious in the project ideation phase. The case study insights and the 2014 insights suggest that applying the lean startup approach with its focus on customer discovery and development might enable radical sustainability-oriented project teams to 'get around' having to demonstrate clarity on the economic value creation during the ideation and development of radically new sustainability-oriented value propositions. Customer discovery and development have the purpose to explore uncertain economic value, therefore radically new environmental and social value propositions can be explored without risking that economic value creation dominates engagement with senior staff. This might be a suitable way to address the tension between social, environmental and economic value creation within firms and

secure internal buy-in for value propositions that are outside the firm innovation status quo. Instead of economic value creation dominating decisions of how to pursue iterative and fast learning, social and environmental value creation can take prominence during iterative learning with the goal to address the uncertain outcome of radical sustainability-oriented innovation.

8.4 4: Engage customers, incognito if needed

To explore business opportunities through innovation, the lean startup argues that customers need to be engaged in the early stage to make a new value proposition a valid business proposition (i.e. there is sufficient economic value to enable business activities). The case study suggested that digital customer engagement enables the testing of new value propositions without impacting an existing corporate brand. The case study and both research phase one data sets indicated that, for large firms, the risk to alienate existing customers is perceived as high. However, developing radically new value propositions with extensive customer discovery and testing will allow firms to link their existing customer base with the value propositions fit to meet the urgency of sustainable development challenges. In the case study, the firm struggled to engage its customers with radically new value propositions. A senior project team member argued in an 2014 interview (43) that the firm has a wealth of useful customer data, the case study (chapter 7) of the same firm showed that this customer data was not suitable to explore radically new value propositions. Drawing on existing customer data created, in effect, a closed learning circle and this learning circle was further reinforced through the company's focus on short-term economic value creation.

8.5 5: Chose collaboration partners wisely

Collaborations are useful to share and generate learning needed to develop radically new value propositions. This was suggested by all data sets, especially the 2014 data set. The 2013 data and associated literature suggested that practitioner and academics find it easier to act and reflect on the technical dimension of radical innovation. Aligned to the arguments on the perspective on time offered by Poole (2004), I argue that the social innovation dimension is the dimension that slows down innovation activities because it is more affected by 'contamination' from human interpretation. I argue that this dimension is the dimension can be sped up through collaboration in the radical sustainability-oriented innovation process because the right collaboration will enable faster learning during the corporate innovation process. In the case study, academic collaborators

were suitable to capture learning and this PhD thesis illustrates this point. However, in order to adopt a fast and iterative learning approach in order to pursue radical sustainability-oriented innovation, collaboration partners that are experienced in fast and iterative learning should be part to any such project team.

8.6 A new descriptive innovation framework

There is no research on how startup thinking may be used to maximise the success of radical innovation with a sustainability goal in large corporates, previous work solely explored the small vs large firm dynamics (Hockerts and Wüstenhagen, 2010). Others have linked customer discovery and validation to business model generation, however without any sustainable development dimension (Osterwalder et al., 2014). The urgent need to pursue sustainable development through corporate innovation activities makes this an important new research area. The interviews conducted in 2013 (chapter 4) and 2014 (chapter 6) and the case study presented in chapter 7 start to fill this gap in the practice of innovation knowledge through linking startup thinking, triple bottom line value creation and the organizational capability identified as most important for radical innovation success in corporates: ‘experimentation’.

I propose that the key insights from the three data sets and the lean startup approach build on Blank (2013) and Ries (2011) as the basis for a descriptive framework for radical innovation for sustainability in large firms. The framework (**Figure 34**) shows that whilst the broadening out of economic, social, and environmental value creation boundaries is acceptable and can be expected during the pursuit of radical sustainability-oriented innovation in firms, all experimentation activities must be directed towards achieving an agreed corporate sustainability goal. The boundaries specifics for each radical sustainability-oriented innovation project will depend on the sustainability problem addressed in the respective project, firm division, or even corporate innovation activity.

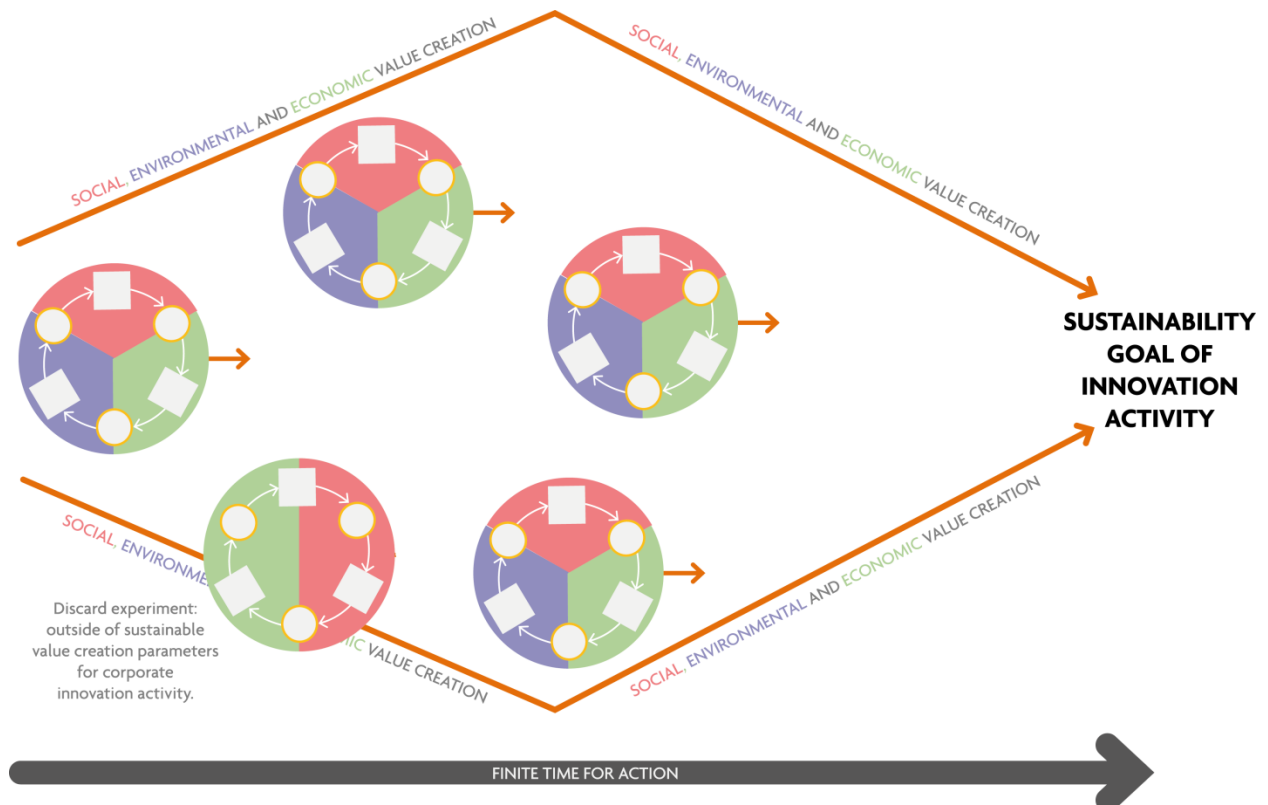


Figure 34: Urgency of triple bottom line value creation and the corporate innovation process

The framework illustrates that the problem to be solved -the goal of the innovation activity- guides an iterative learning approach. Furthermore, experiments that are outside of triple bottom line value creation boundaries fit to meet the goal should be discarded. This approach to innovation might enable established firms to meet the urgency of sustainable development challenges through innovation activities.

8.7 Summary

This research explored the practice of radical innovation with a sustainability goal from the perspective of a large firm and addressed two important research gaps. Firstly, how a firm might pursue economic, social and environmental value creation in the context of the urgency of addressing sustainable development challenges. Secondly, how startup thinking may be used to maximise the success of radical innovation with a sustainability goal in a large firm. This transdisciplinary research made a conceptual link between organizational learning, lean startup thinking, triple bottom line value creation, and organizational capabilities. A new descriptive framework based on the insights generated from the case study is offered as the basis for further

research and action. The key insights generated through this research are a starting point for large firms looking to develop the organizational capability of experimentation in order to pursue urgent sustainable development challenges.

This PhD research generated insights towards closing the gaps in the organizational radical sustainability-oriented innovation knowledge through the question: “How might organizations experiment to pursue radical sustainability-oriented innovation projects?” with three sub questions. The sub questions and the answers generated through this research are as follows:

What are the characteristics of radical sustainability-oriented innovation?

A literature synthesis presents the input, process, and output characteristics of radical sustainability-oriented innovation in chapter 3. The process of pursuing such innovation is most challenging for firms. The number of input and process factors for radical sustainability-oriented innovation is higher than during conventional radical innovation. The process of pursuing radical sustainability-oriented innovation must include a time dimension. The data presented in chapter 4 confirmed these literature synthesis conclusions.

What are the characteristics of the organizational capability of experimentation?

The literature synthesis in chapter 5 on the process of pursuing radical sustainability-oriented innovation in firms suggests technical and social competences that firms need to develop. Corroborated by the data analysis and discussion in chapter 6 and 7, these technical and social competences are the key to enable fast and iterative learning to further radical sustainability-oriented innovation activities.

How might an organization develop the organizational capability of experimentation in order to pursue radical sustainability-oriented innovation?

A firm might draw on the lean startup approach to develop the technical and social competences needed to solve the sustainable development problem to be addressed through innovation activities. This research offers key insights from an in-depth case study and a descriptive process framework.

9. Further research

This chapter presents how the insights generated through this research might be expanded and deepened in the context of additional academic literature. This is followed by a presentation of the research limitations and an auto-critique.

9.1.1 Contextualising case study insights

The case study insight of the unplanned and action based learning should be set in the context of open innovation and absorptive capacity. This research domain argues that organizations benefit from open innovation because it results in innovation activities that are faster (i.e. quicker) than pursuing innovation through internal research and development (West et al., 2014). It has been argued that exploiting information external to the organization to further innovation activities internal to the organization requires the nurturing of a special set of capabilities (Cohen and Levinthal, 1990), with technology emerging as a key enabler to absorb knowledge that is external to the business (Füller and Matzler, 2007) .

Another key insight from the case study is that the case study experiments benefitted from the learning and insights drawn from privately conducted experiments. These on-the-side experiments were not officially part of the corporate innovation activities. This finding should be set in the context of the shadow-track approach observed by Loorbach et al. (2009). Furthermore, this case study insight might be explored and contrasted with the arguments of the 'shadow-track' literature in the context of organizational complexity as explored by Stacey et al. (2000).

9.1.2 Technology push and market pull

Schumpeter (1934) takes the position of the technology push innovation perspective that advocates that increasing resources into research and development increases the output of new technologies (Hanna et al., 2015). In contrast, this research found that adopting a customer pull perspective might enable firms to overcome inertia and pursue radical sustainability-oriented innovation. Revisiting the arguments of the technology push perspective will enable the detailed contrasts between these two positions. A starting point might be setting the role of the market pull and regulation for technological innovation (Ashford and Hall, 2011) and the implication for the policy landscape (Teece, 1986) in the context of pursuing innovation activities with a sustainable development goal.

9.1.3 Financial research priorities at the level of the firm

Analysing research and development spending in industries should be explored as an indicator of willingness to invest in the 'discovery' ability at the firm level. This might help to identify which industries are well placed to pursue radical innovation already, and which industries would most benefit from experimentation for sustainability to break down the uncertainty associated with new product and service value propositions. Others have started to put research and development spending within businesses in the context of knowledge creation (e.g. Denicolai et al., 2016), this exploration would further this new research direction.

9.1.4 Linking the level of the firm to the macro level

This research found that pursuing radical sustainability-oriented innovation in firms benefits from adopting an entrepreneurial process. How policy may enable entrepreneurship within organizations and institutions (Stam and Nooteboom, 2011) would be interesting to link to this exploration. This would enable to link innovation activities at the level of the firm aimed at solving a specific sustainable development challenge with the sustainable development challenges addressed through institutional activities. This might be suitable to co-ordinate radical sustainability-oriented innovation activities at the meso level of the firm with the macro level of the government.

How small startups can form innovation networks (Larson, 2000) to deliver radical sustainability-oriented innovation may be contrasted with the input and process characteristics of pursuing radical sustainability-oriented innovation in large firms. This can help to explore the summary conclusion offered by Schaltegger and Wagner (2011) that large firms may open up mass markets to radical innovations through being fast second.

9.2 Research limitations

This section reflects on the methodological limitations of this research. Throughout this thesis, I aimed to demonstrate that this transdisciplinary research had outcomes in the three spaces that are deemed as indicators of high quality transdisciplinary research by Mitchell and Willetts (2009):

1. *Clarity on the problem space*: the gap between current speed (and goals) of business innovation activities and the urgency of sustainable development challenges
2. *Peer reviewed knowledge*: parts of this research have been published in a peer-reviewed academic journal (Weissbrod and Bocken, 2017). The co-author did feed into the structure of

the paper but was not involved in the data analysis or the detailed development of the framework.

3. *Transformational change within the researcher and learning by research subjects*: without the PhD research I would have no in-depth understanding of innovation activities with the goal to address urgent sustainable development challenges in firms. The case study firm gained learning when I shared the insights of the case study. Because I did not set out to change the innovation processes of any of the interviewees or of the case study firm, transformational learning of the stakeholders (Mitchell and Willetts, 2009) was not achieved through my research activities.

I go on to present limitations of the research design and the approach taken in this research.

9.2.1 Research design

The research methodology and conceptual framework evolved during the duration of this transdisciplinary research. This is an indication of transdisciplinary qualitative research according to Mitchell and Willetts (2009). The two research phases of this research aimed to narrow down the problem space and knowledge contribution. However, the second part of Research phase 1, the semi-structured experimentation interviews conducted 2014-15, mainly served to confirm the insights generated through the first part of Research phase 1. Some new process insights were generated, however in hindsight it might have been more suitable to explore the process challenges of pursuing radical sustainability-oriented innovation in large firms through a case study straight away.

The 2013 data collection indicated the need to engage with the individuals leading lead radical innovation projects aimed at addressing sustainable development in an informal manner and over time periods that last longer than the duration of a PhD. Chang et al. (2012) acknowledge the limitations of their survey based research into organizational capabilities to further radical innovation projects: *“This paper’s measurement of radical innovation performance is far from perfect. The time from incubation to the launch of radical innovation could be years or decades. It might be very fruitful to include the wider and long-term measurement of radical innovation in future research”* (Chang et al., 2012; p. 450). The need for more longitudinal studies to explore radical innovation and the people pursuing radical innovation has also been asserted (O’Connor and McDermott, 2004), mainly due to the uncertainty of outputs associated with radical innovation projects.

Starting a case study earlier than achieved during this case study would have allowed the exploration of process challenges in more depths, ideally through additional process observations and recordings. In the case study conducted, this way of data collected allowed for the most salient

insights. Sometimes these insights were in contrast with the process accounts provided by interviewees, for example the way the case study firm tests new value propositions with existing and potential customers. However, an earlier case study start would have necessitated the need to secure an appropriate case study and the case study chosen for this research is, to date, still the sole corporate innovation project¹⁶³ that seems suitable to research how a large firm might develop the organizational capability of experimentation in order to pursue radical sustainability-oriented innovation.

This research was conducted with qualitative methods. In year one, I explore a quantitative research approach. Prior to attending the innovation conference in Boston in 2013, I prepared a questionnaire that built on the research of Ford and Probert (2009). However, when trying to use the questionnaire as basis for interviews with three conference delegates, it became clear that the answers were not possible to capture through a questionnaire format. My subject knowledge was, at that stage, not sufficient to ask narrow and appropriate questions to generate knowledge fit to meet the problem space for this research.

9.2.2 *Unsuitable research collaboration partner*

The experimentation research process indicated that an interest other than of academic nature between the researcher and the research subjects is not ideal. In the case of the interviews facilitated by the SDAO in 2014, their organizational priorities came before approaching interviewees suggested by myself. This meant that when asking people for interviews, the contact email included information about other subjects. This is understandable because the first priority of the SDAO is to engage their corporate partners in their own initiatives. Other data collected during this research indicated that the choice of interviewee, and direct contact between the researcher and the research subject resulted in data that more suitable for analysis in light of pre-determined research questions. Hence the case study research was not conducted with any third party outside the academic and research subject communities. For the 2014 experimentation interviews, however, the data set was not ideal¹⁶⁴.

¹⁶³ Of course, there are likely to be projects outside of my research network that might be appropriate to research the problem space of this research.

¹⁶⁴ In fairness, some of the interviewees I suggested were approached by the SDAO but did choose not to engage in this research.

9.3 Auto critique

This section reflects on how I might consider doing this research if I had the chance to do it again, in the light of the things I learned during the last four years.

Systems science and the complexity and uncertainty components of radical sustainability-oriented innovation are closely linked. This research could have drawn explicitly on systems science and interconnected factors, with the view to enabling firms to identify leverage points suitable to address sustainable development challenges. I engaged with systems thinking for the first two years of this research, however made the choice to focus on generating actionable research insights for the practitioner community. In my view, the urgency of sustainable development challenges makes this, still, the only viable possibility for the focus of this research. However, engaging deeper in systems thinking might have enabled me to explore the contrast between radical sustainability-oriented innovation and conventional radical innovation in more depth.

Engaging the 2013 interviewees might have been a fruitful avenue for further data collection to address the research problem space. One of the radical sustainability-oriented entrepreneurs from the 2013 data set offered to be a research case study; however I did not follow up with this interviewee. Another leading entrepreneur asked for a proposal for a follow up case study. Both case studies would have allowed me to explore how entrepreneurial practice impacts sustainable development challenges at the systems level. However, the 2013 data indicated that their individual character traits were at the heart of their success. I talked to employees at both of their respective firms and both were viewed as 'heroes'. Being uniquely 'driven' was considered to be essential for the success of their respective companies. This echoed the 2013 interviewees that referred to Steve Jobs of Apple as driver of radical innovation. However, I think that cultivating charismatic entrepreneurs in the short time available to address sustainable development challenges is not a viable path to change innovation practice in existing firms. The experience with the two entrepreneurs in 2013 and personal experience with other entrepreneurs means that a significant part to this research would have needed to explore individual psychology and how to influence this. I did neither have any knowledge nor enthusiasm for learning about how individuals might be manipulated to become driven enough to view problem solving through business activities as their

purpose in life¹⁶⁵. I therefore chose to engage practitioners from firms that were looking to pursue radical sustainability-oriented innovation in order for the firms to exist in the longer term.

The gender aspect of entrepreneurial beliefs was highlighted in the reviewed literature (McGrath et al., 1992). In retrospective, it would have been interesting to explore this assertion in more detail and I feel that, perhaps, I gave up too quickly in exploring this aspect of entrepreneurial behaviour. The 2013 interview process also indicated that gender impacted the research process. The transcripts and the interview notes indicate that all interviews were conducted professionally. This is corroborated by the Reflection Diary. However, three male interviewees followed up the interview with private enquiries to meet up, sent from the private email accounts of the interviewees. I informed my PhD supervisor about these emails because they made me uncomfortable during the data collection process. Furthermore, these private emails strengthened the argument for conducting all further research in formal settings. It would have been interesting to explore how the 'masculine' beliefs of entrepreneurs affect the choice to pursue high risk business activities and contrast data insights with the values-driven nature of sustainable entrepreneurship. Possibly whilst using the experience of being a female researcher as context to the data narrative.

Finally, at the intersection of practice and academia, the perception of how lean startup methods might be applied within large firms has evolved since the data collection for this research started in 2013. This is an extension of the corporate entrepreneurship domain. Academics that have started to research this space include Rita Gunther McGrath. Furthermore, there are now consultancies that specialise in helping organizations to overcome inertia and explore radically new products and services with the view to create new markets and new capabilities at the firm level (e.g. mach49.com). Ideally, the latter stage of this research would have tapped into these new developments. However, these new developments are based on a linear view of business activities with full focus on economic value creation. This research might have missed out on data and knowledge at the cutting edge of embedding startup principles into business. However the urgency of addressing sustainable development challenges and embedding this into corporate innovation processes was, for me, a non-negotiable during conducting this research.

¹⁶⁵ Both of the entrepreneurs pursuing radical sustainability-oriented innovation were very clear that their businesses were an essential part to their purpose in life. For example, one of the entrepreneurs compared choosing one of his businesses to survive to asking a parent to choose between two children: *"the idea of letting 1 of them die was just, I could not end that idea. It was, I feel like sort of asking someone which of your children should die. You know, it's really difficult to say 'Oh, pick that one'. (...) it's tough [because when] I try to make both of them survive, I reduce the odds of either of them surviving. So there was a conscious choice there to make."*

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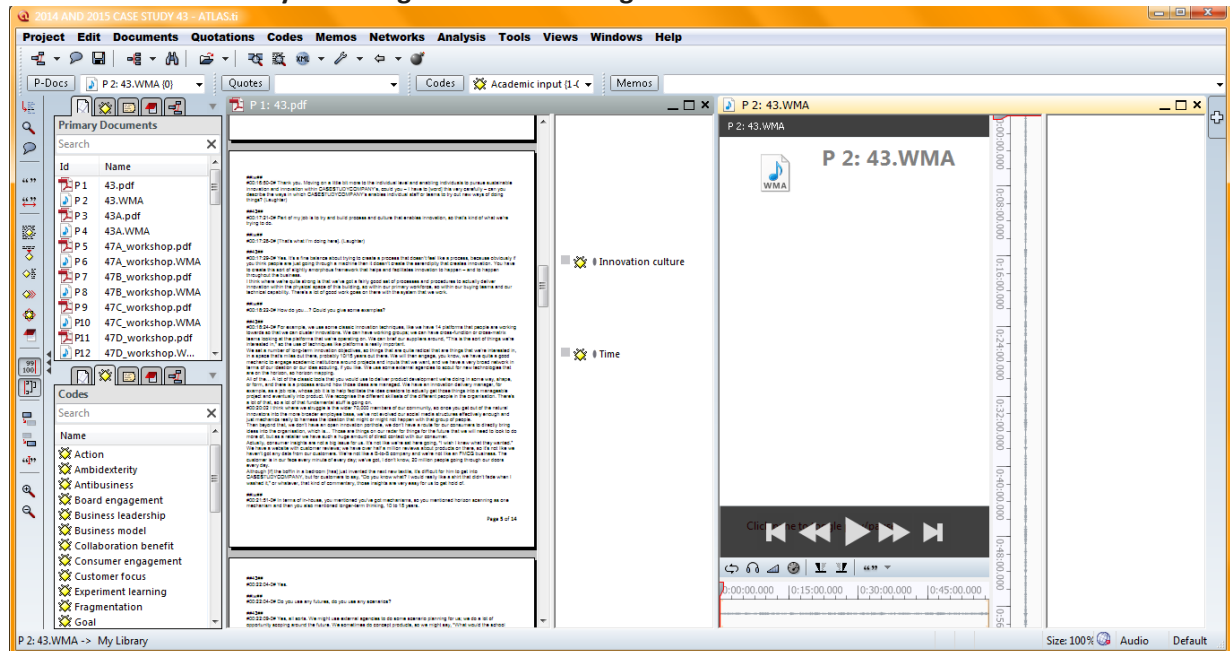
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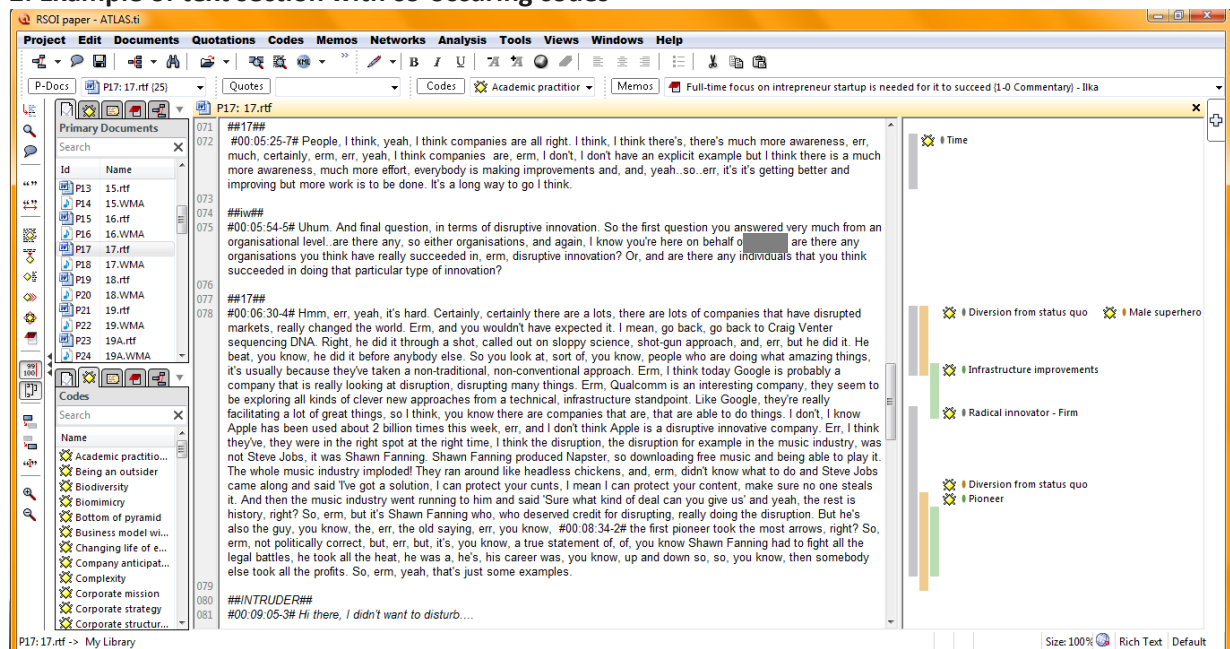
11. Appendices

11.1 Appendix 1 - Examples of data analysis in ATLAS.ti

1: Text and audio analysis through inductive coding



2: Example of text section with co-occurring codes



3: Co-occurring codes of interviews when exported to a Word document

ATLAS.ti Cooccurring Codes HL: 2014 Experimentation File: [C:\Users\jw100\Desktop\ATLAS 2014 EXPERIMENTATION\2014 EXPERIMENTATION.hpr7] Edited by: ilia Date/Time: 2015-10-15 20:10:32 Total number of codes: 48 Breaking BAU - context specific mindset (4-0) [2] Cross-functionality (12-0) [2] Experimentation Success (5-0) [2] Breaking BAU - external experts (11-0) [2] Collaboration need (13-1) [2] Futures thinking (8-1) [3] Breaking BAU - off-site (8-0) [3] Experimentation Success (5-0) [4] KILLER QUOTE (23-0) [3] Firm innovation structure (12-0) [2] Business case for SD evolving (6-0) [7] Business case for unknown territory (5-0) [2] Business Culture - Flexibility (6-0) [3] Competition as business driver (4-0) [2] Cross-functionality (12-0) [2] Need for experimentation culture & techniques (14-0) [2] Social impacts (4-0) [4] Sustainability - right thing to do (5-0) [2] Business Culture - Flexibility (6-0) [5] Business case evolving (6-0) [3] KILLER QUOTE (23-0) [5] Need for experimentation culture & techniques (14-0) [3] Organizational Innovation Management (12-0) [1] Radical SDI - Technology (2-0) [2] Business Culture - org innovation (9-0) [4] Cross-functionality (12-0) [1] Innovation NOT sustainable Innovation (5-0)	KILLER QUOTE (23-0) [6] Firm innovation structure (12-0) [4] Business leading consumers (8-0) [7] Business case for unknown territory (5-0) [2] Exec reporting (9-0) [1] KILLER QUOTE (23-0) [2] Need for experimentation culture & techniques (14-0) [2] Profitability (12-0) [2] Radical innovation (4-0) [2] Sustainability - right thing to do (5-0) [3] Collaboration need (13-1) [9] Breaking BAU - external experts (11-0) [2] Business case for unknown territory (5-0) [2] Competition as business driver (4-0) [2] Futures thinking (8-1) [2] KILLER QUOTE (23-0) [2] Firm innovation structure (12-0) [2] Personal appetite for learning (3-0) [2] Sustainability expertise - external (4-0) [2] Urgency (3-0) [2] Competition as business driver (4-0) [5] Business case evolving (6-0) [2] Business case for unknown territory (5-0) [2] Collaboration need (13-1) [2] Social impacts (4-0) [2] Sustainability - right thing to do (5-0) [2] Complexity (7-0) [5] Cross-functionality (12-0) [1] KILLER QUOTE (23-0) [2] Need for experimentation culture & techniques (14-0) [2] Present day challenges to make sustainability tangible (10-0) [1] Visual engagement (1-0) [2] Exec reporting (9-0) [5] Business leading consumers (8-0) [1] Internal leadership (6-0) [1] Profitability (12-0) [2] Urgency (3-0) [2]	Fast staff turnover (9-0) [2] Sustainability expertise - external (4-0) [2] Futures thinking (8-1) [4] Breaking BAU - external experts (11-0) [3] Business case for unknown territory (5-0) [2] Collaboration need (13-1) [2] Organizational Innovation Management (12-0) [2] Innovation NOT sustainable Innovation (5-0) [1] Business Culture - org innovation (9-0) [1] KILLER QUOTE (23-0) [17] Breaking BAU - off-site (8-0) [3] Business case for unknown territory (5-0) [2] Business Culture - Flexibility (6-0) [5] Business Culture - org innovation (9-0) [6] Business leading consumers (8-0) [2] Collaboration need (13-1) [2] Complexity (7-0) [2] Cross-functionality (12-0) [4] Experimentation Success (5-0) [6] Internal leadership (6-0) [2] Need for experimentation culture & techniques (14-0) [11] Firm innovation structure (12-0) [7] Personal value (6-0) [2] Profitability (12-0) [4] Radical innovation (4-0) [2] Social impacts (4-0) [2] Firm innovation structure (12-0) [11] Breaking BAU - 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right thing to do (5-0) [2] Sustainability - right thing to do (5-0) [7] Business case evolving (6-0) [2] Business case for unknown territory (5-0) [2] Business leading consumers (8-0) [3] Competition as business driver (4-0) [2]
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4: Co-occurring codes of 2013-14 radical sustainability-oriented innovation interviews – detail example

Access to knowledge {1-0} [2]

Innovation goal {13-0} [2]

43:4 and then the internet one was just, erm,...

29:6 in fact in in College I actually [LAUGH]...

Technology {13-0} [2]

43:4 and then the internet one was just, erm,...

1:5 to anyone using the internet..that, erm,...

Perseverance {3-0} [2]

Diversion from status quo {16-0} [2]

34:2 They didn't understand what was in my he.. (42:60):

34:11 Actually we see people come who think th.. (59:60):

Spirituality as driver of sustainability {8-0} [4]

34:2 They didn't understand what was in my he.. (42:60):

34:3 I would agree with that, yes. It's defin.. (72:72):

34:10 It's definitely about not needing the su.. (72:72):

34:11 Actually we see people come who think th.. (59:60):

Increasing consumption {4-0} [4]

Customer collaboration {6-0} [1]

11:9 Because who the fuck cares about new if .. (55:57):

Innovation goal {13-0} [2]

43:1 Well, erm, I'm not exactly sure, erm, in.. (35:39):

43:8 we clearly need -on the on the energy si.. (37:39):

Innovation space outside corporate structure {16-0} [2]

11:8 Everybody downstairs talks about innovat.. (57:57):

11:9 Because who the fuck cares about new if .. (55:57):

Sustainability goal {10-0} [2]

43:1 Well, erm, I'm not exactly sure, erm, in.. (35:39):

43:8 we clearly need -on the on the energy si.. (37:39):

11.2 Appendix 2 – 2014 Experimentation interview template

Aim

Explore organizational capabilities to enable transformational change with a view to

[1] produce a SDAO best practice report and

[2] feed into PhD research on radical innovation for sustainability.

This interview is confidential. Any directly attributable quotes shared through publications will be sent to you prior to publication for sign-off.

Please briefly introduce your background

Is sustainability perceived as a risk or as an opportunity within your organization?

- How are sustainability initiatives linked to innovation initiatives in the organization
- How is materiality of sustainability issues embedded within the organization

Does your organization foster intrapreneurship?

- Can you describe the ways in which your organization enables individual staff or teams to try out new ways of doing things
- What financial resources are available at what levels of the organization

Are you able to remove yourself and your business unit from business as usual?

- Are you asked to prove profitability of a strategic or product experiment
- How are you defining emerging and new industries in your organization
- How can you depart from the core business activities, either in mind or through team activities / What is the benefit of doing this
- What enables you to do this

11.3 Appendix 3 – Case study observation diary extract

Pre-workshop materials

All participants received a box of gifts that contained a mixture of media and information to ‘engage all your senses and get you in the mind-set before the workshop’. The workshop aims were communicated to participants as ‘It’s all about getting out, teaming up and opening your mind to new exciting ideas to address the current issues with achieving sustainability in clothing’. It was clearly communicated that the exercises and information in the box of gifts would be used in the workshop.

The box contained a mixture of normative futures thinking; current clothing-related sustainability challenges; examples of product innovation and business model innovation outside and inside the clothing industry; and storytelling techniques. Also included was a bottle of sparkling wine, popcorn and a PROJECT quiz. The front of the quiz stated ‘There are no shortcuts to an unknown destination. But it doesn’t mean it’s not out there.’

The materials were thoughtfully put together: they felt engaging, substantial in information and had a sense of playfulness. The materials also did not seem to advocate any particular product or service ideas or business model as more valuable than others. Neither did they seem FIRM branded apart from the sparkling wine, the popcorn and the reusable shopping bag.

Participants received this parcel prior to the weekend before the mid-week workshop, hence had the opportunity to dip into the materials in their own time. As contribution, participants were asked to survey their own wardrobes according to items of clothes (their age and how often they are worn) and send a photo of their oldest item of clothing and information of how long they owned the item. The instructions asked participants to return the provided electronic template to an FIRM contact early in the week of the workshop.

Conclusion

The pre-workshop materials seem to enable workshop participants to see beyond FIRM as a clothing provider through high street shops and online retail. After using and experiencing the materials I expected them to be used in the workshop and contribute to the search for radical ideas.

Day 1 observation protocol

Participants arrive and take refreshments in the foyer of the workshop venue. There is little or no telephone reception but good Wi-Fi access. At around 10:30 we enter the workshop room: large and airy, fully set up before the delegates arrived. Music is playing when participants come into the room. There is a stage with 6 flip charts in front of it and to the right of the stage there are some clothing manufacturing related materials. There are 3 tables on both long sides of the room for 6 teams in total; clothing hangs at the end of the room from a mobile stand. There is 1 main facilitator and 1 facilitator assistant.

The participants sit down and after a very brief introduction the main facilitator shows a slide that divides the room into teams. This is done according to the colours of the clothing pictures they sent with their workshop preparation. I sent in a photo of a black jacket and am allocated to Team Light Blue. Other participants laugh and articulate a similar disconnect between what they sent in and the team they are finding themselves in. We move to our allocated team tables. There are FIRM mens t-shirts on the tables in the team colour. Some people put these on immediately; others do so during the course of the morning. Participants do not receive any communication about the t-shirts other than the main facilitator saying: “There are some t-shirts for you to wear.” Some workshop

participants do not wear the t-shirts on either day, some wear them for 1 day, and some wear them for both days of the workshop.

All participants are given booklets to capture any thoughts/ideas during the workshop. We are told that the booklets will be collected at the end of the workshop to harvest any ideas that might not be verbally articulated in the workshop. The books also contain post-it notes for bean stalk displays behind each of the team tables.

The PROJECT briefing is provided by the main facilitator with the aid of Power Point slides. During the presentation the room is darkened. The framing does not make clear what radical innovation is in the context of PROJECT. 'Radical' is mentioned on the slide but is not explained any further. The main facilitator is introducing the project aims, and about 1/3 of the delegates jot down the aims in the notebooks. ##43## asks the main facilitator to switch off the music. Some use other means than the notebooks provided to capture the aims [iPad, own notebook]; others are just listening. At this point the main facilitator says he's not here to capture first and second idea but wants to get the room to do deeper thinking. It is not explained what first and second ideas are, nor why they are not valuable for an ideation process. There is silence in the room as this point.

The main facilitator asks the participants to articulate their expectations for the workshop. They are as follows:

Team Bright Blue

PARTICIPANT 1 – meeting new people outside the business, learn something different

PARTICIPANT 2 – unexpected ideas through multi-disciplinary group

PARTICIPANT 3 – ideas on how to stimulate cultural and behavior change

PARTICIPANT 4 – scary ideas that have no track record in FIRM

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Images taken:



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END OF OBSERVATION PROTOCOL EXTRACT

11.4 Appendix 4 – Informed consent for data collection

Recording this meeting for PhD research purposes

Hello,

I am a PhD student at Imperial College London and receive my funding through the EPSRC Centre for Innovative Manufacturing for Industrial Sustainability and a materials budget from Climate-KIC, a Knowledge and Innovation Community of the European Institute of Innovation and Technology.
[Sentence removed to allow anonymity of PROJECT and FIRM]

I have interviewed PROJECT team members, recorded and attended workshops and meetings, and have access to the project website hosted by FIRM. **All of my data is kept confidential and transcripts or attributable transcript quotes are not shared in academic publications without written consent from FIRM.**

Please note that I am paying for the transcription of this workshop out of my own research materials budget.

My PhD research explores how organizations create the space for experimentation to further radical sustainability-oriented innovation. Please do not hesitate to contact me if you have any queries regarding data use.

Ilka Weissbrod

Contact:

[DELETED FOR PRIVACY]

11.5 Appendix 5 – 2014-2016 Case study interview template

Articulate at the beginning of interview

No materials were shared prior to the interview

No questions were shared prior to the interview

The transcript will be shared with the interviewee if desired

This interview is confidential and no quote/insight/opinion will be shared with other project members

Questions

Please introduce yourself

Please describe how PROJECT was started.

Who was involved in the project inception? What were their respective roles?

What was the rationale to seek government funding for PROJECT?

What collaboration partner did lead on the government funding? What is the reason for this?

How is the money split between the delivery partners, has the original project plan been followed?

Please describe the sustainability goals of PROJECT.

Do you use mechanisms to keep the sustainability goals of the project at the forefront of project goals? If yes, please describe these mechanisms.

What do you think have been the major changes to the original project plan and the current project reality? Please describe these changes.

Please describe the current project phase of PROJECT.

What makes a PROJECT experiment an experiment?

Can you describe what success looks like for the PROJECT experiments?

Can you describe what you perceive as the most stretching PROJECT experiment?

Who or what is the driving force of the experiments in the current project phase?

Is there any big danger for the experiments at this project stage in your view?

11.6 Appendix 6 – Chapter 4 text extract examples

1st-order code • “Extract of coded text section”	2nd-order codes
Company anticipating market need • “(..) historically (Apple) had the vision of looking ahead and looking at things that people didn't necessarily know they wanted and still forged ahead developing those” (2: p.3, ATLAS.ti line 100)	Indicators of radicalness
Corporate mission • “When it comes to Mission Statements, a lot of people think it comes from the top (..) what I think this fellow (IBM CEO) has done is sort of found what's at the heart of every IBM employee and just found a neat way to articulate that (..) radical innovation for them is going from a company that used to just make business machines (..) to a company that now wants to make the planet smarter. And it's pushed them into all kind of business they wouldn't have thought of otherwise. (..) it doesn't come without sacrifice. (IBM) had to sell off a lot of pretty profitable businesses like their PC unit because it didn't fit into this 'Why'.” (1: p.2, ATLAS.ti line 50)	Indicators of radicalness
Corporate strategy • “you want to set that strategy upfront that it is going to be sustainability-based innovation. You're going to do something different than what you had in the past and (..) that's something you're going to put into your business operating principles. (..) your values have to be sort of defined and established and bought into by everybody in order for it to happen. Otherwise it won't happen, people will just go back to do what they're comfortable with. (..) it has to really be integrated into the company's philosophy, values and operating principles ” (17:p.2, ATLAS.ti line 60) • “one of the things management does, it provides a taxonomy” (9:p.6, ATLAS.ti line 75)	Indicators of radicalness
Customer collaboration • “(..) what's so aspirational for me and what we do, and how we're doing it. That we're trying to look deeper into human beings, and understanding them. Really understanding them so that we can meet them in a kind of better place. (But) who's really doing that? It seems like we're in it for how we can make a buck, and let's bang stuff out” (13:p.5, ATLAS.ti line 88) • “he (refers to fictional ideal firm leader) listens to customer requirements for making a better world (..). The customer does not know very well the thing they do behind his eyes. I think he has a dream they share with the customer, but not only decides for his benefit. He is thinking about his customers too for benefits or requirements that the customer doesn't need yet, but he tries to do these requirements before the customer (has to) ask for them” (12:p.2, ATLAS.ti line 64)	Indicators of radicalness
Distance • “(..) breakthrough innovation is doing something that's not near sustaining innovation, which is sort of doing things that just keep your core business going (..) I say, where the amount of (business) functions that have to be innovated, in order to be successful in that business, determines if it's radical innovation or sort of sustaining or adjacent. (17: p.2, ATLAS.ti line 46) it has to be important also the target customer. But what might be important to one target customer might be easy for one company to deliver because it's closer to the core business. Versus another company, which has to change 4 or 5 different functions to go after it (the opportunity) (17: p.2, ATLAS.ti line 48). • “Radical innovation is something which is greenfield innovation. It means you don't have any track record in the product, you don't have any selling track record of the product you want to prepare and you don't really know how it might succeed. Yeah, so probably this is the radical one.” (3: p.1, ATLAS.ti line 15)	Indicators of radicalness
Need to learn new process in firms • “(..) the 1 thing that is often overlooked (..) (is that) this new business, this disruptive innovation is just going through the same pipes and the same process that everything else goes through, if you try to squeeze it in, chances are that it's going to fail. And if you don't do it differently, it is going to fail. That's the 1 difference, the 1 insight, the 1 skill, that's successful innovation teams are able to do to increase the chances of success of their disruptive innovation.” (17: p.6, ATLAS.ti line 102) • “radical innovation would be something that somebody has to learn. It's not enough that it uses technology in a new way” (31: p.2, ATLAS.ti line 52)	Indicators of radicalness
New combinations of things • “Radical innovation, wow. I think that it's all new, new combinations of things that create something brand new to the world.” (13: p. 2, ATLAS.ti line 33) • “I think the people who have succeeded in (changing the way things work) the most, are those who bring together 2 areas of study that have not previously been thought of together. Maybe that..is actually..from an outside point of view what radical innovation looks like. It's taking insights from 2 different places or more, or multiple place where people have done prior work but haven't thought of them together yet. (..) Nicholas Negroponte, even though I disagree with his ideas a lot how	Indicators of radicalness

1 st -order code • “Extract of coded text section”	2 nd -order codes
education should be done, is an example of somebody who has changed the way that we're moving toward producing educational environments.” (4: p.2, ATLAS.ti line 59)	
Outside accepted parameters • “(..) there is innovation and that there's innovation. (..) non-radical innovation and then (..) radical innovation is really paradigm shift. (..) it's innovative but it's radical in a way that has not been conceived or accepted before. The world after that event or thought of vision happens is fundamentally different than the world that is fundamentally different than the world before then. (..) I think in a lot of situations we're not good at recognising even when they're occur that the innovation was radical until maybe a 1000 years later. (..) we're not always the best judges of when something radical has happened because we're too human to assess the implications of something over the span of lifetimes that exceed our own.” (11: p.1, ATLAS.ti line 30) • “(..) bringing together diverse perspectives, trends, insights, to create something that is beyond the normal progression of what's here today. For example, if you have a radical product innovation, then it would be a product that is not a successor to products that are currently in the marketplace, but something completely new that inevitably brings together maybe technologies that exist or other products that exist but transforms it into something that feels fundamentally different.” (10: p.2, ATLAS.ti line 73)	Indicators of radicalness
Pioneer • “That's Standing Bear when he went to trial. He was the first Native American to file habeas corpus and become a person by law. (Beforehand) they were less than citizens. (..) they couldn't do anything. You'd shoot an Indian before then, it was 'Just shot an Indian now.' Indian, coyote, whatever.” (19: p.1, ATLAS.ti line 19) • “(..) the old saying, the pioneer took the most arrows, right? Not politically correct, but a true statement (..) (Napster founder) Shawn Fanning had to fight all the legal battles, he took all the heat, his career was up and down, then somebody else took all the profits.” (17: p.3, ATLAS.ti line 78)	Indicators of radicalness
Radical innovation is not defined • “If I brought to Intel a radical technology that would allow them to make mobile chips better, they're not into mobile chips. So that's a radical innovation but with a value proposition different. And the risks would be different, so I think just asking a question concerning radical innovation (or) the term radical innovation I think is a confusing term.” (9: p.2, ATLAS.ti line 21)	Indicators of radicalness
Technology • “(..) in very recent history from an evolutionary standpoint, just over the last several 1000 years there've been many cases of civilisations achieving a technology level and then..falling back to some much lower level technology.” (29: p.2, ATLAS.ti line 55) “things would go from (..) where we had to go to a library to learn things (to) where you could immediately have access to any of the world's information from anywhere. (..) that's like humanity acquiring a nervous system” (29: p.2, ATLAS.ti line 65) • “(..) there are other technological frontiers that are being sought after. For example ethanol fuelled engines for aeroplanes. Embraer Air already have some models that are flex fuel. Can you think about a passenger aeroplane that runs on ethanol? It's extraordinary.” (16: p.15, ATLAS.ti line 310)	Indicators of radicalness
Biodiversity  (20, ATLAS.ti 59:2081) • “(..) my father, being a marine botanist, he was in the sea. I remember my father using the word and the phrase “global warming”. And this was in 1947. But this very, very small number of scientific communities that were starting exploration and trying to begin to catalogue and save our plants and our animals when there were still exploration to happen, they could already see it. They could already see the damage (of climate change).” (22: p.19, ATLAS.ti line 334)	Sustainability framing
Biomimicry • “(Interface) said, ‘We're innovating in our product from this biomimicry point of view’ it allowed for a really nice product that was easy to install, that really reduced waste, had this great impact to the	Sustainability framing

1 st -order code • “Extract of coded text section”	2 nd -order codes
bottom line. (...) it's only five years that they went from (...) 60% or more of their product was virgin materials and they had high levels of waste, to where now they're trying to develop new channels and new sources of material, because their whole way they acquire product is different. (...) they're buying up all these fishing nets from all around the world, because it's a great source of nylon (...) and [they're] developing new industries. (7: p.2-3, ATLAS.ti line 62)	
Finite resources “(.) it has to do with the fact that ideas or applications exit in the real world and that real world has constraints and that the majority of those constraints really have to do with resource limits. And so this idea of sustainability to me has to do with the fact that the consumable nature of resources means that we can't just do whatever we want for any economic purpose without thinking about the real cost. Even if that idea is innovative or even radically innovative that has to be put, or appropriated, into this context that is responsible”(11: p.2, ATLAS.ti line 47)	Sustainability framing
Life cycle thinking “We're starting to get into the understanding of the life-cycle of our products and how people are interacting with those products over a long period of time. People are seeing opportunity in it in ways that they wouldn't have considered five years ago”(7: p. 2, ATLAS.ti line 64)	Sustainability framing
Triple bottom line “I think you mean it or your question is going in a different direction, which is innovation for the purpose of sustainability. I would take to mean it's innovation that targets the triple bottom line, as in so it's not innovation purely for the sake of making money but for enhancing the social welfare of our community and for the world around us, the environment”(10: p.2-3, ATLAS.ti line 98)	Sustainability framing
Natural resources “land was opening up and it was strictly a business opportunity. Sadly our early people that moved out here was all about either starting a life of their own or straight greed and a lot of greed. (...) we wiped out the grasslands within 30 years (...) 30 years is not very long (22:p.19, ATLAS.ti line 322) “they get tired of travelling, “Let's stop here.” There's a creek that runs right here, so plenty of game, plenty of fresh water; it's a direct route across the state (...)there's a lot of gold in the Black Hills still today, so a lot of people stopped and settled for that reason” (21:p.4, ATLAS.ti line 142)	Sustainability framing
Susty is context dependent “(.) when you start talking sustainability my gosh, it spans across so many different types of people in so many different contexts. So like I said, I don't know that space very well but that's what comes to mind” (13: p.6, ATLAS.ti line 51) “(.) you got two words that don't really mean anything consistently across context, and you are asking it outside of context. There's no way I'm gonna be able to make sense (...) Radical, let's say for this conversation, means outside the expected parameters. (...) It's beyond the boundary of what's accepted as routine or typical. Radical also implies, not just the, the kind of outside that lives in the woods like a hermit, but the kind of outside that tosses rocks back at the establishment.” (14: p.1-2, ATLAS.ti line 51)	Sustainability framing
Business model with sustainable development goal “how do we (in business) tie the concept of sustainability and actually reach a goal of say a better planet or a better society, still having it as a revenue generating model” (6:p.2, ATLAS.ti line 59) “Interface was fortunate, in the sense that they've been able to turn it around fairly quickly internally and see the benefits in a relatively short period of time, from a business model point of view. That's not always the case; I can tell you from my business experience that it's more of a longer mission, it's more of a longer road to travel. Keeping people on board, that's the trick, seeing the end goal” (7:p.3, ATLAS.ti line 74)	Innovation goal
Inno for susty vs susty inno “I would use the word ‘sustainability’ a lot or ‘sustainable for innovation’, as in how do you make the ability to innovate sustainable rather than a moon shot once? (...) I think of sustainable with innovation as being how do you innovate as a matter of course. How do you make it something that isn't a fluke (...) or your question is going in a different direction, which is innovation for the purpose of sustainability” (10: p.2, ATLAS.ti line 91)	Innovation goal
Purpose-driven “I believe there are companies, people, who deep in their heart, they know what's right. (...) it's not for the sake of profit or fame, for the sake of a bigger cause. (...) they're no longer in it for themselves, they're into it for the good of the world. I believe that that is possible (...) you don't see it enough. I think it's growing (...) I think otherwise, what are we doing? You know, why are we doing this? (...), you don't want to just do things for the sake of doing them, they usually have a much deeper, bigger purpose” (15:p.1, ATLAS.ti line 30)	Innovation goal

1 st -order code • “Extract of coded text section”	2 nd -order codes
• “I know I’ve made a difference here and that’s what I wanted my life to be; was to make a difference in whatever I choose to do” (22:p.15, ATLAS.ti line 252)	
Solving humanity’s problems • “(..) we were entering a new age in human innovation. Where instead of needing a new discovery and a new ‘aha’, humans had become so creative, so productive in their innovations that we hadn’t even learnt how to use the things we already knew. (..) to switch the process around from discovery, or “How can it be useful?” To the first design, “What do I need to be useful?” and then be confident that if you knew exactly what you wanted you’d get it. So that’s what we did (..) sat down and said, “What does the world need?” (28: p.10, ATLAS.ti line 241) • “(..) I was trying to figure out things that would most affect the future of humanity. (..) (internet, sustainable energy and multiplanetary living) are fairly obvious. (29: p.1, ATLAS.ti line 35) (..) it’s not like there’s some big list of other things than one could choose from (..) there’s AI and then there’s human DNA. (..) with AI there’s always this question mark of ‘Is it going to be good or bad?’ I’m not sure whether it would be good or bad (..) I just didn’t want to work on something that might have a bad outcome. (29: p.2, ATLAS.ti line 69) (..) and (..) rewriting DNA is fraught with issues” (29: p.3, ATLAS.ti line 77)	Innovation goal
Solving problems • “they gave tours out here for about 3 years after the movie was done (..) then it just got too hard to deal with tourists (..) and running a 6000-acre cattle ranch, so they sold the (movie) sets to his cousins up on the hill (..) that way (my husband’s) family made money and got closer together” (21:p.8, ATLAS.ti line 349) • “we sat down and said “What does the world need?”. Decided that air (carbon) capture’s what they needed. Because the only thing that would close the carbon cycle (..) all the other geo-engineering approaches can’t solve the problem” (28:p.10-11, ATLAS.ti line 241)	Innovation goal
Sustainability goal of innovation activities • “the time when I was in College when I was looking at (writing a business plan) it wasn’t from the starting point of environmental disaster, it was from a starting point of ‘If we don’t have some renewable form of energy generation and consumption then (..) society is going to collapse” (29: p.1, ATLAS.ti line 35). • “at the organizational level it is about (specifics). (we did the materiality assessment and we looked at the customer requirements. (..) it was me asking ‘Do you measure your carbon? Do you record it? Do you have a goal? Do you measure your waste? Do you have a goal?’ (..) it’s energy, waste, water, supplier code of conduct, packaging” (18: p.3, ATLAS.ti line 67)	Innovation goal
Separate radical & susty innovation • “That’s a situation where we can’t always see or identify what is sustainable short-term but sometimes it’s good to separate the thing, have somebody from of the radical innovation and then have another group, or mind, or person, or group of people, to figure out how to make it sustainable” (6: p.2, ATLAS.ti line 62)	Radical sustainability-oriented innovation = more factors
Sustainability = firm innovation process more ambitious • “My answer would be very similar to my previous answer but (..) with respect to any (..) attributes that will be used to define sustainability. It’s innovation that is going through disrupt the way we are currently doing things that are not as efficient, not as long-term viable and allows us to still do things we need to do but radically changes <u>how</u> we do those. And again becomes a disruptive innovation so that it breaks the cycle of how we traditionally embark on using our resources or operating our company and fundamentally changes it so that the long-term viability is enhanced rather than degraded.” (2: p.2, ATLAS.ti line 58)	Radical sustainability-oriented innovation = more factors
RSOI costs more • “(..) the implications are greater to that radical innovation, and what it takes to create it and what it takes to sell it in. Seems like the implications are greater to - in terms of costs, and implementing a radical sustainability innovation” (13: p.2, ATLAS.ti line 47)	Radical sustainability-oriented innovation = more factors
RSOI more factors • “I think it’s just another piece of the solution. It’s kind of how you create that solution. How you market that solution, how you’re going to design the product, use the product, make the product, everything from the start. You add certain criteria into the product but (..) I don’t think it changes the term of the disruption or breakthrough innovation” (17: p.2, ATLAS.ti line 54)	Radical sustainability-oriented innovation = more factors
Complexity • “I was the leader of the (chaotic complex systems) laboratory. (..) and so I knew from complexity that it’s impossible to predict the future.(..) and intuitively, people knew that when the climate scientists	Breaking down uncertainty

1 st -order code • “Extract of coded text section”	2 nd -order codes
tell them that know for certain that 50 years from now disaster waits. (...) they couldn't even predict the weather 3 days from now” (28: p.16, ATLAS.ti line 306) • “even though a chaotic or complex system cannot be predicted because of all these butterflies and other things, it's easier to control than a linear system because you can have the feedback do the work for you. (...) change those systems (...) if you're smart enough to know which way to have the butterfly do its wings” (28A: P.1, ATLAS.ti line 16)	
Data as decision aid • “So how do you actually then use data and technology to understand that role (corporate responsibility in society) and then potentially alter our behaviour in a way that benefits all? (...) I do think IBM are doing a great job (...) I think they are certainly marketing around this whole concept of the smarter planet and I think that in terms of being able to really then start to create these proof points of how they are delivering on that promise of, ‘Together we will create a smarter planet’ is interesting.” (6: p.3, ATLAS.ti line 87)	Breaking down uncertainty
Experimenting • “Innovation is something that's still fostered, even on a larger team. Especially on this because we're doing things, even as we grow, we do more and more things for the first time. (...) we spend a lot of time experimenting with different styles and how to attach it and how to make them modular and all these things.” (31:p.4, ATLAS.ti line 145) • “(...)when I (...) and did my first experiment (...) doing some measurements. And I got this data that was very surprising (...). And I found that so amazing, and I had the privilege to be the first person to think about what it meant” (28B:p.2, ATLAS.ti line 29)	Breaking down uncertainty
Fast technology change • “(...) anyone who has a smartphone has been dramatically affected by that change of lifestyle that smartphone has brought to them (...). How we receive news, how we, how we entertain ourselves, watching television programmes, seeing new movies (...) it's just so completely radically different than it was 10 to 15 years ago. And I think that's, that's probably had the biggest tech impact on society at large around the world.” (2: p.2, ATLAS.ti line 76)	Time
Intergenerational relevance • “(...) if you look at the products that have been around a long time, that would be testament to their relevance. Because generationally they have a shelf life that says: I'm gonna have meaning for you, and I'm gonna have meaning for your children, and I'm gonna have meaning for your grandchildren.”(14: p.4, ATLAS.ti line 149) • “(...) this woman I was listening to- gave a talk about 3 conceptions of time and being a human lifespan, which is about 70 to 100 years; a species lifespan which is about a million years and geological lifespan. And I think the more we start thinking longer, and longer could mean different things for different groups of people - I think sustainability gets built into that (...) that's the lens that I'd like to look at sustainability and innovation. Are we, like the American Indians say, planning for 7 generations?” (1: p.2, ATLAS.ti line 44)	Time
Lack of urgency • “(...) most companies (...) get the general business case for sustainability, ‘If I do it I can save money, build market share(...)’ (...) what is lacking is a sense of urgency, maybe not global urgency, but company specific urgency, ‘Why do I need to do this now?’ “(18: p.2, ATLAS.ti line 54)	Time
Long-term economic thinking • “Unilever is a great example of a really large company that has done what I would consider radical things that other big companies have not been able or willing to do.(...) when the new CEO was hired, (...) he said, ‘We're not going to do quarterly recording anymore ‘cause that doesn't help us look good for long term investors.’ And that was very closely tied into sustainability. So is that, not, not playing the game of the quarterly investments.” (18: p.5, ATLAS.ti line 122) • “And in 2007/2008 sort of when Al Gore and ‘Inconvenient Truth’ movie came out you saw a lot of companies wanting to ask the question and kick it around in the board room, and really talk about, you know, ‘What this, how do we reform, you know, our business around sustainability?’ just as an exploration. And then the economy tanked and 95% of that went away. And so there are a lot less conversations happening, but I noticed the ones that were still happening were the more serious ones(...). They said, ‘Even though are numbers are down. Even we had to lay people off. Even though we're really struggling we see sustainability as a way to grow the business, or to innovate or as a lens to make good business decisions.’ And I think those are the ones that (...) are more willing to link sustainability and innovation in all areas of their business.”(18: p.6, ATLAS.ti line 154)	Time
Radical inno implementation time • “a lot of situations we're not good at recognising even when they're occur that the innovation was	Time

1 st -order code • “Extract of coded text section”	2 nd -order codes
radical until maybe a 1000 years later (...) we're not always the best judges of when something radical has happened because we're too human to assess the implications of something over the span of lifetimes that exceed our own.” (11: p.1, ATLAS.ti line 30) • Interviewer: “Is there a difference for you between disruptive innovation and sustainability driven disruptive innovation?” – “Absolutely. The second takes much longer. (...) perhaps the effects are also taking longer. And I think one very good example that we can come up with is the example of biofuels in Brazil.” (16: p.11, ATLAS.ti line 296)	
Short-term economic thinking • “I was just at a conference where people are lamenting the fact that we think or we're trained to think in such short-term cycles. Especially in business, it's a quarter, at most. And for the most enlightened companies it's maybe a year or two years.” (1: p.1, ATLAS.ti line 37)	Time
Short-term vs long-term human ability • “(...) we've not evolved to deal with this problem. (...) (climate change) is gonna end up being far worse than most people realise” (29: p.6, ATLAS.ti line 190) • “The tension between the short term priorities, the pressures and the long term needs, and the issue is, as humans have gotten more knowledgeable they are better able to understand the longer term priorities, but (...) they're still trapped by the shorter term.” (28: p.12, ATLAS.ti line 249)	Time
Corporate structure resists change • “(...) big companies are making a lot of money themselves playing the existing game. They've got a good thing going and so they become more and more short term oriented and self-consistent that creates a lock in that the existing order, prospering very well without the need to innovate.” (28B: p.4, ATLAS.ti line 76) • “It is a personal struggle of mine constantly, because I do work in a corporate structure and I find it... I know where I want to go, but getting there is the hardest thing.(...) I used to think that (colleagues) had to find the same (sustainability) meaning in (the innovation opportunity) that I did, and what I'm finding is that that's not necessarily the case. People could find 10 different things in the same thing to get to the same result. (...)I'm constantly working within a system that resists change, so even for some people what might be a simple thing is sometimes quite hard.” (7: p.1-2, ATLAS.ti line 40)	Corporate inertia
Focus during radical innovation process • “(...) it's something I could stand to think about more, is how they thoughts of innovation because, 31FIRM seems to do very well. I haven't put too much thought into it, just kind of enjoyed it (...) but that's something, certainly worth thinking about, how do you foster that culture effectively in that you have runaway creativity without runaway tangents.” (31: p.5, ATLAS.ti line 171)	Corporate inertia
Individual leadership • “hierarchies become established and (...) one person can be responsible for something (...), that's great. For a team to be successful as it grows, I think it needs leadership. (...) the flip side of that is, once you have leadership you have to respond to that leadership (...). group dynamics come in. 31FIRM (...) suffers the same political shenanigans that any large corporation does” (31:p.3, ATLAS.ti line107) • “My favourite clients are the ones where I actually sit across from the CEO (...) I think you need that executive participation and dissemination through the company (...) you need that buy-in from a top leader (into doing the risky thing) who green lights it and says ‘Go run with it.’ You know, ‘CFO, make it happen.’” (18: p.6, ATLAS.ti line 141)	Corporate inertia
Innovation space outside corporate structure • “(...) they (Herman Miller) have shareholders, that's what, gets them stuck. They have to do things for the bottom line. But when you set that aside (...) they spend a lot of effort keeping a core group of people away from all of that so that you can do your best work in a meaningful way.” (15: p.2, ATLAS.ti line 58)	Corporate inertia
Need to change corporate culture • “I've also seen very successful radical innovations in the news and in other companies and I don't always know what's the key (success) factor. Probably, perseverance is one of them, proper resources also but, actually, how to embed culturally and from the communication aspect in the environment..that's probably also a very important factor.” (3: p.2, ATLAS.ti line 59) • “(...) it is a very interesting word, ‘radical’. I think there is a definite component which is really surprising but at the same time it is something that feels incredibly behaviouristic, so that it is something that is completely in tune with either a behaviour that we currently do but that can be served through a completely different way of thinking.” (6: p.2, ATLAS.ti line 46)	Corporate inertia
Reluctance to change • “the big companies are making a lot of money (...) playing the existing game. (...) that's the existing	Corporate inertia

1 st -order code	2 nd -order codes
• “Extract of coded text section”	
order, prospering very well without the need to innovate” (28B: p. 4, ATLAS.ti line 76) • “Their eyes are on a screen and they’re not experiencing (..) this planet and the beauty of it. (..) I hire young people to work for me and when they leave me a note, it’s a text” (22: p.14, ATLAS.ti line 214)	
Risk acceptance • “if you have a radical technology and an innovation that makes sense to the company, the risks and assumptions are different; in other words, the company can justify the value risk” (9:p.1, ATLAS.ti line 15) • It’s a contact lens with a sensor and a WiFi (..) the end goal is that it’s going to be able to use the fluid in your eyes to test for your blood sugar and it will be wirelessly talk to your insulin part of your dichotomy. And it can translate medical data. (..)(Contacts, sensors and wireless broadcast have) been around for a while. But combining them and being willing to take a risk on something that isn’t immediately, you know, a profitable idea. The idea behind that kind of technology is just proving that it can be done.” (31:p.2, ATLAS.ti line 64)	Corporate inertia
Intrapreneur driving radical innovation • “We pull out the other resources as COMPANY. But (at the beginning), you’re just a small team that has to prove your concept” (31: p.3, ATLAS.ti line 83) • “(we need to solve) this problem of getting things integrated (..) into the company.(..) I called it corporate entrepreneur and superneur and I think we need to shift from open innovation to more business management, entrepreneuring skills inside of large companies (..) we have a CEO – whatever you call it, CEO, GM, Project Manager, Program Manager, who takes it from start all the way to finish to the point where they’re in the market.so they’ve not only been involved with R&D but now they’re in the market, they’re learning and they’re taking it all the way to follow-through. That ability to not suffer the fall-off when you hand off to another function or R&D hands it off to product development who hands it off to a business unit and they put it in the market. Those are all gaps, spaces where something gonna get dropped and passion and enthusiasm is lost. So (..) having someone who is is going all the way with the new idea is a critical success factor.” (17:p.4, ATLAS.ti line 96)	Large firm vs Startup
Startup • “I think (..) openness (..) is a terrific path for radical innovation, in part also because it harnesses the power of people interested in collaborating with other people and building stuff. Of their own free will without a venture capitalist standing over them saying “You must have a 20XX exit”. ” (30:p.9, ATLAS.ti line 145) • I found the critical difference between startups outside the company and entrepreneurs starting their own company versus doing (it) inside a large company, so 1 step is different in the process. And that’s a step I called deconstruction,(..) sort of mentally ripping apart your company and its assets from product development process, supply chain, going to market, branding, all that and saying ‘Is this the right business model? Are these the right skills and capabilities for this new opportunity that we’re going after? (..)’, that deconstruction phase forces you to rethink how you’re going to be successful. It’s all a little bit on a par with Alex (Osterwalder, who also spoke at the conference), the business model innovation guy” (17:p.4, ATLAS.ti line 96)	Large firm vs Startup
Startup funding • “I think there’s some amount of luck involved. Or at least not too much bad luck. It is fortunate that it worked out, (..) that I had just enough resources to keep the companies live through that period (..) and was also able to convince other investors to participate” (29:p.4, ATLAS.ti line 138) • “and the biggest issue is actually fundraising, getting somebody to..(..) (he) was told that there’s no way he can do that because the capital he would have to put together to start up would be huge” (9:p.13, ATLAS.ti line 161)	Large firm vs Startup
Academic practitioner grounding • “I’m not a full time academic, I’m an academic and I try to live in a little bit of the concrete world (..) Cause the world (..) of academia is too abstract. I think it’s very important to have a kind of link between the two” (16:p.7, ATLAS.ti line 183) • “I left Bell Laboratories because I felt that the challenge facing mankind was not how to make a computer faster but how to provide energy to support our human needs. I came out of that, making a long story short, with believing the holy grail was for humans to find an industrial way (..) to mimic the natural process. That is to make our fuel from CO₂ in the air and hydrogen from water. (..) So to close the carbon cycle” (28:p.3, ATLAS.ti line 96)	Personal motivation
Being an outsider • “a lot of people I found as inspiration (..) were in fact heretics in their own fields because what they were proposing to their peers was too radical for their peers to actually accept and understand. I feel	Personal motivation

1st-order code • “Extract of coded text section”	2nd-order codes
<i>like the same.” (30:p.2, ATLAS.ti line 39)</i>	
Escape rat race • “It’s hard for people to understand why you would choose to come to this place of beauty, but that’s the draw (...) and not needing to participate in the rat race; not feeling the need to be surrounded by hundreds of people and playing those games; being confident enough” (30: p.2, ATLAS.ti line 21)	Personal motivation
Source of inspiration • “she would get on a horse and she would ride around the one-room school houses (...) and so that one woman was single-handedly responsible for really helping to educate so many young people in Wyoming” (22:p.16, ATLAS.ti line 266)  • (23, ATLAS.ti 32:2978)	Personal motivation
Spirituality as driver of sustainability • “(...) a lot of the Dutch people migrated there and with that deep religion of just simplicity and purity and very conservative. It was through his values as a person that, how he continued to lead the company. (...) It was the basis for the value system but that’s something that’s taboo to really articulate in any corporate now. (...) That’s the company’s roots. Now it’s changed drastically” (15: p.4-5, ATLAS.ti line 144) • “(the ribbons in the sauna signify) the directions. White is for the north, red is for the east, yellow’s for the south, black is for the west, blue is for mother sky and green is for mother earth. (...) Mother earth has given us everything. We came from Mother Earth. One day we’re going to return.” (20A; p.6-7, ATLAS.ti line 261)	Personal motivation
Startup founder motivation • “(...) we drove up and most of these buildings were empty back in 97. (...) And we kind of were looking at it so we went to a realtor (...) and introduced ourselves and said, you know, “We have a fairly sizeable company and it looks like the town could use some jobs and we’d be hiring close to 100 people for our company (...) Do you have any old buildings?” (...) And she drags us down the block and opens up this door and said, “The buildings going down in 10 weeks.” (...) A 15 foot wall of water came through here in 1912 and just about destroyed the town and... But to us, that’s the history. (...) It’s the nails and the stains and the scratches and the marks. And we spent several hours in the building and we looked at each other and said, you know, “This is an extraordinary piece of history. Somebody has to save this building.” (22: p.3-4, ATLAS.ti line 41) • “(...) my (business) partner, she has no doubt been affected and impacted by the fact she’s from a developing country, the plight of developing countries and how they are oppressed by the developed countries is an important part of her framework and has dictated her journey. My journey - I can’t see any connections between how I grew up and why I’m working in energy.” (28B: p.3, ATLAS.ti line 37)	Personal motivation
Values • “There are no atheists in Foxholes. (...) Organised bodies help to be a weekly reminder of the good habits. Having the church gives you a choice of doing that. Physical experience of nourishment when going to church is a good grounding (...) if you get out here to stay you really have to have still a Pioneer spirit because otherwise you’re not going to stay (...) you can’t try and understand America without realising how much people are basing their values in religion” (23:p.4-5, ATLAS.ti line 150) • “Cause most people say “God. I sin against God.” And actually you don’t. (...) because the one that you sin against are your friends, neighbours, people next to you, whatever. Those are the ones you hurt.” (20A:p.9, ATLAS.ti line 305)	Personal motivation
Individual analytic capability • “(...) in the science world Einstein is (a radical innovator) (...) he used his brain to figure out things about the universe that we’re just today confirming to be true when he had no way to verify these things. He used sheer logic to determine things that were well beyond the capacity of him to measure. And had the confidence in his logic to know that it would be the case (...) even though it was leading to conclusions that you couldn’t prove, support or even justify on many intuitive criteria - radical to me” (11: p.2, ATLAS.ti line 53) • “(...) one guy who’s definitely a radical innovator is Nikola Tesla (...) he invented an insane number of things that he could envision way beyond anybody else’s capability to do so.” (30: p.6, ATLAS.ti line	Decision maker abilities

1 st -order code • “Extract of coded text section”	2 nd -order codes
113)	
Individuality of entrepreneur • “(..) a collective approach to manufacturing, collective approach to industry, does not place that much of an emphasis on the individual. (..) another important question is how important is the individuality of the entrepreneur in (..) taking that (radical innovation) trip.” (16: p.3, ATLAS.ti line 93)	Decision maker abilities
Innovation as culture • “I don't know the names because these people tend to be anonymous but I think there is a lot of..erm..thought and innovation just, just everywhere. At all levels and it takes, err, I don't know, a relatively enlightened leader or movement to kind of trigger that in people.” (1: p.3, ATLAS.ti line 68)	Decision maker abilities
Innovation potential in everyone • “Muhammad Yunus, (..) just the idea of democratising finance, I think is a wonderful idea and much needed in the world. I can point to a lot of other sort of famous people. The kinds of people who grace the stages at TED talks (..). But I wonder if it's, if part of this radical thing is just unleashing innovation potential in everyone” (10: p.3, ATLAS.ti line 104)	Decision maker abilities
Intuition required • “In many of the things when it comes to innovation you don't have to understand, you have to feel, it's about feelings, it's thinking with your skin rather than just operating.” (16: p.7, ATLAS.ti line 194)	Decision maker abilities
Male superhero • “(..) as an individual, Dean Kamen is a great example. He produces all kinds of innovations which really do change the world (..) because he thinks outside the box and doesn't get shackled by traditions we have. The way he operates is to find and invent new and disruptive things, so it's almost like a <i>raison d'être</i> for him.” (10: p.3, ATLAS.ti line 104) • “That dude (Elon Musk) is a bad motherfucker (..) He was out there busting it before it was even time to go bust it. He saw a real need (..) and set about trying to do something smart about it. (..) but I don't think most of the world is going to appreciate what his contribution has been until he's dead.” (14: p.5, ATLAS.ti line 161)	Decision maker abilities
Perseverance • “but to live there is different. (..) you're willing to take the downside of it (..). the solitude can be lonely as well as enticing” (23: p.2, ATLAS.ti line 72) • “(..) the idea of letting one of (my firms) die, I could not end that idea (..) like asking someone which of your children should die” (29: p.4, ATLAS.ti line 138)	Decision maker abilities
Person processing many decision factors • “I think I have a better memory than most people (..) a very good memory for facts and figures. I wouldn't say I have a particularly good memory for people (..) not that good at remembering names and faces. But I can remember a large amount of information, especially related to a bit of science. I would say it's photographic in the sense that it's perfectly recalling things.” (29: p.5, ATLAS.ti line 146)	Decision maker abilities
Self-belief • “And he didn't let anything get in his way of convincing him that he was not on the right path” (11: p.2, ATLAS.ti line 58)	Decision maker abilities
Sustainability knowledge • “To reverse out the carbon in the atmosphere will necessarily take a huge amount of energy (and) obviously you can't use carbon to remove carbon. (..) It's really difficult I think. (..) if you look at the annual carbon, the ppm number and how that varies through the year you can see as you hit summer in the northern hemisphere, there's a lot more carbon capture going into plants but you can see the bad variance so that's a pretty small movement. Even if you grew an enormous number of plants, almost all biomass and very little on the ground somehow, you'd take a <u>lot</u> (..) to reduce the carbon that way.” (29: p.6, ATLAS.ti line 175)	Decision maker abilities
Bottom of pyramid • “I was struck by the difference between the guys who think that biochalk is (..) supposed to be carbon negative in a sense that if you do agriculture with this it, it acts as a carbon sink and soaks up carbon. So these guys are convinced that this is going to solve global warming..(..) contrast that with other people (..), who are talking about things like providing banking services to the unbanked in Africa. And I find that to be way more innovative because they're trying to change the way people think and act about finance and connecting people.” (1: p.3, ATLAS.ti line 92)	Innovation output
Changing the life of the end-user • “(..) radical innovation means when you hit the market and the market remembers you after a time. When your goals and – the money comes later, but I think the meaning of radical innovation is when	Innovation output

1 st -order code • “Extract of coded text section”	2 nd -order codes
you hit the final customer.” (12: p.1, ATLAS.ti line 34) • “(..) any product that causes a fundamental change in the end-users lifestyle..and what had previously done that particular task, whatever that product originally would have been done by some other product, the new way of executing that task is now fundamentally different.” (2: p.1, ATLAS.ti line 34)	
Disrupting existing business model • “(..) radical innovation is truly when you are looking at potential existing business models that are completely disrupted by something new and, in some cases, coming to market. (..) iTunes as a very good example (..) because when (Apple) were looking at iTunes they really did – they had no permission at that point to really play in if you like music catalogue and catalogue space” (6:p.1, ATLAS.ti line 44)	Innovation output
Diversion from status quo • “(..) radical innovations are the ones that really disturb the status quo. Because anything that’s just an extension of the status quo is just an improvement on something that existed.” – “What would be an example, for you, for something that disturbed the status quo?” – “So un-schooling, for example. Un-schooling is a radical innovation, even though, it’s how we all used to learn before everybody got forced into the compulsory education system.” (30: p.1, ATLAS.ti line 21) • “(radical innovation) is coming up with new ideas that people thought were not possible and suddenly make them possible. So why be so closed to the newness of it?” (28: p.10, ATLAS.ti line 236)	Innovation output
Economic viability • “(..) I would say that, to me, and when we think of radical it has this kind of iconoclastic, disruptive connotation that in (composer) Bach was less (the case)..I mean he was fairly commercially successful when he was alive and so I feel like his music just rewrote the way we perceive of sound.” (11: p.2, ATLAS.ti line 53) • “Of the course the impact (of radical innovation) should also be a huge one, especially for the user or somebody who would like to apply the result.” (3: p.1, ATLAS.ti line 17)	Innovation output
Ethnic minority • “the way the Japanese endured the injustices that were perpetrated by our government (..) I feel passionate about informing people of it because it’s very much glossed over” (24:p.5, ATLAS.ti line 189)	Innovation output
Inclusiveness • “We sold our books, wholesale, for only a dollar and 20 cents; that’s not a lot of money but we wanted our books to be affordable for everyone” (22:p.5, ATLAS.ti line 62) • “well, he is white. He married my second cousin’s daughter but he seems more native than a lot of the natives. Oh, I’m all for it” (19A:p.5, ATLAS.ti line 202)	Innovation output
Increasing consumption • “for my intents and purposes, it’s not innovation if you, and not to pick on my clients, but if you put a pop top on your little beer can that has your icon imprinted on it, you haven’t made my life better, you’ve only shoved your brand in my face, literally. This is not innovation, it’s a new thing, but it’s bullshit. (..) sexy hits the shelves and 6 months later it’s gone, and the people get fired” (14:p.2, ATLAS.ti line 55) • “we have so much in our reach of innovations that are being done within these corporations, and yet the focus is often on producing something that (..) has a revenue behind it that is more for consumerism” (6:p.2, ATLAS.ti line 55)	Innovation output
Infrastructure improvements • “ (..) Toyota are doing some really interesting things in terms of connectivity. Not just in terms of connecting you personally to your car and the technologies that could actually make it perform better or you could drive better or you could conserve energy better, they are actually building cities to actually see about how we can literally think about the concept of connectivity and the intersection of people and transport and communities in a much more different way” (6: p.2, ATLAS.ti line 62) • “Qualcomm is an interesting company, they seem to be exploring all kinds of clever new approaches from a technical, infrastructure standpoint. Like Google, they’re really facilitating a lot of great things, so I think, there are companies that are able to do things.” (17: p.3, ATLAS.ti line 78)	Innovation output
Original knowledge holders • “I’ve been doing this since 2000 (..) This weather got em (refers to buffalos) all messed up. They’re a month-and-a-half earlier (with calving) this year than they were last year. (..) the climate and stuff (..) But these last few years has been real warm (..) I got about 20 (buffalos) out there, probably about 5 more (calves) to go but, like I say, they’re almost done calving. Hmm, for this time of year.” (19:p.11, ATLAS.ti line 378)	Innovation output
Societal impact of business	Innovation output

1 st -order code • “Extract of coded text section”	2 nd -order codes
• “I was lucky enough to go to Japan and do some work with them (..)the Japanese approach to society and this amazing concept of, “Our role in society,” and the Haku – what is the expression? We all have a part and a responsibility in society, and that we play a part in that, we have to be aware of it. So how do you actually then use data and technology to understand that role and then potentially alter our behaviour in a way that benefits all?” (6: p.3, ATLAS.ti line 87) • “We’ve still got more plans for this (venture)(..), that’ll be my local grocery store and over there I’ll have some South-Dakota made gift items and South-Dakota made wines. (..) we’ll do dinners in what we call our community room’ back there. (..) Tomorrow (..) all the local ranchers will bring their branding irons. Then we have a stove that you keep the branding irons in and usually you brand calves (..)Tomorrow, they’re going to brand this board back here.” (21: p.7, ATLAS.ti line 309)	
Technology isn’t the answer • “whenever I hang out in San Francisco, I’m struck by the level of naïve optimism I think. There’s this sense that technology will solve everything and people don’t have to change, which I find terrifying” (1:p.3, ATLAS.ti line 92) • “(Radical sustainability-oriented innovation) breaks the cycle of how we traditionally embark on using our resources or operating our company and (it) (..) fundamentally changes it so that the long-term viability is enhanced rather than degraded. (..) it’s changing a mind-set. (..) I think a lot of what we do in terms of sustainability revolves around buzzwords or they’re incremental changes but they don’t necessarily break the fundamental way we do things” (2:p.2, ATLAS.ti line 58)	Innovation output
Geographical region • “Russia for me is the beginning, because I think it’s perhaps the greatest mismatch between talent and capacity and, and underachievement.” (16: p.9, ATLAS.ti line 221) • “San Franciscans tend to surround, or, I mean, the culture has evolved in such a way that it attracts like-people. And I think it’s a self-reinforcing bubble and you never get out of that.” (1: p.4, ATLAS.ti line 98)	Institutional impact
Support of societal leaders • “we ended up getting a lot of backing from some senators and all the other tribes” (19: p.4, ATLAS.ti line 110) • “(..) it’s also the business environment. (..) how you value innovation and institutions that allow for creative construction (..) I think it would be important for your research (..) is the book by Daron Acemoglu and James A. Robertson (Robinson) called Why Nations Fail” (16: p.4, ATLAS.ti line 101)	Institutional impact
Government ruled by economic interest • “When people started travelling West the forts were built first. Basically to protect homesteaders moving West but the forts were also there to annihilate the Indian people. That’s what the soldiers were all about: ‘We want this land. It’s rich and we’re going to take it.’ And so basically our history is not terribly kind to our native American people. It was all about greed” (22: p.18, ATLAS.ti line 306)	Institutional impact
Radical the word • “I don’t believe that there’s anything that is truly new under the sun that the new things of radical innovation are taking the existing elements or beliefs or systems and processing them, and putting them together in new ways, that create something new and radical.(..) radical’s an interesting word, because it suggests a massive gap in where things exist in the universe as what could be which also suggest a need from people.” (13: p.2, ATLAS.ti line 33)	Rhubarb bag
Superweird • “and I’m a straight dancer but I hate straight dancing” (19A: p.4, ATLAS.ti line 157) • “Are you talking about sustainability in terms of ecological relevance?” (14: p.3, ATLAS.ti line 86) – “Ecological, social, economic, together. As opposed to..” (iw in 14: p.3, ATLAS.ti line 86) – “Jesus Christ, what are you doing?” (14: p.3, ATLAS.ti line 86) – “It’s my PhD.” (iw in 14: p.3, ATLAS.ti line 86)	Rhubarb bag

11.7 Appendix 7 - Key insights summary table

RESEARCH PHASE ONE

2013 data: characteristics of radical sustainability-oriented innovation

Key insights: <i>What makes innovation radical</i>
The data suggests that novel combinations of previously unconnected factors and novel combinations of previously unconnected factors are perceived as indicator of innovativeness. At the level of the firm, radicalness means new processes for established companies, with technology perceived as an enabler of innovation in the data. In contrast to the data, in the reviewed literature technology is portrayed as the driver of radical innovation (Ashford and Hall, 2011; Chandy and Tellis, 2000; Foster, 1986). Some literature singles out individuals as key to overcoming radical innovation in firms (Garcia and Calantone, 2002) and this is supported by some interviews. These interviewees indicate that the individuals can expect opposition during the pursuit of radical innovation activities.
Key insights: <i>Who pursues radical innovation</i>
Interviewees highlighted individuals and firms is almost equal measure, with some interviewees offering societal movements. The data on individuals and firms further confirms new combinations of things as indicator of radicalness, in line with literature arguments (Nooteboom, 2000; Schumpeter, 1934). Individuals and firms were identified as radical because they pursued activities outside the accepted status quo within their domain or industry, where this status quo is context-specific to the innovator.
Key insights: <i>Sustainability means different things to different people</i>
The data suggests that personal circumstance and the relating context influence how sustainable development challenges (Ashford and Hall, 2011; Charter et al., 2008) are perceived. This will influence which sustainable development challenges are perceived as important and, therefore, might have implications for which and how sustainable development challenges are addressed.
Key insights: <i>Solving problems and setting goals</i>
The data suggests that radical sustainability-oriented innovation is different to 'conventional' radical innovation because it sets out to explicitly address a sustainable development challenge or it sets out to avoid an innovation outcome that might create or worsen sustainable development challenges. Common between the articulated purposes of innovation is the aim to solve problems. The value creation at the heart of a business model (Osterwalder and Pigneur, 2009; Osterwalder et al., 2014) must be broadened out beyond purely economic value creation (Boons and Lüdeke-Freund, 2013; Schaltegger et al., 2012) according to the literature. This assertion was confirmed by interviewees, with value creation beyond the economic business case dependent on individual context.
Key insights: <i>Radical sustainability-oriented innovation is and takes more than radical innovation</i>
The data suggests that radical sustainability-oriented innovation is associated with higher economic costs during development and implementation than conventional radical innovation at the level of the firm. The reviewed literature (Jay and Gerard, 2015) do not mention the need to address higher cost at the firm level, or the mindset that sustainability-oriented innovation costs more. The data also suggests that innovation activities need the freedom to experiment during the innovation process, without necessarily considering the economic value creation during these experimental learning activities. Balancing the individual freedom needed to experiment during an innovation process with uncertain outcomes is hard.
Key insights: <i>Human response time to sustainable development challenges</i>
The data suggests that sustainable development challenges are urgent. However, pursuing radical sustainability-oriented innovation takes longer than pursuing conventional radical innovation activities. The technology dimension of radical innovation is extensively reflected on in the innovation management literature (Dosi, 1982; Foster, 1986; Hanna et al., 2015). However, in the data set this was not replicated. This suggests that it might be easier to reflect on the technological innovation dimension from the academic perspective than it might be on the social dimension of innovation. The human element in change and innovation processes has been asserted to lead to 'lumpy' time scales (Poole, 2004). The data suggests that the human elements are, equally, perceived as most challenging by innovation practitioners and academics.
Key insights: <i>Large firms and radical innovation capabilities</i>
The data suggests that a corporate mindset (Sandberg and Aarikka-Stenroos, 2014), manifested in management structure and existing processes impacts radical innovation activities. Making the existing structure and processes fit with radical sustainability-oriented innovation is hard for individuals trying to do this. Using entrepreneurial practice was suggested as a desired way to restructure corporate innovation processes. This approach would enable to see through an innovation from the ideation stage to commercialization without losing speed and momentum when the project is handed off to different business functions.
Key insights: <i>Personal motivation and the leaders of radical innovation activities</i>
The data suggests that many individuals act out of personal frustration. However, the entrepreneurial individuals identified by others as radical sustainability-oriented innovators were mainly motivated by solving the biggest problems with their

respective innovation activities. Sustainable development challenges are perceived as most important by these two individuals, therefore innovation activities are tailored towards addressing these challenges. Personal values were not offered as motivation. This is in contrast to the reviewed literature so far (Dewberry and de Barros, 2009).

Key insights: *Affecting others than only the business and technology as enabler*

The data suggests that the sustainability goal of radical sustainability-oriented innovation activities, and therefore the outputs created through such innovation were guided by the background of the interviewees. The outputs of radical sustainability-oriented innovation should first and foremost benefit human beings. At the same time, human beings need to change for sustainable development challenges to be addressed successfully.

2014 data: characteristics of experimentation to pursue radical sustainability-oriented innovation activities

Key insights: Economic value creation vs the urgency of sustainable development challenges

The data suggests that the tension between efficiency and a clear economic business case with longer-term and uncertain innovation outcomes are similar for radical innovation and sustainability-oriented innovation. Some data indicates that the speed of change to innovation processes in firms is not suitable to address sustainable development challenges in a timely fashion. Triple bottom line value creation was acknowledged as desirable, however economic value creation was the motivation to the pursuit of all innovation activities at the level of firm.

Key insights: Challenges of the corporate innovation management process and culture

The data suggests that firms try different approaches to encourage the pursuit of radical innovation activities within their respective firms. However, embedding sustainability considerations into value propositions that are new to the firm is perceived as challenging.

Key insights: Experimental learning in large firms during the innovation process & learning from failure

The data suggests that pursuing new business opportunities is challenging for firms because there is little indication which processes and changes will lead to future success or will end in chaos for the business. Action led learning was perceived to be the key component of experimental learning, used to address innovation uncertainty. Some suggested that structures and processes of startups are suitable to pursue action led learning. However, existing firms face the challenge of engaging their existing customer base in the testing of radically new value propositions.

Key insights: Collaboration ambition and reality

The data suggests that there is tension between the knowledge of what should be done to address sustainable development challenges and what is currently done at the level of the firm. Collaboration to share knowledge is a mechanism used to break down the uncertainty associated with addressing sustainable development challenges. The interviewees suggested that they were the ones to choose how and when collaborations are used to further an innovation process, address sustainable development challenges, or both at the same time through radical sustainability-oriented innovation.

Key insights: Breaking the business-as-usual innovation mindset

The data suggests a mechanism and confirms one insight from the 2013 data. The mechanism is as follows: firms trying to break a business-as-usual mindset during innovation activities might benefit from taking staff outside their familiar work environment, with the location chosen to highlight social and/or environmental problems associated with firm activities. The insight confirmed from the 2013 data set is that personal values, shaped through personal experiences, drive the pursuit of innovation and business activities that go beyond the objective of economic value creation (i.e. go beyond business-as-usual activities).

Key insights: The role of corporate leadership in supporting innovation activities with uncertain outcomes

The data suggests that senior management can encourage and enable radical innovation with a sustainable development goal through making explicit that radical sustainability-oriented innovation activities can be explored without an immediately obvious economic business case.

RESEARCH PHASE TWO

2015 Case study on developing the organizational capability of experimentation

Key insights: Reinforcing the organizational innovation status quo
The data suggests that the desire to use familiar processes reinforces a firm's innovation status quo. Defining key PROJECT terms (i.e. experiment) will enable teams in pursuit of radical sustainability-oriented innovation to minimise confusion in meetings and workshops.
Key insights: Creating internal buy-in
The data suggests that creating internal buy-in across all levels of seniority is necessary. The timing with which senior staff is engaged is important: too early will result in the killing of projects with high uncertainty, too late will result in lack of senior ownership. This mirrors the literature assertion about the need to create buy-in to the customer development process (Blank, 2013).
Key insights: Balancing multiple roles and freedom to experiment
The data suggests that despite the corporate practice of multi-project working, enabling key team members to significantly focus on a radical innovation project will enable entrepreneurial focus (Katz and Shepherd, 2004; Livingston, 2007). It is important to have clarity on how to use freedom to experiment and clarity on who leads areas of decision making during radical sustainability-oriented innovation activities.
Key insights: The project collaboration
The data suggests that academic collaboration partners are useful to capture learning during a radical sustainability-oriented innovation process. However, it might be beneficial to include entrepreneurs as collaboration partners during the development of radically new value propositions to encourage action-based and practical learning.
Key insights: Ambition and complexity of sustainability goals
The data suggests that a sustainability project goal might quickly broaden out to other sustainability issues, such as social sustainability, as suggested in the literature (Hockerts and Wüstenhagen, 2010). Articulating the value creation goal on an ongoing basis (Alexander and van Knippenberg, 2014; Guarana and Hernandez, 2014) helps to maintain and increase the project ambitions.
Key insights: Embedding entrepreneurial principles
That data suggests that a project that introduces lean startup principles will benefit from highlighting the new social and technological capabilities that are needed to implement this approach. Engaging customers is a must in radical innovation projects that look to apply a lean startup approach. The need for new organizational capabilities for radical innovation has been suggested by the literature (Chang et al., 2012; Garcia and Calantone, 2002) as has the need to create team-wide understanding of the specifics of conducting customer development (Blank, 2013).
Key insights: Time
The data suggests that the urgency of operationalising sustainable development (Ashford and Hall, 2011; Boons et al., 2012) is easily forgotten when trying to meet short-term project goals and other commitments in the firm. In the case study, new technical capabilities would have helped to speed up the experimental learning needed to further radical sustainability-oriented innovation activities because these technical capabilities would have enabled incognito customer engagement. However, the data did not indicate an appetite of the project team to acquire these new capabilities. Instead, new team members were added to fill the skill gaps, however this did not significantly speed up the learning.
Key insights: Unplanned, action-based learning
The data suggests that personal motivation drives action-based learning outside of project boundaries. This is desirable and useful to happen in addition to more deliberate learning. Unplanned action-based learning will enable project members to become more confident negotiating experiments with uncertain outcomes.
Key insights: Tension between economic, social, and environmental value creation
The data suggests that the corporate mindset (Sandberg and Aarikka-Stenroos, 2014) dominated by economic value creation can block experimentation activities with high output uncertainty, even if highly promising from a social and environmental value creation perspective.
Key insights: Discarding experiments
Some data suggested that experiments that prove unfit to meet firm specific triple bottom line value creation goals should be discarded. At the same time, process learning lessons can be useful and influence wider corporate sustainability and innovation practice.

11.8 Appendix 8 – Research scoping case study 2014: interview topic guide

This appendix illustrates the research direction I explored in 2014, mentioned in chapter 2.

Case study research aims to explore through in-depths interviews

Definitions of radical sustainability-oriented innovation

Reasons for contributing/not contributing to the community buying of the island

Perceived motivators and barriers to engage in island activities

Potential ways of attracting more residents to take an active role in the running of the island

Perceived contribution of the Isle of Eigg to avoid run-away climate change

Perceived success factors and barriers to happy resident life on the island since 1997

Introduction

- PhD research at Imperial College London / Recorded interviews that will be transcribed / If using any quotes in any context I'll be in touch to ask if that is fine, could you confirm your email / address? / Takes no more than 60min in total to do the interview

PART 1 – LIVING ON THE ISLAND

- When did you move to the Isle of Eigg?
- Why did you move to the Isle of Eigg?
- What are your main activities here, both in your private and professional life?
- In your view, what were the main success factors for the buying of the island in 1997?

Culture within geographic boundaries

- Do you think the way of life on the Isle of Eigg is different to the way of life on Canna, Rum and Muck? If yes, how?

PART 2 – SAVING THE WORLD

Sustainability Challenges

- If I throw the phrase 'radical innovation' at you – what does this mean to you?
- And 'radical sustainability-oriented innovation'?
- The UNFCCC Annex 1 countries have to reduce their carbon emissions by at least 8% per year in the decade 2020-2030. What do you think is the Isle of Eigg's role in enabling the UK to meet this reduction target?
- There's a very limited time window for humanity to avoid run-away climate change. How do you think a community like Eigg can contribute to the survival of humanity?

PART 3 – INDIVIDUALS & STRUCTURAL CONDITIONS

Individuals as Leaders

- Who were the people driving the buying of the island?
- In your view, why do you think they did this?
- How can you encourage others to take initiative and address a perceived power imbalance?

Micro-macro dynamics

- What did impact your life on Eigg most before 1997?
- What did impact your life on Eigg most after 1997?
- And over the last 5 years?
- Have you come across the term 'transitions'? If yes, how do you explain the term 'transitions'?
- Do you think 'transitions' is relevant to Eigg?

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Page No.	Type of work	Name of work	Source of work	Copyright holder and contact	permission requested on	I have permission yes /no	Permission note
47	figure	Figure 9: Relationship between technical and social innovation	De-babelizing the language of innovation. Technovation (2009), Vol. 29, pp.729-737	© 2009 Elsevier Ltd	03.05.17	yes	Written permission, license number 4101410221858
48	figure	Figure 10: Radical innovation and the relationship between technical and social innovation	De-babelizing the language of innovation. Technovation (2009), Vol. 29, pp.729-737	© 2009 Elsevier Ltd	03.05.17	yes	Written permission, license number 4101410221858
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63	figure	Figure 15: Sustainability-oriented innovation dimensions	Sustainability-oriented Innovation: A Systematic Review. International Journal of Management Reviews (2015) Vol. 18, No. 2, pp. 180–205	© 2015 British Academy of Management and John Wiley & Sons Ltd	04.05.17	yes	Written permission, license number 4102030698487
63	figure	Figure 16: Final model of sustainability-oriented innovation	Sustainability-oriented Innovation: A Systematic Review. International Journal of Management Reviews (2015) Vol. 18, No. 2, pp. 180–205	© 2015 British Academy of Management and John Wiley & Sons Ltd	04.05.17	yes	Written permission, license number 4102030698487
65	figures	Figure 17: Sustainability-oriented innovation dimensions Figure 18: Sustainability-oriented innovation evaluation framework	Accelerating the Theory and Practice of Sustainability-Oriented Innovation. SSRN Electronic Journal - MIT Sloan School Working Paper 5148-15	unclear	n/a	n/a	To the best of my knowledge this research paper is not copyrighted
66	table	Table 6: Characteristics of	Accelerating the Theory and	unclear	n/a	n/a	To the best of my knowledge

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		sustainability-oriented innovation versus 'conventional' innovation	Practice of Sustainability-Oriented Innovation. SSRN Electronic Journal - MIT Sloan School Working Paper 5148-15				this research paper is not copyrighted
71	table	Table 7: Key distinctions related to time in theories of change and innovation	Central Issues in the Study of Change and Innovation. In: Handbook of Organizational Change and Innovation (2004) Oxford University Press	© 2004 Oxford University Press	04.05.17 + 25.05.17	Not yet	Sent an email asking for permission to journals.permissions@oup.com
76	figure	Figure 19: Criticality versus Latency	A Comprehensive Model of Uncertainty Associated with Radical Innovation. Journal of Product Innovation Management (2013) Vol. 30, pp. 2-18	© 2013 Product Development & Management Association	04.05.17	yes	Written permission, license number 4102050045582
76	figure	Figure 20: Three dimensions of project uncertainty	A Comprehensive Model of Uncertainty Associated with Radical Innovation. Journal of Product Innovation Management (2013) Vol. 30, pp. 2-18	© 2013 Product Development & Management Association	04.05.17	yes	Written permission, license number 4102050045582
119	figure	Figure 23: Cycle of exploitation and exploration	Learning and innovation in organizations and economies. Oxford University Press, 2000	© Bart Nooteboom	25.05.17	yes	Written permission through email from the copyright holder
119	figure	Figure 24: Cycle of exploitation and exploration	Learning and innovation in organizations and economies. Oxford University Press, 2000	© Bart Nooteboom	25.05.17	yes	Written permission through email from the copyright holder
130	table	Table 13: Array of entrepreneurial beliefs	Elitists, risk-takers, and rugged individualists? An exploratory analysis of cultural differences between entrepreneurs and non-entrepreneurs. Journal of Business Venturing (1992) Vol. 7, pp.115-135	© 1992 Elsevier Inc.	22.05.2017	yes	Written permission, license number 4114271466388

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131-132	table	Table 14: Characterization of different kinds of sustainability-oriented entrepreneurship	Sustainable entrepreneurship and sustainability innovation: categories and interactions. Business Strategy and the Environment (2011) Vol. 20, No. 4, pp. 222-237	© 2010 John Wiley & Sons, Ltd. and ERP Environment	22.05.2017	yes	Written permission, license number 4114280697067
135	figure	Figure 28: Perspectives and development of sustainable entrepreneurship and sustainable innovation	Sustainable entrepreneurship and sustainability innovation: categories and interactions. Business Strategy and the Environment (2011) Vol. 20, No. 4, pp. 222-237	© 2010 John Wiley & Sons, Ltd. and ERP Environment	22.05.2017	yes	Written permission, license number 4114280697067

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