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Entrepreneurial behaviour and the development of entrepreneurial ecosystems under uncertainty: Essays on regenerative medicine venturing at the university-industry boundary

David Johnson

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Declaration

I hereby declare that the work contained herein has been composed by me and is entirely my own work. No part of this thesis has been submitted for any other degree or professional qualification. Parts of this thesis have been published and/or presented as per the following list:

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David Johnson

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Abstract

Entrepreneurial ecosystems are an important economic consideration but remain an understudied phenomenon. In particular, research emphasising the role of the entrepreneur within entrepreneurial ecosystems is scant. Entrepreneurial universities, particularly the commercialisation activities by academic entrepreneurs, contribute to both the emergence and development of entrepreneurial ecosystems at the university-industry (U-I) boundary. Yet, an understanding of the links between university characteristics and micro-level cognition on entrepreneurial ecosystems remains limited. Furthermore, it is not clear how the dynamics of entrepreneurial ecosystems differ across different national geographies.

Venture development at the U-I boundary is difficult and uncertain. Entrepreneurs must make decisions under intense ambiguity and make sense of the highly uncertain situation. Nowhere is this more evident than in knowledge and technology-intensive sectors, where venturing relies on entrepreneurial coping responses to uncertainty. However, little is known about how entrepreneurs cope with uncertainty, especially when uncertainty is irreducible.

To progress understanding of entrepreneurial behaviour amidst uncertainty, and the emergence and development of entrepreneurial ecosystems at the U-I boundary, this PhD thesis investigates venturing in the field of regenerative medicine (regenmed). This is a particularly suited study context since regenmed commercialisation activities, which are driven by university-based stem cell research, are highly uncertain and the industry is still in a formative stage.

This PhD thesis explores entrepreneurial behaviour amidst uncertainty and the development of entrepreneurial ecosystems at the U-I boundary. The thesis comprises of three empirical studies (essays) that can be read independently, however, together the essays provide an enhanced understanding of entrepreneurial behaviour and the development of entrepreneurial ecosystems at the U-I boundary.

Essay 1 reveals how ecosystem participants make sense of venturing processes in a highly uncertain, technology-intensive field. It highlights the development of coping strategies during the sensemaking process, and illustrates an association between university entrepreneurial culture and coping strategies. A model of sensemaking process under uncertainty is presented and a typology of sensemaking types in uncertain ecosystems is proposed.

Essay 2 is a cross-national study of entrepreneurial ecosystems in Edinburgh (UK) and Madison (USA). The study investigates the development of entrepreneurial ecosystems around two research-intensive universities, which have a long history in stem cell innovation. The essay highlights the effects of cultural artefacts on micro-level behaviours. The influence of behaviour and cognition on the development of entrepreneurial ecosystems is modelled. This reveals different development paths for similar ecosystems.

Essay 3 explores the emergence and development of entrepreneurial ecosystems, and considers how these help drive technology-based economies. More specifically, the study explores technology transfer and contextual factors across three regenmed ecosystems (Edinburgh, Madison, and Moscow) to reveal the emergence of entrepreneurial ecosystems at the U-I boundary. Findings show that ecosystem and venture characteristics emerge from institutional characteristics, micro-level cognition and regional context. Additionally, university culture and entrepreneurial coping strategies generate a typology for spinouts within the ecosystem.

Collectively, these three essays reveal novel phenomena explaining how ecosystem actors make sense of uncertainty and how this influences the emergence of entrepreneurial ecosystems at the U-I boundary. Additionally, they reveal the importance of context in the venturing process and in entrepreneurial ecosystem dynamics. This provides important contributions to theories of entrepreneurial behaviour, entrepreneurial ecosystems and technology transfer. These scholarly contributions impart important practical implications.

Abbreviations

BioQuarter	The Edinburgh BioQuarter
BMI	Business model innovation
CAQDAS	Computer assisted qualitative data analysis software
CEI	Center for Entrepreneurship and Innovation
CREI	Center for Research, Education and Innovation
EOE	Experimentally Organized Economy
ESC	Embryonic stem cells
ESRC	Economic and Social Research Council
ERI	Edinburgh Research and Innovation
IP	Intellectual property
iPSC	Induced pluripotent stem cells
MIT	Massachusetts Institute of Technology
PEU	Perceived environmental uncertainty
Regenmed	Regenerative medicine
RMEE	Regenerative medicine entrepreneurial ecosystems
SCRM	Scottish Centre for Regenerative Medicine
SCRMC	Stem Cell and Regenerative Medicine Center
SCSCR	Skoltech Center for Stem Cell Research
Skoltech	The Skolkovo Institute of Science and Technology
TTO	Technology transfer office
UEBS	University of Edinburgh Business School
U-I	University-industry
VC(s)	Venture capitalist(s)
WARF	Wisconsin Alumni Research Foundation
WID	Wisconsin Institute for Discovery

Table of contents

List of figures

List of tables

Part I

Chapter 1: Introduction

> "*...we looked to create a spin out company…Because of the sort of links to the university and regenmed, we wanted to get the university engaged – that was a bloody nightmare…my negativity probably is a bit harsh to some extent…spin outs are not something they want to get involved with."* (Executive – regenmed support entity engaged in supporting academic commercialisation)

The triple helix of university-industry-government has resulted in the birth of the 'entrepreneurial university' (Etzkowitz, 2003a; 2003b). An entrepreneurial university is one that practices academic entrepreneurship and strategically adapts the entrepreneurial culture across the organisation, whilst encompassing technology transfer activities (Yosuf and Jain, 2010). Various mechanisms to transfer technology exist, including knowledge-related collaboration by academic researchers with non-academic organisations, licensing of inventions and spinout venture creation (Perkmann et al., 2013). To encourage technology transfer activities, universities and their technology transfer office (TTO) have implemented various incentives structures (Friedman and Silberman, 2003), and at the same time have encouraged an entrepreneurial culture to support commercialisation activities at the university-industry (U-I) boundary (Wright et al., 2004).

Commercialisation activities at the U-I boundary are highly uncertain, especially in technology-intensive fields where uncertainty is often irreducible (Santos and Eisenhardt, 2009). When uncertainty is high, entrepreneurs struggle to identify and assemble key resources necessary for venture development and growth (Alvarez and Barney, 2005). High levels of uncertainty challenge entrepreneurial decision-making (Milliken, 1987), requiring entrepreneurs to address uncertainty (Lipshitz and Strauss, 1997). Ventures that successfully address uncertainty can

expect greater success and firm value (Sirmon et al., 2007). Thus, uncertainty is inseparable from entrepreneurship and managerial decision-making. Yet, our understanding of uncertainty, and how entrepreneurs cope with it, is relatively underdeveloped. Therefore, the relationships between uncertainty and entrepreneurial decision-making and venturing, especially in high-technology sectors, warrant further attention. In particular, there is limited understanding of the influence of institutional context on entrepreneurial behaviour (Jennings et al., 2013; Nelson, 2014).

When uncertainty is high, ecosystem participants must manage uncertainty and make sense of the unfamiliar (Cornelissen and Clarke, 2010; Weick, 1995). Sensemaking is a process of meaning construction (Cornelissen, 2012), providing entrepreneurs with a viable narrative (Weick, 1995). During commercialisation activities, sensemaking assists entrepreneurs to cope with uncertainties (Cornelissen and Clarke, 2010; Hill and Levenhagen, 1995) and deal with mistakes or failures (Byrne and Shepherd, 2013; Cardon et al., 2011). Yet, the unique role of sensemaking, particularly as entrepreneurs explore unfamiliar opportunity sets or create entirely new markets, warrants further attention (Grégoire et al., 2011).

Along with research and teaching activities, university technology transfer and commercialisation activities are key elements driving entrepreneurial ecosystems (Audretsch, 2014). While scholars have explored ecosystems via studies on clusters (Porter, 1998; 2000) and innovation systems (Adner, 2006; Cooke et al., 1997), generally these studies have failed to recognise the role of the entrepreneur within the ecosystem. The entrepreneur, as a central actor within the ecosystem, is a distinguishing factor of entrepreneurial ecosystems. Entrepreneurs are required to make decisions under high levels of uncertainty (Alvarez et al., 2013). In doing so, they must be competent (Eliasson and Eliasson, 1996). Venturing under uncertainty requires experimentation (Eliasson and Eliasson, 1996; Carlson and Eliasson, 2003; Johansson, 2010), which drives entrepreneurial ecosystem dynamics, including economic growth. Both experimentation and competency can be explained via consideration of the experimentally organized economy (EOE) and competence bloc theory. Despite the importance of entrepreneurial ecosystems, the emergence of

entrepreneurial ecosystems at the U-I boundary is an understudied phenomenon (Audretsch et al., 2014; Thomas and Autio, 2014).

Venturing at the U-I boundary and the development of entrepreneurial ecosystems is context specific (Zahra et al., 2014). At the U-I boundary, context is a key driving force to help explain entrepreneurial behaviour and commercialisation activities (Nelson, 2014). Ecosystem participants are embedded in a wider socio-cultural context, which accounts for differences in micro-level entrepreneurial activities (Autio et al., 2013; McMullen and Shepherd, 2006), and both national and regional differences (Garud et al., 2014; Zahra and Wright, 2011). However, a contextualised view of entrepreneurship requires further attention, especially as we attempt to understand the what, how and why of entrepreneurial activities at the U-I boundary (Welter, 2011) and differences across nations (Bruton et al., 2013).

Given the lack of understanding towards uncertainty, decision-making and entrepreneurial ecosystems, this PhD thesis investigates entrepreneurial behaviour under irreducible uncertainty and the development of entrepreneurial ecosystems at the U-I boundary. More specifically, this investigation explores the following research question: **"How does irreducible uncertainty affect entrepreneurial behaviour and the development of entrepreneurial ecosystems at the U-I boundary?"** In answering this research question, several sub-questions are employed across three independent empirical studies (essays). In essay 1, entrepreneurial sensemaking and decision-making under irreducible uncertainty are explored via the following research questions:

> **Research sub-question 1**: How do regenerative medicine ecosystem participants make sense of highly uncertain venturing contexts?
>
> **Research sub-question 2**: What are the unique features of collaborative knowledge development in regenerative medicine venturing?

Essay 2 addresses the following research questions in order to progress understanding of the development and dynamics of entrepreneurial ecosystems at the U-I boundary:

Research sub-question 3: How does micro-level cognition and behaviour differ across ecosystems?

Research sub-question 4: Why do apparently similar entrepreneurial ecosystems develop differently?

Finally, building upon essays 1 and 2, essay 3 considers the following research questions through the lens of the EOE and competence bloc theory:

Research sub-question 5: What is the role of the university and the technology transfer process in assisting with the emergence and development of entrepreneurial ecosystems at the university-industry boundary?

Research sub-question 6: How does context influence entrepreneurial ecosystem development?

While each of the three essays can be read independently, each essay is connected and centred on the principal research question of understanding the effects of uncertainty on entrepreneurial behaviour and the development of entrepreneurial ecosystems. To address these research questions, the regenerative medicine (regenmed) industry is utilised as a study context.

The regenmed industry provides a useful setting to study ecosystem development at the U-I boundary. Regenmed venturing is disproportionately driven by university research. Venturing in regenmed presents unusually high levels of uncertainty associated with complex and unresolved regulatory and intellectual property (IP) regimes. This limits entrepreneurial planning, hinders the identification of key capabilities and prevents *ex ante* validation of business models (George and Bock, 2012). The development of a regenmed ecosystem depends heavily on the actions of individual entrepreneurs (Wright et al., 2012b), but emerges from a highly institutionalised framework (Walshok et al., 2014; Zahra and Wright, 2011).

Findings from this PhD research reveal novel phenomena explaining how

ecosystem participants make sense of uncertainty during the venturing process and how this influences entrepreneurial ecosystem development. Additionally, by exploring technology transfer at the U-I boundary, this investigation reveals how entrepreneurial ecosystems emerge and highlights the importance of a contextualised view of entrepreneurial processes. In doing so, this PhD research contributes to theories of entrepreneurial behaviour, ecosystem emergence and development, technology transfer, and contextual influences on entrepreneurial activities. These contributions have important theoretical and practical implications. A summary of each of the three essays is provided in Table 1.1.

Table 1.1. Overview of empirical studies

Essay	Study Objectives	Study Questions	Methods	Findings
1	Provide deeper insights into entrepreneurial cognition and decision-making under irreducible uncertainty.	- How do ecosystem participants make sense of highly uncertain venturing contexts? - What are the unique features of collaborative knowledge development in regenmed venturing?	Mixed-methods. Long-form interviews and pilot online survey.	A model of sensemaking process under uncertainty is proposed. This states: perceived environmental uncertainty and institutional entrepreneurial culture affect an individual's preferred coping strategy. The chosen coping strategy then influences both the generation of venture narratives as well as collaboration efforts. A key purpose of the venture narrative is the legitimisation of the firm's innovation or business model.
2	Provide a rich understanding of the dynamics of entrepreneurial ecosystem development at the U-I boundary.	- How does micro-level cognition and behaviour differ across ecosystems? - Why do apparently similar entrepreneurial ecosystems develop differently?	Qualitative. Long-form interviews (and pilot online survey).	A model of entrepreneurial ecosystem development under uncertainty is proposed. Behavioural differences across ecosystems, driven by perceived environmental uncertainty and culture, results in different ecosystem development paths (despite ecosystems being similar).
3	Provide a deeper understanding of the emergence and development of entrepreneurial ecosystems at the U-I boundary, with a focus on nascent entrepreneurial ecosystems operating within unique socio-cultural contexts.	- What is the role of the university and the technology transfer process in assisting with the emergence and development of entrepreneurial ecosystems at the university-industry boundary? - How does context influence entrepreneurial ecosystem development?	Qualitative. Long-form interviews (and pilot online survey).	The findings reveal a framework for entrepreneurial ecosystem emergence and development at the U-I boundary, and illustrates how this differs within distinct contextual settings. A typology of spinout ventures is also proposed based on university culture and how regenmed entrepreneurs cope with uncertainty.

(Source: Author)

1.1. Motivations

Unpacking uncertainty, whether absolute or perceived, is not well explained (Ashill and Jobber, 2010; Lueg and Borisov, 2014). Foundational theories of entrepreneurial cognition, behaviour and opportunity discovery incorporate uncertainty as an intrinsic or causal factor. Yet, extremely limited theory exists on how entrepreneurs perceive or account for uncertainty during or after venture formation. To date, there have also been limited efforts to distinguish and unpack the interconnected cultural and cognitive drivers of entrepreneurial behaviour around entrepreneurial universities (Hayton and Cacciotti, 2013; Hayton et al., 2002). In particular, the impact of university policy, practice and culture on micro-level entrepreneurial cognition and behaviour are not well explored (Jennings et al., 2013). The limits of prior theoretical and empirical research on uncertainty are especially problematic for entrepreneurship scholars.

At the U-I boundary, venturing is difficult and challenged by high levels of uncertainty. Entrepreneurs looking towards venturing activities must address and make sense of this uncertainty (Hill and Levenhagen, 1995). Despite a growing body of research on sensemaking, particularly its importance in the study of organisations, research remains fragmented (Maitlis and Christianson, 2014; Sandberg and Tsoukas, 2015). There is little understanding of the fundamental mechanisms that activate, influence and enable sensemaking. Whilst recent research has investigated specific cognitive patterns, which link meaning-making to entrepreneurial behaviour (Byrne and Shepherd, 2013), the roles of affect-based patterns in sensemaking remain understudied in the entrepreneurial literature (Maitlis et al., 2013). In particular, there is limited information on how entrepreneurs make sense of the venturing process under conditions of irreducible uncertainty. Entrepreneurial coping strategies to uncertainty are potentially important but poorly understood mechanisms, linking institutional context to entrepreneurial activities and action (Autio et al., 2014).

Entrepreneurial ecosystems are crucial for regional and national economics. The emergence and development of entrepreneurial ecosystems has become a critical consideration in university (Audretsch, 2014; Graham, 2014) and government (Isenberg, 2010; Mason and Brown, 2014) policy making. While the emergence and

dynamics of entrepreneurial ecosystems is clearly important, our understanding remains limited (Autio et al., 2014; Thomas and Autio, 2014). This is precisely the situation when considering the effects of institutional characteristics and university-based commercialisation activities on ecosystems (Audretsch et al., 2013; Audretsch et al., 2014; Wright, 2013). Additionally, the role of the academic entrepreneur has generally been ignored when considering the contributions of universities and TTOs to ecosystem economics (Wright et al., 2012b).

Entrepreneurial activities depend on specific contextual factors (Aldrich and Fiol, 1994; Zahra and Wright, 2011). Institutional contexts drive entrepreneurial action but differ across ecosystems (Autio et al., 2013; Bowen and De Clercq, 2008). However, the role of context is often overlooked in entrepreneurship studies (Autio et al., 2014; Welter, 2011; Zahra et al., 2014), which provides opportunities for further theory development. The influence of institutional context on individual-level behaviours has generally been ignored (Nelson, 2014). Whilst research has been directed towards understanding the effects of context on entrepreneurship across nations (Levie et al., 2014), limited research exists on context-embedded theory in emerging economies (Bruton et al., 2013; McCarthy and Puffer, 2013; Morris et al., 2013). This presents an opportunity to investigate institutional contexts in emerging economies, and the effects on entrepreneurial behaviour and ecosystem development in comparison to more Westernised economies.

1.2. Theoretical framing and research questions

Venture formation and growth requires entrepreneurs to manage uncertainties. Since opportunity exploitation and new venture formation are key determinants of entrepreneurial ecosystems, entrepreneurial responses to uncertainty during venturing represent a fruitful area for investigation. This PhD research explores entrepreneurial behaviour and the development of entrepreneurial ecosystems at the U-I boundary. In doing so, the stem cell-based regenmed field serves as an edge case for understanding how micro-level entrepreneurial cognition is linked to culture at the university and the implications for the development of entrepreneurial ecosystems. To investigate these phenomena, this PhD investigation asks:

"**How does irreducible uncertainty affect entrepreneurial behaviour and the development of entrepreneurial ecosystems?"** (Principal PhD research question)

Exploring the current literature on uncertainty, ecosystems and academic entrepreneurship can emphasise the importance of this research and highlight areas that warrant further investigation.

1.2.1. The nature of uncertainty and entrepreneurial sensemaking

The distinctions between *risk* and *uncertainty* have been relatively well developed across a variety of literatures (c.f. Knight, 1933; Milliken, 1987). Risk deals with the probabilities of a particular decision and future outcomes being known (Knight, 1933). In contrast, with uncertainty entrepreneurs are unable to predict the outcomes of a particular decision and the future remains unknown (Milliken, 1987). Thus, risk is about known unknowns, whereas uncertainty is about unknown unknowns. However, confusion has often surrounded the use of the term uncertainty, since scholars have often used uncertainty, ambiguity, risk and volatility interchangeably, and used environmental uncertainty to describe both environmental and individual states (Buchko, 1994).

Environmental uncertainty has, and remains, an important construct for management scholars (Duncan 1972; Knight, 1933). It plays a central role in entrepreneurship studies, assisting our understanding of how firms manage their resources under uncertainty (Sirmon et al., 2007), and how firms and entrepreneurs organise and act under uncertainty (Alvarez and Barney, 2005; McKelvie et al., 2011; McMullen and Shepherd, 2006; Sarasvathy and Berglund, 2010). While the measurement and conceptualisation of environmental uncertainty remains open to debate (Ashill and Jobber, 2010; Downey and Slocum, 1975), Milliken's (1987) definition of perceived environmental uncertainty (PEU) provides a valuable description. Milliken's definition explains environmental uncertainty to exist as three distinct types, which include state, effect and response uncertainties. *State* uncertainty refers to a lack of clarity on the venture's current status. The inability of individuals to predict the impact of environmental changes on the firm is referred to

as *effect* uncertainty. Finally, *response* uncertainty reflects the difficulties in foreseeing the consequences of a response choice (Ashill and Jobber, 2010; Milliken, 1987). Perceptions of environmental uncertainty play a significant role in determining how managers and entrepreneurs respond to the environment (Ashill and Jobber, 2010). It is Milliken's (1987) definition of PEU that is utilised for this PhD investigation.

Entrepreneurs face multiple sources and types of uncertainty during venturing activity. Venture success depends on entrepreneurs recognising and responding to uncertainties (McKelvie et al., 2011). The appropriate responses to uncertainty can lead to firm growth and value (Sirmon et al., 2007). During venture formation, entrepreneurs must acquire scarce resources, capabilities and partners, often with limited knowledge or prior experience (Alvarez and Barney, 2005). Collaboration and knowledge exchange mechanisms are especially important under high levels of uncertainty as they enable the development of deep capabilities needed to exploit opportunities (George et al., 2008; Powell et al., 1996). This is particularly relevant in nascent, knowledge-intensive fields where success likely depends on acquisition and deployment of unique, specialised knowledge resources. Yet, high levels of perceived uncertainty places severe limits on entrepreneurial decision-making (Milliken, 1987), even as entrepreneurs struggle to identify which resources to assemble and coordinate (Alvarez and Barney, 2005).

Uncertainty appears to be a simultaneously necessary and restricting parameter for entrepreneurial action (McMullen and Shepherd, 2006). Since uncertainty, in contrast to risk, cannot be resolved via data gathering or analysis (Knight, 1933), entrepreneurs cannot manage uncertainty. They can only be prepared for contingencies and cope with living with the unknown. Entrepreneurs transform uncertainty into opportunities and leverage uncertainty to generate successful ventures (McKelvie et al., 2011; York and Venkataraman, 2010). At the micro-level, entrepreneurial response to uncertainty depends in part on cultural norms and values, but also on a temporally-generated narrative that relies on firm-level social construction (Dimov, 2007a; Downing, 2005; McMullen and Dimov, 2013; Wennberg et al., 2013). However, there is extremely limited theory on how entrepreneurs perceive or account for uncertainty during or after venture formation.

More specifically, the relationship between uncertainty and entrepreneurial cognition, decision-making and venturing warrants further attention. This is particularly the case when considering high-technology sectors, where uncertainty is explicitly linked to venturing activities.

A key element of venturing amidst uncertainty in high-technology sectors is establishing and maintaining legitimacy. Suchman (1995) defines legitimacy as *"a generalised perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions."* When uncertainty is high, legitimacy can enable entrepreneurs and their ventures access to critical resources, which can assist venture growth (Zimmerman and Zeitz, 2002). Legitimisation of the entrepreneur, their innovation and their venture is important during the emergence of new markets (Aldrich and Fiol, 1994; Navis and Glynn, 2010). Entrepreneurial narratives or stories are crucial mechanisms for legitimisation practices (Garud et al., 2014; Lounsbury and Glynn, 2001; Martens et al., 2007), and are important sensemaking devices (Humphreys et al., 2011; Weick, 1995).

When PEU is high, sensemaking is especially valuable because it helps individuals understand and interpret uncertainty, and assists them to take action (Maitlis and Christianson, 2014; Weick, 1995). Originally developed by Karl Weick (1979), sensemaking is the process of meaning construction whereby individuals seek to comprehend uncertain or ambiguous events (Brown et al., 2015; Weick, 1995). While there is no single definition of sensemaking, in their extensive review of the sensemaking literature, Maitlis and Christianson (2014) define sensemaking as *"a process, prompted by violated expectations, that involves attending to and bracketing cues in the environment, creating inter-subjective meaning through cycles of interpretation and action, and thereby enacting a more ordered environment from which further cues can be drawn."*

During venture formation and growth, sensemaking activities are critical since they help individuals grapple with the inherent uncertainties associated with venturing and assists them in making sense of the unknowable (Weick, 1995). Sensemaking is context specific (Sandberg and Tsoukas, 2015), and is affected by cognition (Bogner and Barr, 2000) and emotions (Bartunek et al., 2011; Maitlis et al.,

2013). While sensemaking has often been considered as being retrospective (Weick, 1995), in the context of new ventures, it can also be prospective (Cornelissen and Clarke, 2010; Ybema, 2010). Uncertainty and legitimacy associated with new venture creation mediate sensemaking mechanisms (Cornelissen and Clarke, 2010). Thus, micro-level decisions relating to the venture are influenced by sensemaking devices (Brown et al., 2015; Colville et al., 2013; Webber and Glynn, 2006).

Since exploiting opportunities requires uncertain decision-making (Alvarez et al., 2013), entrepreneurs may utilise a variety of coping mechanisms to make sense of uncertainty and avoid paralysis. Some entrepreneurs may be more effective in organising, acting and making sense of uncertainty (Alvarez and Barney, 2005; Korsgaard et al., 2015; Sarasvathy, 2001). Fundamentally, sensemaking is a cognitive process. Entrepreneurs use cognitive frames to actively interpret uncertain environments (Weber and Mayer, 2014), which may assist in organisational change (Barr et al., 1992) and decision-making under technological uncertainty (Kaplan, 2008). Narratives of emotion and cognition are important sensemaking devices (Byrne and Shepherd, 2013), assisting venturing under uncertainty. However, despite a significant amount of research on cognition in entrepreneurship, there have been further calls for research that provides a richer understanding of cognitive processes either during *de novo* venture formation or in nascent markets (Grégoire et al., 2011).

The underlying mechanisms of sensemaking under uncertainty remain vague (Sandberg and Tsoukas, 2015). Limited scholarly attention has addressed the cognitive processes and behavioural responses to uncertainty (Hayton and Cacciotti, 2013). More specifically, little is known about patterns of sensemaking cognition, especially when PEU is high. Additionally, the implications of these cognitive processes on the development of entrepreneurial ecosystems at the U-I boundary require further attention. With this in mind, essay 1 of this PhD thesis addresses this lack of understanding through the following research sub-question:

> **"How do regenerative medicine ecosystem participants make sense of highly uncertain venturing contexts?"** (Essay 1 research sub-question)

1.2.2. Entrepreneurial ecosystems

Research exploring entrepreneurial ecosystems has been directed towards the study of clusters (Porter, 1998; 2000), networks (Stuart and Sorenson, 2005), social capital (Feldman and Zoller, 2012; Qian et al., 2013), innovation systems (Adner, 2006; Fritsch, 2001; Zahra and Nambisan, 2011) and the central role of the academic institution (Audretsch, 2014; Audretsch and Feldman, 1996).

Work on clusters is closely linked to entrepreneurial ecosystems. Alfred Marshall in the 1920s first emphasised the benefits from the co-location of firms, such as the availability of knowledge. Porter (2000) defines an industrial cluster as *"a geographically proximate group of interconnected companies and associated institutions."* The concentration of these companies and institutions benefits transaction costs and improves access to critical resources, including access to skilled human capital (Bell et al., 2009). Within clusters, the co-location of firms, their linkages with each other, their embeddedness, and their competition with each other can result in enhanced firm performance and regional development (Delgado et al., 2010; Feldman et al., 2005). Clusters are often specialised around a particular industry (Maine et al., 2010) and regional idiosyncrasies account for variations in cluster performance (Kenney and von Burg, 1999; Saxenian, 1996).

Studies on innovation systems emphasise three basic characteristics: a common set of goals and objectives; a shared set of knowledge and skills; and dependencies amongst ecosystem members (Nambisan and Baron, 2013). Similarly to clusters, innovation ecosystems rely on loosely interconnected firms and institutions that coevolve around a shared set of technologies and knowledge. Yet, central to these ecosystems is innovation, which reflects the commercialisation of new and existing knowledge in novel ways to develop new products and services (Cooke, 2001). Within innovation ecosystems, public policies and supportive cultural and institutional artefacts are necessary to drive innovation (Doloreux and Parto, 2005; Guillaume and Doloreux, 2011). Innovation ecosystems have emerged as important contexts for entrepreneurship (Nambisan and Baron, 2013). These entrepreneurial regional innovation systems highlight the importance of venture capital, entrepreneurs, scientists, market demand, and incubators that support innovation (Asheim and Coenen, 2006; Cooke, 2007). Yet, despite the emphasis of

the entrepreneurs in entrepreneurial regional innovation systems, with a few exceptions (Acs et al., 2014; Stam, 2015), the central role of the entrepreneur in ecosystems is largely overlooked.

Entrepreneurial ecosystems became popularised through the works of Isenberg (2010) and Feld (2012). While entrepreneurial ecosystems draw heavily upon clusters and innovation systems, within entrepreneurial ecosystems the emphasis is on the role of the entrepreneur, which is missing from the cluster and innovation system literature (Stam, 2015). With this in mind, this PhD investigation places the entrepreneur at the centre of the ecosystem and defines an entrepreneurial ecosystem as *a set of interdependent and competent actors and infrastructure capable of selecting, recognising, diffusing, and commercially exploiting opportunities in such a way that they support productive entrepreneurship.* The emergence and development of such an ecosystem at the U-I boundary requires: 1) entrepreneurs (including academic entrepreneurs) that are able to identify novel and profitable innovations, 2) innovators that can combine technologies in novel ways, 3) supporting organisations and individuals that have the ability to recognise, finance and commercially progress novel opportunities, 4) an institutional culture supportive of entrepreneurship, and 5) exit markets (Eliasson and Eliasson, 1996; Eliasson and Eliasson, 2006). Productive entrepreneurship reflects any entrepreneurial activity that contributes directly, or indirectly, to net output of the ecosystem, innovative activities, aggregate welfare increases, and may also include failed ventures that support the recycling of resources within the ecosystem (Baumol, 1990; Stam, 2015).

Networks are a critical aspect of entrepreneurial ecosystems, which drive entrepreneurial activities (Hoang and Antoncic, 2003; Stuart and Sorenson, 2005). Networks support resource mobilisation (Nijkamp, 2003), and can reduce information asymmetry (Baron and Markman, 2003) and uncertainty (De Vaan, 2014). Collaborative networks are important for venture growth since they assist in resource acquisition, the development of key capabilities and enhance legitimisation (Ferreira et al., 2011; Teece and Pisano, 1994; Wiewel and Hunter, 1985). This often results in ventures achieving their strategic objectives and improving their strategic positions (Arya and Lin, 2007; Wiewel and Hunter, 1985).

Since knowledge is a fundamental aspect of entrepreneurial ecosystems, particularly the spillover of this knowledge (Audretsch and Belitski, 2013), networks are well placed to support the circulation of knowledge (Hayter, 2013; Huggins and Johnston, 2010). The value of this knowledge depends on its tacitness, content specificity and dispersion (Galunic and Rodan, 1998). Where knowledge is tacit and complex, knowledge exchange is often slow and costly (Kogut and Zander, 1992). To be valuable, entrepreneurs and new ventures must have the appropriate absorptive capacity to recognise, acquire, assimilate, transform and exploit novel knowledge (Cohen and Levinthal, 1990; Zahra and George, 2002).

Research on entrepreneurial ecosystems is underdeveloped and under-theorised (Spigel, 2015). In particular, the actual emergence of entrepreneurial ecosystems has received little attention (Thomas and Autio, 2014). Since the individual entrepreneur is central to entrepreneurial ecosystems (Stam, 2015), their competence in making decisions under uncertainty is important to the organisation of the ecosystem. To understand this human embodied competence and ecosystem organisation, this thesis now turns to consider EOE and competence bloc theory.

1.2.3. The experimentally organized economy and competence bloc theory

Entrepreneurial ecosystems at the U-I boundary contribute to economic growth (Etzkowitz, 2003; Miner et al., 2001). Whilst this growth may be explained at the macro level, micro level factors are clearly important (Stam, 2015). Exploiting opportunities requires uncertain decision-making (Alvarez, et al., 2013). Entrepreneurial ecosystem emergence and development, therefore, requires entrepreneurs to experiment with commercialisation activities and opportunities (Johansson, 2010). Thus, entrepreneurial ecosystem dynamics depends on human embodied competence. It also relies on experimental project creation and selection, and the capacity of the economic system to capture winning projects and remove losers (Carlsson and Eliasson, 2003). This forms the basis of the EOE and competence bloc theory (Eliasson and Eliasson, 1996; Johansson, 2010).

The EOE derives from the fact that there is an infinite number of ways by which factors of production can be combined within a venture. There are some

combinations that are superior to others, and other combinations that have yet to be discovered. Therefore, in order to improve these combinations and exploit opportunities, experiments are needed to test all of the best possible options (Eliasson, 1996b). Thus, the EOE provides a useful way to analyse the economy by recognising that actors are unlikely to possess perfect information and as a result, decision-making is best described as business experiments (Johansson, 2010).

A competence bloc is defined as *"the total infrastructure needed to create (innovation), select (entrepreneurship), recognise (venture capital provision), diffuse (spillovers), and commercially exploit (receiver competence) new ideas in clusters of firms. The competence bloc is dominated by human-embodied competence capital that determines the efficiency characteristics of all other factors of production, including the organisation of all economic activities that constitute the competence bloc"* (Eliasson and Eliasson, 1996: p14). Whilst EOE and competence bloc theory had often been viewed as two separate but complementing theories, Johansson (2010) proposed their integration into a single theory.

This PhD research is the first to study entrepreneurial ecosystems within an EOE and competence bloc framework. Within this framework, entrepreneurial ecosystem emergence and development is determined by the decisions made by actors within the ecosystem. These decisions are made based on limited information (Eliasson and Eliasson, 2009). Thus, venture activity is experimental and must be tested within the market (Eliasson, 1996b). Potential high-growth ventures, which reflect winning experiments, must be retained. Failing or failed ventures must be removed. Yet, EOE defines two potential errors within the ecosystem, which requires competent actors to overcome. These errors, defined at *type I and II errors* (Eliasson and Eliasson, 1996), include:

Type I error: Failing ventures/innovations are kept alive for too long.
Type II error: Winning ventures/innovations are rejected and lost.

Venture capitalists (VCs) are a critical component in the competence bloc and entrepreneurial ecosystem since they have the potential to recognise and finance (winning) nascent ventures (Eliasson and Eliasson, 1996). Yet, other actors within

the competence bloc and entrepreneurial ecosystem are important too. Table 1.2. highlights the actors in the competence bloc that can support the selection of winning ventures/innovations. These actors must ensure that they minimise type I and II errors.

Table 1.2. Competence bloc actors

1. Competent and active customers
2. Inventors/academic scientists that derive novel innovations
3. Innovators that integrate technologies in novel ways
4. Entrepreneurs that identify profitable innovations
5. Competent VCs that recognise and provide financial capital to the entrepreneurs
6. Exit markets that support ownership change
7. Industrialists that take successful innovations to industrial scale production
8. Skilled human capital

Table adapted from Eliasson and Eliasson (1996); Eliasson and Eliasson (2006); and Johansson (2010).

Within the competence bloc, entrepreneurs can be assumed to have the most critical function since they recognise, understand, select and initiate commercialisation activities with the ecosystem (Johansson, 2010). This supports Stam (2015) who places the entrepreneur at the focal point of the entrepreneurial ecosystem and is consistent with this PhD research, which emphasises the role of entrepreneurial behaviour in entrepreneurial ecosystem development. The entrepreneurs that form new ventures within the entrepreneurial ecosystem must be competent for ventures to survive and remain competitive. They must identify business opportunities and select amongst potential ideas. Additionally, they must coordinate firm activities and have the required capacity to learn from their mistakes (Eliasson, 1996a; Eliasson, 1998). This requires a specific set of competencies, as set out in Table 1.3. Thus, EOE and competency bloc theory is particularly well suited to study how individuals (competently) make decisions under high levels of uncertainty, often via experimentation, and how these decisions influence the development of entrepreneurial ecosystems

Table 1.3. Competency requirements of entrepreneurs in the EOE

Orientation
Sense of direction
Risk-taking
Selection
Identifies mistakes efficiently
Efficiently corrects mistakes
Operation
Effectiveness in managing successful experiments
Effectiveness feeding acquired experience back into orientation

Table adapted from Eliasson (1996a); Eliasson (1990); and Johansson (2010).

However, even with the entrepreneur as a central actor within the competence bloc, a high-growth entrepreneurial ecosystem requires the presence of other factors and appropriate incentives for profit sharing (Eliasson, 2000).

University and governmental policies are well placed to create the appropriate environment and incentive structures for the effective functioning of the competence bloc. This is important, since a successful competence bloc can attract firms to the bloc or encourage knowledge exchanges and partnerships between other competence bloc members. This is particularly useful for knowledge creation, which is essential for ventures to remain competitive (Johansson, 2010).

Therefore, knowledge is an important aspect within the competence bloc. Competent actors are those that are able to utilise knowledge for a specific purpose. Entrepreneurs and firms must support the spillover of knowledge for appropriate learning to occur. Since entrepreneurs and new ventures lack complete information, new knowledge is valued via market experiments (Johansson, 2010).

1.2.4. University-centred entrepreneurial ecosystems

The development of an entrepreneurial ecosystem at the U-I boundary involves interactions between the university, industry and government (Etzkowitz, 2003b). Universities can play an important role in the economics and growth of entrepreneurial ecosystems, particularly as a consequence of their research and teaching activities, knowledge transfer and formation of spinout ventures (Breznitz and Feldman, 2012; Guerrero et al., 2015).

At the U-I boundary, knowledge becomes a critical resource during new venture creation, especially in technology-intensive fields, where firms will likely need to rely on collaborations to access knowledge in order to exploit opportunities (George et al., 2008). The university assumes a central position in the creation of knowledge (Acs et al., 1994; Svensson et al., 2012), which drives commercial activity (c.f. Clark, 1998; Etzkowitz, 2004; Rothaermel et al., 2007). This has a positive impact on ecosystem dynamics (Guerrero et al., 2015). Those universities that foster an entrepreneurial culture can facilitate the spillover of knowledge (Audretsch, 2014), which is especially important for entrepreneurship (Acs et al., 2013; Ghio et al., 2015; Hayter, 2013) and ecosystem economics (Acs et al., 1994; Audretsch and Feldman, 1996; Romer, 1990). Since knowledge is clearly important during venturing, but challenged when uncertainty is high, essay 1 seeks to understand:

> **"What are the unique features of collaborative knowledge development in regenerative medicine venturing?"** (Essay 1 research sub-question)

Networks enable the spillover of knowledge, which promotes clustering effects and drives firm and ecosystem outcomes (Hayter, 2013). Yet, this is contingent on contextualised motivations and norms that effectively serve as knowledge filters (Guerrero and Urbano, 2014). Ecosystem participants are embedded within social networks. These play an important role in the entrepreneurial process (Aldrich and Zimmer, 1986; Birley, 1985; Jack, 2010), enabling access to resources and the creation and exchange of knowledge (Aldrich and Martinez, 2001; Ardichvili et al., 2002). Within emerging ecosystems, well-developed social network ties can reduce environmental uncertainty (Leyden et al., 2014). This can lead to improved venture and ecosystem performance (Boso et al., 2013). In particular, the level of network openness, network diversity and the ability to form ties with other ecosystems can influence ecosystem performance (Eisingerich et al., 2010). Strong network ties, and networks containing diverse participants, are likely to be better

positioned to leverage resources and assist with venture formation (De Vaan, 2014; Meyskens and Carsrud, 2013).

Even with access to knowledge spillovers and network externalities, venture development at the U-I boundary is uncertain and difficult. The development of *de novo* ventures at the U-I boundary and the drivers of entrepreneurial ecosystems are dependent upon institutional culture and entrepreneurial behaviour (Walshok et al., 2014; Zahra and Wright, 2011), which may differ across ecosystems (Clarysse et al., 2011). However, an understanding of the full effects of university commercial activity on the emergence and dynamics of entrepreneurial ecosystems remain limited (Audretsch et al., 2014; Autio et al., 2014; Wright, 2013). Given this limited understanding, essay 2 investigates the following research question:

> **"Why do apparently similar entrepreneurial ecosystems develop differently?"** (Essay 2 research sub-question)

1.2.5. Academic entrepreneurship

Research universities have evolved into engines of technological and economic development (Audretsch, 2014). Patent licensing and knowledge-based consulting are now complemented by industry collaborations, equity-based spinouts and even direct financial investments in technology ventures. At the same time, the institutional stability and long-term perspective of a research university creates unique tensions in supporting entrepreneurial and commercial activity (Grimadli et al., 2011). This is especially evident in the context of stem cell-based regenmed, a nascent industry combining extremely knowledge-intensive innovation and high levels of market uncertainty.

Universities across the globe have become increasingly entrepreneurial via technology transfer activities (Rothaermel et al., 2007). While there are numerous ways in which university research can be transferred at the U-I boundary (Markman et al., 2008; Perkmann et al., 2013; Salter and Martin, 2001), new venture creation has become an important and high profile translational mechanism (Djokovic and Souitaris, 2008; O'Shea et al., 2005; O'Shea et al., 2008). However, ventures formed at the U-I boundary are typically small life style ventures, which contribute little to

the ecosystem (Harrison and Leitch, 2010). University technology transfer involves the disclosure of inventions to the TTO. The TTO evaluates these inventions and may seek IP protection for the invention, usually by filing a patent application. Revenue may then be generated from the IP through the transfer of IP to an existing interested commercial party or to a spinout venture, either through licensing the right to use the IP or by transferring its title in the IP. However, despite this relatively straightforward model, policies, processes and business models for technology transfer differ between university TTOs, resulting in differences in commercialisation activities (Degroof and Roberts, 2004; Di Gregorio and Shane, 2003).

U-I collaborations are an important technology transfer mechanism, dependent upon individual, organisational and institutional contexts (Perkmann et al., 2013). Collaborations can assist ventures in acquiring new technologies and skills (Hamel et al., 1989), gaining access to financial resources (Miner et al., 1990), acquiring knowledge (Powell et al., 1996), creating economic value (Chan et al., 1997) and enhancing innovation (De Man and Duysters, 2005). In technology-intensive fields operating under high levels of uncertainty, collaborations can enable ventures to gain access to deep capabilities necessary to exploit opportunities (George et al., 2008). This can help improve the strategic position of new ventures (Eisenhardt and Schoonhoven, 1996). Yet, there are also downsides to collaboration. For example, they may result in core competencies being forfeited (Hamel et al., 1989), be time consuming (Huxham, 1996), incur costs (Gomez-Casseres, 1993) and fail to deliver (Kogut, 1989; Kale et al., 2002; Madhok and Tallman, 1998).

A key aspect driving commercialisation activities at the U-I boundary is the culture for entrepreneurship at the research institution. Traditionally a weak entrepreneurial culture has existed within the university setting (Clarysse et al., 2005). However, universities are now realising the importance of encouraging an entrepreneurial culture and there is a more positive attitude towards this, especially within the scientific disciplines (Wright et al., 2004). The non-entrepreneurial culture within universities is due to the institutional mechanisms in place (Argyres and Liebeskind, 1998). In order to address this lack of entrepreneurial activity, universities need to "deinstitutionalise" their traditional academic culture and adopt a

more commercially oriented and entrepreneurial one (Scott, 2001; Dacin et al., 2002). This involves consideration of the competitive and social external environmental pressures, as well as considering internal political, functional and social pressures (Oliver, 1992). Ultimately, the goal for the entrepreneurial university is for the acceptance of an entrepreneurial culture, which is entrenched or institutionalised within the daily operations of the university (Lozano, 2006). This culture should encourage faculty and students to commercialise their research. In achieving this goal, university management play an important role in adopting a more commercially orientated university (Gumport, 2000). Management and academics exist as separate sub-cultures, possessing conflicting values, norms and beliefs towards each other (Siegel et al., 2003). University management, therefore, need to address the structural and cultural inhibitors of change, such as excessive hierarchy, and challenge the ingrained organisational routines (Middlehurst, 2004). This may include management adopting a decentralised management policy in which academic researchers have the freedom to be more immersed in the technology transfer process. As a result of this, universities can expect to be more effective in their transfer of technology, resulting in greater innovation (Debakere and Veugelers, 2005). In the US, a bottom-up organisational approach has successfully been adopted in order to achieve a more entrepreneurial culture. This is in contrast to many European universities, which have adopted a top-down approach (Etzkowtiz, 2003a). It has been suggested that a bottom-up approach is more successful in creating an enhanced entrepreneurial culture (Goldfarb and Henrekson, 2003), however, such a drastic change towards an entrepreneurial culture may in fact rely on a combination of both a bottom-up and top-down approach (Lozano, 2006).

Micro-level factors are important for venturing activity at the U-I boundary (Wu et al., 2015). For example, university academics play an important role in commercialisation activities. Academic entrepreneurial intentions to engage in commercialisation activities are influenced by the university mission, university role models and appropriate reward structures (Huyghe and Knockaert, 2015). Yet, the role of the academic entrepreneur in ecosystem economics has been ignored (Wright et al., 2012b). Academics that engage in commercialisation activities must fulfil research-centred job requirements but modify this role-identity to one that is more

commercially orientated (Jain et al., 2009). Academics often perceive clear tensions between commercially orientated activities and academic research policies and practices (George and Bock, 2008). This results in venture development at the U-I boundary being uncertain and difficult. To date, there have been limited efforts to distinguish and unpack the interconnected cultural and cognitive drivers of entrepreneurial behaviour around entrepreneurial universities (Hayton and Cacciotti, 2013; Hayton et al., 2002). While studies have begun to explore the role of cognition in ecosystems (Nambisan and Baron, 2013), this remains an area for further development. To address the scant research in this area, essays 2 explores the following research question:

> **"How does micro-level cognition and behaviour differ across ecosystems?"** (Essay 2 research sub-question)

At the U-I boundary, the entrepreneurial culture of the institution directly impacts commercialisation efforts (Huyghe and Knockaert, 2015). Departmental support for commercialisation activities may also be important in venture formation (Rasmussen et al., 2014). The rules, norms and routines of the organisation, that guide social behaviour within the institution, have influenced participants who span the boundary (Scott, 2004). *De novo* ventures originating at the U-I boundary experience imprinting effects associated with resource availability and prevailing cognitive frameworks (Kimberly, 1975). Thus, the entrepreneurial university plays an important role within entrepreneurial ecosystems (Audretsch, 2014; Breznitz and Feldman, 2012; Guerrero et al., 2015). However, since our understanding of the links between university characteristics and entrepreneurial ecosystems remains limited (Audretsch et al., 2013; Audretsch et al., 2014), essay 3 addresses:

> **"What is the role of the university and the technology transfer process in assisting with the emergence and development of entrepreneurial ecosystems at the university-industry boundary?"** (Essay 3 research sub-question)

1.2.6. Context in entrepreneurship

Entrepreneurial opportunities within a specific ecosystem either exist and await discovery by the entrepreneur, or are created by the entrepreneur (Alvarez and Barney 2007). While the opportunity exploitation/discovery conversation is open to debate, constant to these two views is that both depend on context. That is to say, external factors influence entrepreneurial processes based on time and place (Baumol, 1990; Gartner, 1995). Thus, context clearly affects entrepreneurial behaviour (Johns, 2006).

Scholars have explored the importance of context in entrepreneurship through considering national, regional and industry context-centric perspectives. For example, De Clercq et al. (2014) consider the influence of national culture on national-level entrepreneurial activity. Regional-level studies have helped our understanding of why some regions are more entrepreneurial than others (Florida and Kenney, 1988; Powell et al., 2012; Saxenian, 1996). Studies at the industry level have revealed how industries evolve (Schoonhoven and Romanelli, 2001). Institutional and social contexts have helped explain entrepreneurial entry into specific industries (Welter and Smallbone, 2008). Therefore, geographical, institutional and industrial contexts, which incorporates socio-cultural factors, are clearly important to aid our understanding of the what, how and why of entrepreneurship (Welter, 2011). University contextual settings are also well placed to explore entrepreneurial activities and ecosystem development (Audretsch, 2014; Fetters et al., 2010; Rothaermel et al., 2007; Wright, 2012).

However, despite the importance of context-centric studies, such approaches have been overlooked (Autio et al., 2014; Zahra et al., 2014), particularly qualitative studies that can capture the richness and diversity of the particular context (Welter, 2011). Therefore, investigating the role of context in the emergence and development of entrepreneurial ecosystems is an important step forward in our understanding. To address this, essay 3 asks:

> **"How does context influence entrepreneurial ecosystem development?"** (Essay 3 research sub-question)

An important stream of research investigates the influences of cognition and culture on entrepreneurship across nations (Hayton and Cacciotti, 2013; Manolova et al., 2008; Mitchell et al., 2000) but focuses predominantly on developed economies. While this research is important to help explain theories of entrepreneurial ecosystem emergence, it is not sufficient to explain entrepreneurial ecosystem development in less developed or emerging economies (Elenkov, 1998). With this in mind, investigating the influences of cognition and culture on entrepreneurial ecosystems in an emerging economy is particularly justified (Puffer et al., 2010). Thus, this PhD research investigates entrepreneurial ecosystem emergence and development in Russia, since this represents an interesting area for further theory development (Bruton et al., 2013; McCarthy and Puffer, 2013; Morris et al., 2013).

1.2.7. Regenerative medicine ecosystems

To address the research questions previously discussed, and to assist our understanding of entrepreneurial behaviour and ecosystem development under irreducible uncertainty, this PhD investigation utilises the regenmed sector as a study context. Regenmed belongs to the field of life sciences and is defined as the *"process of creating living, functional tissues to repair or replace tissue or organ function lost due to age, disease, damage or congenital defects"* (NIH, 2006). It encompasses the use of stem cells, which are cells that develop into different cell types in the body. Stem cells can be categorised into three main groups: Tissue stem cells, embryonic stem cells (ESCs) and induced pluripotent stem cells (iPSC). Each are capable of renewing themselves and being induced to become tissue- or organ-specific cells (NIH, 2015).

Broadly speaking, stem cell ventures fall into services, tools, diagnostics or therapeutic ventures. However, high levels of irreducible uncertainty have thwarted venturing in regenmed. For this PhD research, irreducible uncertainty is defined as *uncertainty that cannot be reduced by information gathering or analysis, and which reflects an unknown but not an unimaginable future* (Gloria-Palermo, 1999). The regenmed sector faces complex political and social forces, uncertain regulatory frameworks, unresolved IP rights issues, and untested production and distribution systems (Hogle, 2014). Attracting funding beyond early stage research funding is

challenging. Nowhere is this more evident than in ventures focusing on therapeutics, since the timescale to take therapeutics to market far exceeds the time limits of investors. The major pharmaceutical companies and investors have been reluctant to make any significant investment in early stem cell technologies due to the high levels of uncertainty (Giebel, 2005; McKernan et al., 2010).

The technological requirements of regenmed commercialisation suggest that ventures must collaborate for access to critical resources, including knowledge (George et al., 2008). New regenmed ventures will require knowledge spillovers, and access to human capital and networks for ecosystem formation (Saxenian, 1996; Zucker et al., 1998). This is likely to be contingent on ecosystem-specific factors (Fini et al., 2011). Regenmed firms must operate with little or even no slack in their resource pool, which limits product-market and business model exploration and testing (Bock et al., 2012; George, 2005). Novel business models and capability development processes will be required to support venture growth in regenmed venturing, but are currently unproven and potentially unknowable in advance (George and Bock, 2012; Heirman and Clarysse, 2004). In the short term, regenmed ventures focusing on tools, diagnostics and services may be the most viable commercialisation options, since there are no clear commercialisation pathways for therapeutics. However, in reality a blockbuster therapeutic application is likely to be the more attractive option, despite the lack of a clear commercialisation pathway. Studies of regenmed business model development must address resource assembly processes that may differ across ecosystem boundaries (Clarysse et al., 2011; Grimaldi et al., 2011).

The regenmed industry is predominately driven by scientists and clinical entrepreneurs rather than established life science companies (McKernan et al., 2010; Trounson et al., 2011). Thus, the investment and infrastructure requirements of regenmed commercialisation currently favour entrepreneurial activities with explicit links to university research programmes. Since regenmed venturing is disproportionately driven by university-led stem cell research, inherent tensions of culture and expectation across the U-I boundary confound new venture formation. The stem cell academic entrepreneur faces considerable challenges engaging in commercialisation activities. Whilst universities may encourage commercialisation

activities, the decision to become an inventing entrepreneur in the stem cell field may be controversial, difficult and uncertain (George and Bock, 2008). The stem cell scientist may perceive commercially orientated activities to interfere with their research and career (Etzkowitz, 1998). The inventing academic entrepreneur that participates in commercialisation activities will need to modify their role-identity, shifting from a scientific orientation to a more market-driven approach (Jain et al., 2009). Yet, this creates tensions for the individual, university and the venture, precisely because the embedded culture within academic institutions preferentially focuses on research and publications at the expense of commercialisation activities (Decter et al., 2007). While the academic stem cell entrepreneur is essential for commercialisation activities, venturing at the U-I boundary will also depend on the university TTO.

The barriers surrounding regenmed venturing present major problems to university TTOs, since they are typically focused on short-term cash maximisation and are extremely risk-averse (Phan and Siegel, 2006). Furthermore, given the different processes and business models in place at university TTOs, we can expect this to impact on stem cell venturing. Even in the absence of these problems and assuming the TTO and universities' policies and processes are well codified, stem cell venturing also creates unique tensions for the TTO's social mission, and the balance between potential social good and the obligation to engage in commercial activities is open to controversy. This perceived social value is likely to challenge the opinion that TTO financial returns should accrue to the TTO and the university. Given this controversy and the novelty surrounding stem cell technology, an approach to foster stem cell venturing could involve legitimacy building by the TTOs. This would involve the TTO being engaged in lobbying and shaping external actors' perceptions of the technology, but at the same time shielding the technology from the institutional environment in those situations where it is hostile to the innovation (Jain and George, 2007).

Venturing in regenmed has not been rigorously studied. The field of regenmed represents a rich context to investigate entrepreneurial behaviour under uncertainty and the development of entrepreneurial ecosystems at the U-I boundary for several reasons. First, it is a sector that is dominated by high levels of irreducible

uncertainty. Second, venturing in regenmed is primarily driven by university-based stem cell research. Third, it is a nascent industry with few fully developed ecosystems.

1.2.8. Theoretical frameworks: Integration

The theoretical frameworks adopted for this PhD research are suitably positioned to investigate entrepreneurial behaviour and the development of entrepreneurial ecosystems at the U-I boundary under uncertainty.

Entrepreneurial ecosystem emergence and development at the U-I boundary contributes to economic growth (Etzkowitz, 2003a; Miner et al., 2001). This output-oriented approach has limited investigations of important micro-level factors (Stam, 2015; Wright et al., 2012b). The role of the university is an important element of entrepreneurial ecosystem economics (Audretsch, 2014; Guerrero et al., 2015). Central to the university's role in ecosystem emergence and development is the academic scientist, who alongside their formalised teaching and research role, has become increasingly encouraged to participate in technology commercialisation activities (George and Bock, 2008; Jain et al., 2009). Whilst there are many different pathways that university research can be commercially exploited (Markman et al., 2008), the formation of spinout ventures is a critically important one for ecosystem emergence and development. Yet, the formation and development of spinout ventures at the U-I boundary is difficult and highly uncertain (George and Bock, 2008).

High uncertainty at the U-I boundary requires entrepreneurs to make sense of venturing uncertainties in order to ensure venture formation and growth (Alvarez and Barney, 2005; Maitlis and Christianson, 2014; Weick, 1995). In particular, when uncertainty is high entrepreneurs must engage in coping mechanisms to avoid paralysis (Lazarus and Folkman, 1984; Milliken, 1987). Additionally, since entrepreneurs do not possess perfect market information, venturing at the U-I boundary requires entrepreneurs to experiment with commercialisation/venturing activities (Johansson, 2010). Entrepreneurial ecosystem emergence and development relies on entrepreneurs, and other actors within the ecosystem, to competently make decisions under uncertainty (Carlson and Eliasson, 2003; Eliasson and Eliasson,

1996). However, these entrepreneurial processes and sensemaking activities at the U-I boundary are context specific (Autio et al., 2014; Welter, 2011; Zahra et al., 2014) and likely differ across ecosystems (Autio et al., 2013; Bowen and De Clercq, 2008).

Essay 1 utilises theories of sensemaking and coping to explain how entrepreneurs make sense of the high levels of venturing uncertainty at the U-I boundary. This is further developed in essay 2 to explain how sensemaking mechanisms to uncertainty, and technology transfer activities at the U-I boundary, differ across two similar ecosystems and the influence on entrepreneurial ecosystem development paths. Essay 3 builds even further and utilises theories of the EOE and competency blocs to specify the role of venturing activities at the U-I boundary and the importance of micro-level (and regional) competency to entrepreneurial ecosystem emergence. Additionally, in consideration of an emerging economy, essay 3 provides a more nuanced understanding of the role of context in entrepreneurial activities.

1.3. Contributions

In addressing each of the aforementioned research questions, this PhD investigation makes several important contributions to theories of entrepreneurial behaviour, ecosystem emergence and U-I technology transfer. First, research findings progress knowledge of micro-level cognition and behaviour under uncertainty. In particular, essay 1 suggests how regenmed ecosystem participants make sense of irreducible uncertainty at the U-I boundary through the use of preferred coping strategies. Individuals differ in their coping responses to uncertainty, which has important consequences for venturing behaviour and knowledge development.

Second, essay 2 advances knowledge on the development of entrepreneurial ecosystems at the U-I boundary and institutional entrepreneurship. More specifically, building on essay 1, it reveals how entrepreneurial cognition and sensemaking processes are directly implicated in the development of entrepreneurial ecosystems at the U-I boundary. By focusing on the entrepreneur, this PhD research progresses understanding and highlights the importance of the entrepreneur in entrepreneurial ecosystems at the U-I boundary.

Third, essay 3 builds upon essays 1 and 2 to reveal a framework of entrepreneurial ecosystem emergence. A key requirement for entrepreneurial ecosystems at the U-I boundary is the generation of spinout ventures. With this in mind, essay 3 reveals a typology of spinout ventures formed at the U-I boundary amidst uncertainty. Finally, since entrepreneurial processes and entrepreneurial ecosystem emergence depends on context, essay 3 emphasises the importance of a contextualised view of entrepreneurial activities within entrepreneurial ecosystems.

From a practical perspective, findings from each of the three essays contribute to entrepreneurial planning and the development of policies in emerging technology sectors. More specifically, this PhD research reveals the necessity for entrepreneurs to adapt their coping mechanisms to the specific environment or context. In addition, findings highlight the need for university and governmental policymakers to acknowledge the importance of micro-level factors in the development of entrepreneurial ecosystems.

1.4. Summary of the three essays and findings

The three essays extend understanding of entrepreneurial behaviour and ecosystem development under irreducible uncertainty. Essay 1 provides deeper insights into entrepreneurial cognition and decision-making under irreducible uncertainty. Essay 2 builds on this to provide a richer understanding of the differences in cognition across two ecosystems and how this influences the specific path along which ecosystems develop. Essay 3 builds further on essays 1 and 2. In particular, it provides insight into the emergence of entrepreneurial ecosystems at the U-I boundary and how context matters. A summary of each essay is provided below.

1.4.1. Essay 1 synopsis

Entrepreneurs face multiple sources and types of uncertainty during venturing activity. Converting novel or speculative opportunities into viable commercial businesses requires entrepreneurs to address or even leverage uncertainty. This process is especially relevant in nascent, knowledge-intensive fields, where success likely hinges on acquisition and deployment of unique, specialised knowledge resources. Venture development will be partly determined by the sensemaking

strategies entrepreneurs employ to cope with irreducible uncertainty, especially as they seek critical collaborations. The regenmed sector represents a unique context for studying entrepreneurial sensemaking under high levels of uncertainty. This essay considers how uncertainty in regenmed venturing affects entrepreneurial behaviour. Informed by long-form narrative interviews a sensemaking model is proposed, which links uncertainty, university culture, coping and narratives of venture potential in the regenmed field. This helps explain how participants in the regenmed sector cope with uncertainty and explore knowledge partnerships. Essay 1 findings advance theories of entrepreneurial sensemaking and the impact on nascent entrepreneurial ecosystems.

1.4.2. Essay 2 synopsis

In the field of regenmed, new ventures face unformed markets and inconsistent industry practices. Essay 2 studies two university-centric regenmed ecosystems to explore the characteristics of venturing activity and ecosystem development under irreducible uncertainty. The situational analysis reveals multi-level effects. At the micro-level, entrepreneurial coping strategies are significantly affected by cultural artefacts generated by the ecosystem university. At the macro-level, entrepreneurial ecosystems may develop along different paths, generating idiosyncratic contexts for venturing activity. A model of entrepreneurial ecosystem development is presented, with implications for theories of entrepreneurial behaviour as well as policy practice in developing technology sectors.

1.4.3. Essay 3 synopsis

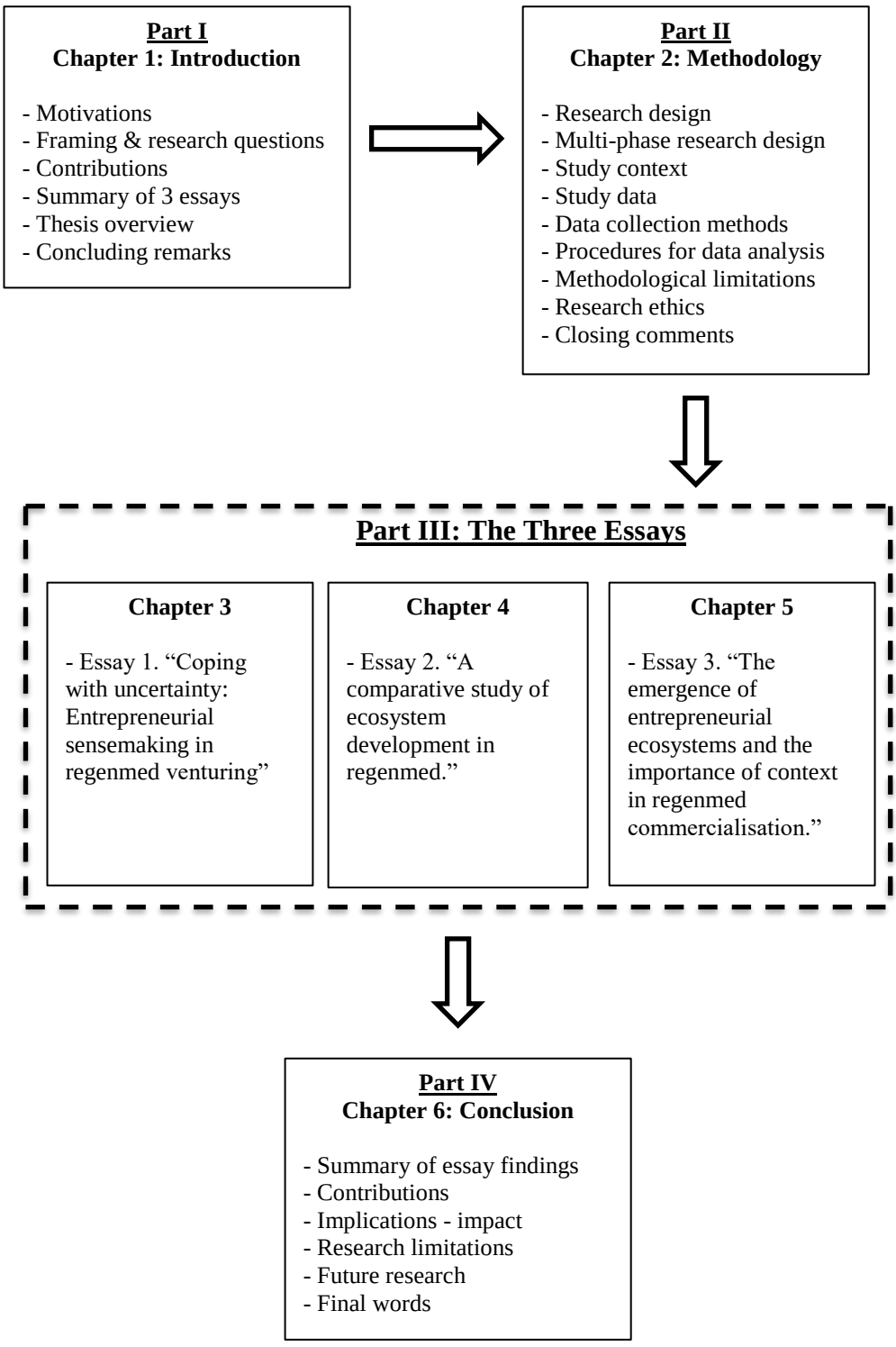
The emergence and development of entrepreneurial ecosystems help drive technology-based economies. The early-stage development of such ecosystems is, however, relatively unstudied. This essay explores technology transfer and contextual factors across three regenmed ecosystems to reveal the emergence of entrepreneurial ecosystems at the U-I boundary. Ecosystem and venture characteristics emerge from institutional characteristics, micro-level cognition and regional context. University culture and entrepreneurial coping strategies generate a typology for spinouts within the ecosystem. This inductive investigation advances

theories of entrepreneurial ecosystems and highlights the importance of a contextualised view of entrepreneurial processes.

1.5. Overview of the thesis structure

Figure 1.1 outlines the structure of this thesis. Part I of this thesis has provided an introduction to the PhD investigation. In part II, the research methodology is considered. Part III of this thesis is devoted to the three essays, with each essay being presented in turn. Following this, Part IV offers a conclusion. This includes integrating the findings from each of the three essays and a discussion on the collective contributions from the three essays. Additionally, an important part of this PhD investigation is the impact on policy and practice. With this in mind, the concluding chapter considers the implications of this PhD research and presents three published practitioner-based articles. Following this, the overall PhD research limitations and areas for future research are considered. The thesis concludes with some final, brief comments.

Figure 1.1. Overview of the thesis structure



(Source: Author)

1.6. Part I concluding remarks

This introductory chapter has presented the research under investigation. The chapter highlighted the implementation of three empirical studies, presented as three essays, to progress the understanding of entrepreneurial behaviour under irreducible uncertainty and the development of entrepreneurial ecosystems at the U-I boundary. Given the scant research on entrepreneurial behaviour under irreducible uncertainty and entrepreneurial ecosystem development at the U-I boundary, the chapter reported on the motivations behind this PhD research. Following this, a theoretical framing section provided the background setting to each essay and highlighted the research questions for each of the empirical studies. This led to a discussion of the research contributions. Finally, a summary of each essay was presented. It is to the *Methodology* chapter that this thesis now turns.

Part II

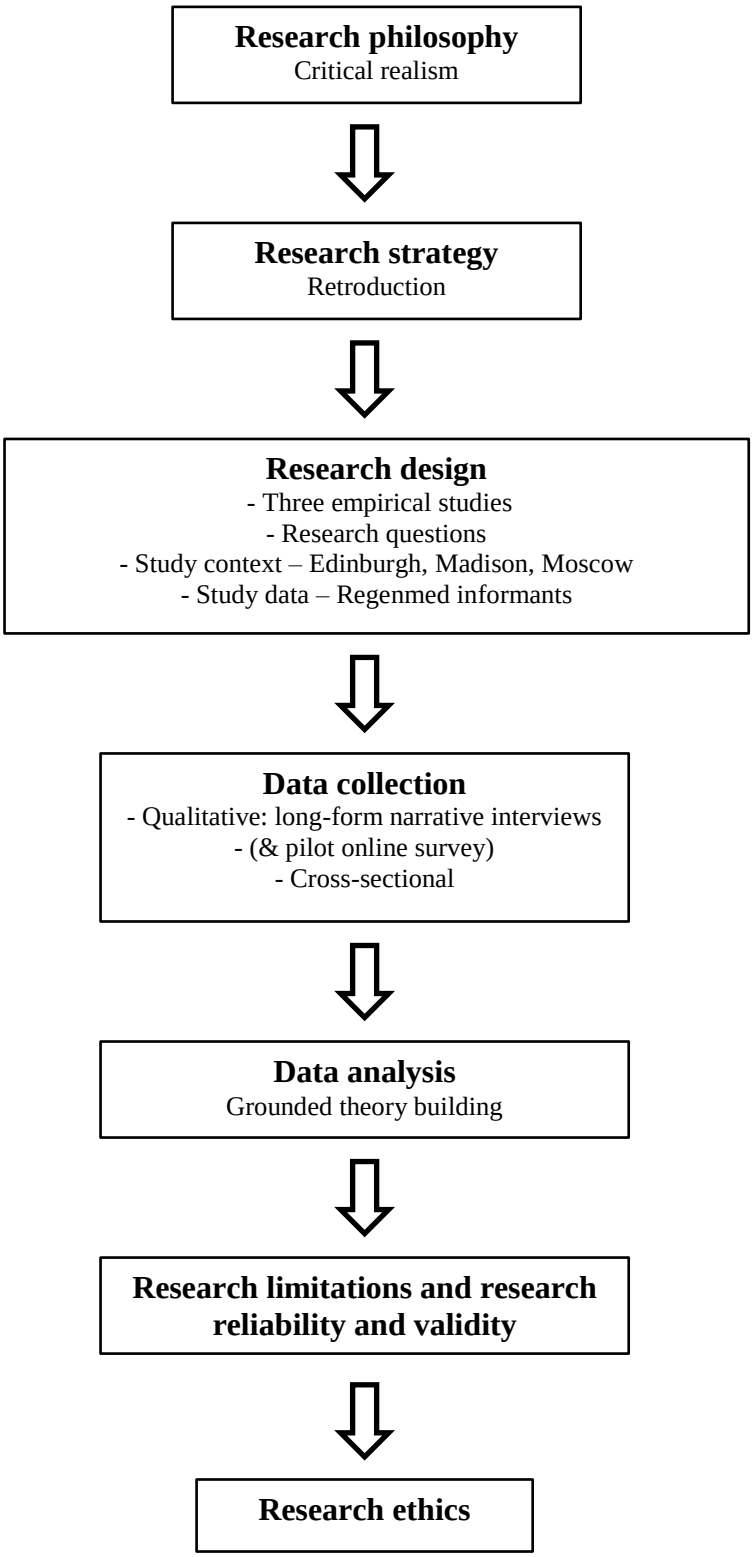
Chapter 2: Methodology

This PhD investigation was driven by a critical realist philosophy. Influenced by the scant research on entrepreneurial behaviour under irreducible uncertainty and the development of entrepreneurial ecosystems at the U-I boundary, this research pursued a retroductive, exploratory approach to data collection. Whilst an initial online pilot survey was utilised, the principal data collection method consisted of long-form narrative interviews with regenmed ecosystem participants across three different countries. Data analysis was informed by grounded theory building. This chapter now provides a detailed report on the methodological considerations for this PhD investigation.

2.1. Research design framework

A vital element of this PhD investigation was establishing an appropriate research design framework that would address the phenomena under investigation. Fundamental research design factors that were considered are highlighted in Figure 2.1. A key element driving the design of this PhD research was the critical realist paradigm.

Figure 2.1. Research design framework



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2.2. Research philosophy: Critical realism

This PhD investigation was motivated by a critical realist philosophy. This influenced the study design, including the methods for data collection and procedures for data analysis. Critical realism suggests that *"reality consists not only of events that are experienced but also of events that occur whether experienced or not, and of the structures and mechanisms that produce these events"* (Blaikie, 2010: p.101). The relative importance of these structures and mechanisms often requires the construction of hypothetical models, as researchers search for evidence of their existence. Proposed models of sensemaking under uncertainty and ecosystem development are used in this thesis to assist the understanding of reality.

Critical realism, akin to all research paradigms, is contained within ontology and epistemology (Bhaskar, 1997). Ontology reflects reality and questions whether reality is a product of an individual's consciousness or peripheral to them (Burrell and Morgan, 1979). For critical realists, reality is believed to exist independent of observers (Easton, 2010), and requires deep observations to interpret causality (Bhaskar, 2008). While ontology relates to reality, epistemology is concerned with knowledge. In particular, the kinds of knowledge that exist, the acceptance of this knowledge and the legitimacy of knowledge (Crotty, 1998). Critical realists posit that a particular entity exists independently to our knowledge of that entity (Fleetwod, 2005). Since ontology reflects a researcher's investigation into reality, and epistemology reflects the relationship between reality and the researcher, both have an inter-dependent relationship with each other (Hatch and Cunliffe, 2006).

In the field of management, critical realism has been well reported (Ackroyd and Fleetwood, 2004). For example, organisational studies (Tsang and Kwan, 1999) and entrepreneurial studies (Blundel, 2007; Leca and Naccache, 2006) have both been approached from a critical realist perspective. Entrepreneurial studies investigating individual behaviour within institutional contexts challenge researchers to avoid conflating behaviour and context. Critical realism, however, overcomes these challenges, as it prevents a preference of behaviour over context (or vice versa) (Leca and Naccache, 2006). This enables an enhanced explanation of the phenomena under investigation, since it allows the researcher to explain the phenomena rather than just understand it (Mole and Mole, 2010).

A critical realist approach addresses calls for greater attention to be directed towards context in entrepreneurship studies, since it provides a greater understanding about the pre-conditions for entrepreneurship and a nuanced understanding of contextual issues (Leca and Naccache, 2006). Additionally, it is well suited to investigations that consider entrepreneurship from multiple levels, such as micro, meso and macro-levels (Blundel, 2007). This PhD research, which is nested within the entrepreneurship domain and considers both context and multiple-level analysis, is precisely suited to theorising from a critical theorist perspective. However, other research philosophies exist, with positivism and interpretivism being the most commonly adopted in management studies.

Positivists view social science similar to the natural sciences. Positivists often rely on quantitative measures to test hypothesis from existing theories (Healy and Perry, 2000). This approach tends to be led by experimentation (Blaikie, 2001), resulting in a belief that the knowledge discovered is more accurate (Crotty, 1998). For positivists, organisational structures are often viewed as shaping the activities of organisational members in deterministic ways (Gioia and Pitre, 1990). Such views lead to theory-neutral observations, a tendency to reject science as a social activity, and tensions in accepting an interpretive element to the understanding of phenomena (Sayer, 2004). As such, scholars have argued that positivism is inappropriate in approaching social science phenomena and leads to an under-determination of theory development (Sobh and Perry, 2006). A positivist paradigm is inconsistent with the views of this author.

In contrast, interpretivism postulates that multiple realities exist. These realities are constructed through individual interpretations towards their actions, social situations and the actions of others (Blaikie, 2000; Sobh and Perry, 2006). Thus, social reality reflects the structure and interaction of social actors (Saunders et al., 2009) who construct and sustain their own organisational realities (Gioia and Pitre, 1990). While critical realists share similar views to interpretivists in that social phenomena are concept dependent and require interpretive understanding, unlike interpretivism, critical realists do not exclude casual explanation (Zachariadis et al., 2013). Critics of interpretivism challenge the notion that the researcher's own beliefs

and meanings are likely to interfere with the research subject's understanding of reality (Saunders et al., 2009).

2.3. Research strategy: Retroduction

Retroduction is closely aligned with critical realism and relies on reasoning and imagination to construct a model of the structures or mechanisms that are responsible for creating observed phenomena (Blaikie, 2007). It involves going beyond the empirically observable in order to obtain knowledge, by asking questions and developing concepts that relate to the phenomena under investigation (Meyer and Ward, 2014). The lack of existing theories pertaining to entrepreneurial ecosystems at the U-I boundary supports a retroductive approach to this PhD investigation.

While not necessarily consistent with a critical realist paradigm, other modes of reasoning exist. These include inductive, deductive and abductive. Retrodution and abduction share a close relationship, often being used interchangeably (Peirce, 1931). Abduction is associated with taking an empirical event or phenomena that is related to theory as a point of reference and generating a new theory about the event or phenomena (Meyer and Ward, 2014). The new theory generated is derived through the perspective of social actors (Bryman, 2012). It is distinguished from retroduction since retroduction is often viewed as abduction but with a specific question in mind (Oliver, 2012).

A deductive approach was rejected given that this is associated with testing hypotheses from existing theories, often via quantitative research (Healy and Perry, 2000). This approach is often associated with a positivist research paradigm. Deduction relies on theory guiding specific hypotheses, which are tested to either confirm or refute these hypotheses (Saunders et al., 2009). Since this investigation was interested in generating theories from observation, which is consistent with a qualitative methodology, a deductive approach fails to align with a critical realist paradigm.

Induction relies on theory development from observations or findings (Blaikie, 2010). This requires extrapolating patterns from the observations to form conceptual categorisations (Charmaz, 2006). It is closely related to qualitative

research (Miles et al., 2013) and often associated with exploratory studies that establish deeply embedded descriptions of the phenomena under investigation (Blaikie, 2010).

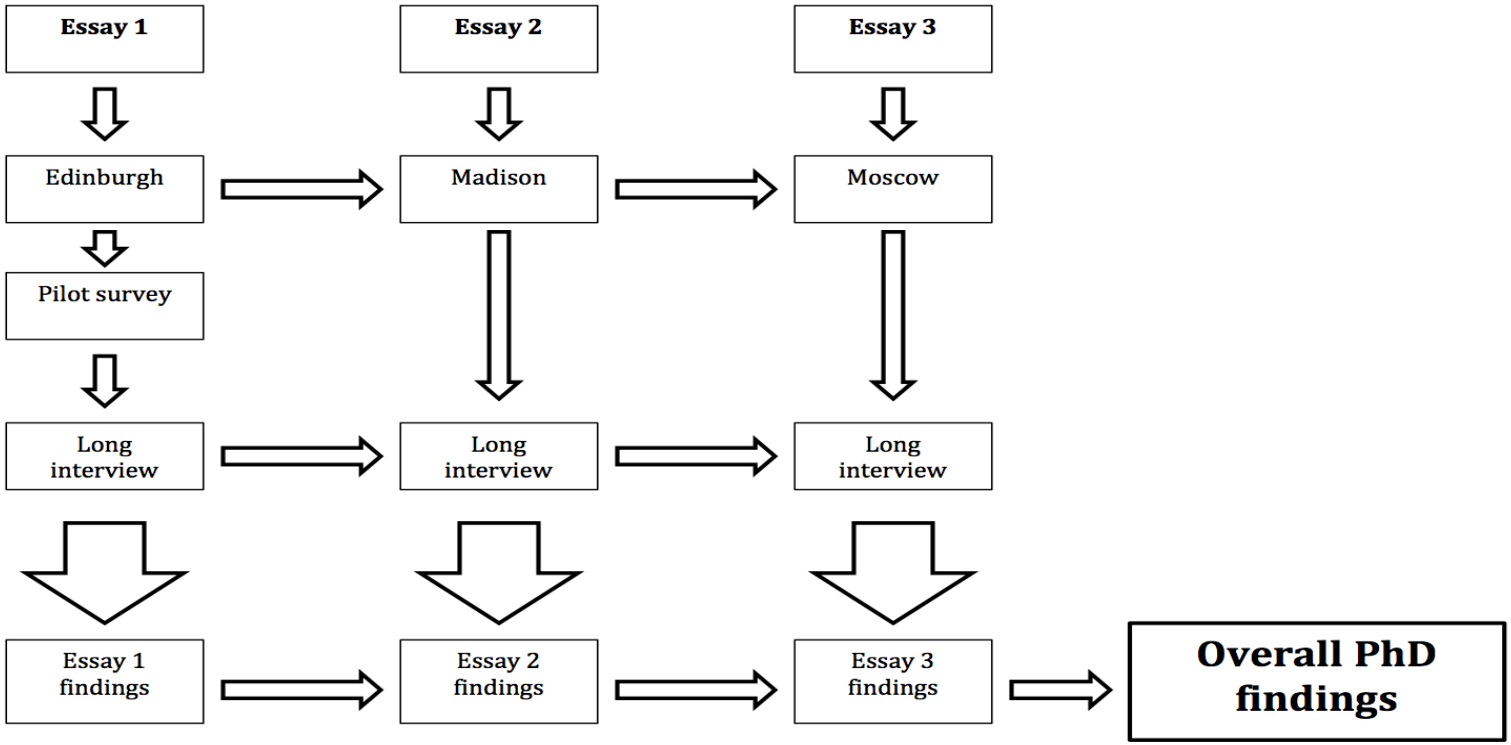
This investigation relied on understanding how regenmed ecosystem participants make sense of uncertainty and how this influences the development of entrepreneurial ecosystems. This understanding was constructed through the perspectives of ecosystem participants, leading to the emergence of new theories and phenomena about entrepreneurial behaviour and ecosystem development in contexts of extremely high uncertainty. In developing new theories, analogies and models were developed through a process of abstraction, whereby theories and models were developed and refined as the research (essays) developed. Phenomena were constructed according to ideas about elements that fit together to explain relationships (Sayer, 2004). Abstraction is a crucial element of the retroductive analysis (Zachariadis et al., 2013). This is precisely consistent with critical realism and led to the rejection of positivist or interpretivist philosophies.

It is evident that this PhD investigation does not reflect a positivist or an interpretivist philosophy, but is grounded in a critical realist philosophy. This critical realist approach was consistently applied across all three empirical studies. However, while it is important to adhere to a single ontological and epistemological viewpoint, doing so is challenging for researchers because they exhibit several identities and experience numerous realities (Weick, 1995). In reality, it has been suggested that individuals can be expected to oscillate between ontological and epistemological viewpoints (Burrell and Morgan, 1979).

2.4. Multi-phase research design: The three empirical studies

The research design is influenced by the research philosophy and strategy. It guides the research questions, the data collection methods and analysis necessary to address the defined research questions (Saunders et al., 2009). To address entrepreneurial behaviour and ecosystem development at the U-I boundary, this PhD investigation adopted a multi-phase research design. Figure 2.2. illustrates the relationship between each of the three empirical studies.

Figure 2.2. Multi-phase research design: The three empirical studies



(Source: Author)

The adoption of a three empirical studies approach was suitable in the context of this investigation for several reasons. First, the sequential nature of the three empirical studies enabled an overall research question to be answered through a set of incremental research questions. Second, this enabled findings from essay 1 to be further developed in essay 2, which were then further developed in essay 3 (Creswell and Clark, 2007). Third, the multi-phase research design allowed for convergence and subsequently corroboration of evidence (Yin, 2003). Thus, as this investigation progressed from essay 1 to essay 3, a deeper and richer understanding of entrepreneurial behaviour and ecosystem development under uncertainty was established.

Investigations adopting a multi-phase research design often utilise both qualitative and quantitative measures. For example, study 1 may adopt a qualitative approach, with the theory generated being tested quantitatively in study 2. For this PhD investigation, a quantitative pilot online survey was initially utilised. This supported and enabled triangulation of data sources, which is especially important for data validity and reliability (Jick, 1979). However, in departure from multi-phase research that utilises mixed-methods, the principal method for each of the three essays in this PhD investigation was qualitative, narrative interviews. Thus, the multi-phase research design reflects a multi-method design (rather than a mixed-method design), which is "*the conduct of two or more research methods, each conducted rigorously and complete in itself, in one project/study*" (Morse, 2003). Therefore, multi-method research involves a series of studies that are interrelated within a broader research topic and designed to solve an overall research problem. This may involve a sequence of qualitative studies (Morse, 2003), as is the case for this PhD investigation.

The decision to adopt this multi-phase/method research design approach was driven by the scant research on entrepreneurial behaviour and ecosystem analysis at the U-I boundary. Whilst a greater emphasis on a quantitative element could have potentially been valuable, such as the implementation of a large-scale survey, it was felt that the dominant qualitative approach would enable deeper theorising. This was necessary given the scant research in the area being investigated and fits precisely with the exploratory, narrative interview approach adopted for each of the three

essays. However, this does not mean that triangulation, including data validity and reliability, were compromised. Triangulation consists of four distinct types: data triangulation, investigator triangulation, theory triangulation and methodological triangulation (Patton, 2002). While triangulation of the pilot survey findings and the narrative interview findings was initially conducted for essay 1 (i.e. methods triangulation), data and theory triangulation within each of the essays ensured data validity and reliability.

Each of the three essays in this PhD research reflects a cross-sectional investigation, with additional data being collected in turn for each essay as the PhD investigation progressed. Whilst the total data collection took place over a time period of three years, since the data collection did not involve repeated interviews with the same informant, it does not reflect a longitudinal study.

2.4.1. Research questions

The research philosophy and strategy guided the research questions. To assist the understanding of entrepreneurial behaviour under irreducible uncertainty and the development of entrepreneurial ecosystems at the U-I boundary, this PhD thesis explores the following overarching research question:

> **"How does irreducible uncertainty affect entrepreneurial behaviour and the development of entrepreneurial ecosystems at the U-I boundary?"**

In answering this research question, several sub-questions are employed. In essay 1, entrepreneurial sensemaking and decision-making under irreducible uncertainty are explored via the following research questions:

> **Research sub-question 1**: How do regenerative medicine ecosystem participants make sense of highly uncertain venturing contexts?

> **Research sub-question 2**: What are the unique features of collaborative knowledge development in regenerative medicine venturing?

Essay 2 addresses the following research questions in order to progress understanding of the development and dynamics of entrepreneurial ecosystems at the U-I boundary:

> **Research sub-question 3**: How does micro-level cognition and behaviour differ across ecosystems?

> **Research sub-question 4**: Why do apparently similar entrepreneurial ecosystems develop differently?

Finally, building upon essays 1 and 2, essay 3 considers the following research questions through the lens of the EOE and competence bloc theory:

> **Research sub-question 5**: What is the role of the university and the technology transfer process in assisting with the emergence and development of entrepreneurial ecosystems at the university-industry boundary?

> **Research sub-question 6**: How does context influence entrepreneurial ecosystem development?

2.4.2. Study context: Regenerative medicine ecosystems under investigation

This PhD research investigates three regenmed ecosystems to explore entrepreneurial behaviour and ecosystem development at the U-I boundary. Essay 1 studies the regenmed ecosystems centred on the University of Edinburgh. In essay 2, a cross-national comparison of the regenmed ecosystem surrounding the University of Edinburgh and The University of Wisconsin-Madison are explored. The regenmed ecosystem centred on The Skolkovo Institute of Science and Technology (Skoltech) in Moscow is examined in essay 3. Each ecosystem is now discussed in turn.

2.4.2.1. The University of Edinburgh

Founded in 1583, The University of Edinburgh is the sixth oldest university in the United Kingdom (UK) and fourth oldest in Scotland. Located in Edinburgh, the capital city of Scotland, the university is a member of the Russell Group universities, which are noted for their academic excellence in both research and teaching. The university has an established history of stem cell research, made famous by Dolly the Sheep. Dolly was the first mammal cloned from an adult somatic stem cell, culminating extensive research at Edinburgh led by Professor Sir Ian Wilmut.

The Edinburgh BioQuarter (BioQuarter) is a public-private facilities-based initiative to promote and translate life science research at The University of Edinburgh. First proposed in 2002, the $925 million BioQuarter incorporates research, industry and venturing incubation facilities. Situated at BioQuarter is the Scottish Centre for Regenerative Medicine (SCRM). Housing scientists and clinicians, SCRM is charged with accelerating world-class regenmed research and translating this to industry and the clinic. Research at SCRM is focused around brain cancer, diabetes, leukaemia, liver disease, motor neurone disease, multiple sclerosis and Parkinson's disease. Working closely with BioQuarter is Edinburgh Research and Innovation (ERI), which is the university's TTO. Founded in 1969, ERI was amongst the first TTOs in the UK.

2.4.2.2. The University of Wisconsin-Madison

The University of Wisconsin-Madison is a public, land-grant institution located in Madison, Wisconsin, USA. Founded in 1848, the university has become one of the largest research universities in the United States, with an annual research budget exceeding $1.2 billion. Professor James Thomson from The University of Wisconsin-Madison derived the first human and primate ESC lines, and the first human iPSC lines, establishing the university as a global leader in regenmed research.

The responsibility for advancing stem cell and regenmed science falls primarily upon the Stem Cell and Regenerative Medicine Center (SCRMC) at the university. Operating under the School of Medicine and Public Health, SCRMC

focuses its research into 5 priority areas: stem cell bioengineering, cardiovascular regeneration, musculoskeletal regeneration, blood research and neural regeneration. Protection and commercialisation of university-derived research at The University of Wisconsin-Madison is the responsibility of The Wisconsin Alumni Research Foundation (WARF). WARF was founded in 1925 and is one of the oldest and most successful TTOs in the world. It is generally credited with the world's most foundational patent portfolio covering stem cell and regenmed technology (Bergman and Graff, 2007).

At the centre of The University of Wisconsin-Madison's focused effort to facilitate world-class research, engage with industry and encourage entrepreneurial activity is The Wisconsin Institute for Discovery (WID). This special-purpose faculty was proposed in 2004 and completed in 2010 at an investment of $210 million.

2.4.2.3. The Skolkovo Institute of Science and Technology

Skoltech is a private research university located on the outskirts of Moscow, Russia and has been labelled as Russia's 'Silicon Valley.' Established in 2011 in collaboration with the Massachusetts Institute of Technology (MIT), a critical mission of Skoltech is to foster an entrepreneurial ecosystem, driven through innovation and technology transfer. The priority fields of research include Biomedicine, Energy, IT, Nuclear Technologies and Space Technologies. Stem cell research, which falls under the field of biomedicine at Skolkovo, has been identified as a priority area in assisting with ecosystem development.

The Skoltech Center for Stem Cell Research (SCSCR) has been established in collaboration with The European Institute for the Biology of Aging (Netherlands) and The Hubrech Institute (Netherlands). SCSCR is one of fifteen Centers for Research, Education and Innovation (CREI). The notion of the CREIs is to provide world-class educational training and generate research that can assist in driving innovation and entrepreneurial activities at Skoltech and within the Russian economy. While the CREIs have Skoltech as the lead university, one of the key criteria for their establishment is the requirement to have two or more major international university or research institution partners.

At the heart of ensuring Skoltech becomes an innovation and entrepreneurial powerhouse is the Center for Entrepreneurship and Innovation (CEI). It is responsible for providing entrepreneurial support to scientists at Skoltech, assisting them with taking their innovations towards licensing or spinout venture formation. In assisting this, the Skoltech Innovation Programme is in place. This programme, which has been developed with the Deshpande Center for Technological Innovation at MIT, offers one year of funding to selected innovations in order to bridge the gap between the laboratory and market. Those innovations that move towards start-up formation also have the support of the Skolkovo Foundation, which offer incubation facilities.

The selection of the three regenmed ecosystems was driven by three principal motivations. First, all ecosystems are in their formative stages, enabling sufficient investigation of ecosystem emergence and development. Second, the Edinburgh and Madison regenmed ecosystems are both similar in terms of their established history of stem cell and regenmed research, university characteristics, TTO activities and regional demographics. Thus, as was the case for essay 2, these similarities enabled a controlled comparison to explore the development of regenmed ecosystems at the U-I boundary. Third, the regenmed ecosystem surrounding Skoltech provides an ideal setting to explore the role of context in entrepreneurial ecosystem development. Since the Russian regenmed ecosystem represents a unique social-cultural context, it can help explain the idiosyncrasies of entrepreneurial ecosystems in an emerging economy, which is not possible with the Edinburgh and Madison ecosystems.

2.4.3. Study data

To explore entrepreneurial behaviour and ecosystem development in regenmed, a theoretical sampling approach was utilised (Charmaz, 2006). Selection of target informants was purpose-based (Morse et al., 2002), focusing on informants that had direct involvement in regenmed commercialisation. Target informants consisted of several categories that would enable a holistic exploration of regenmed ecosystems. These included: 1) regenmed entrepreneurs and companies/ventures, 2) regenmed academic scientists, and 3) regenmed support entities. Regenmed support entities are defined as organisations that have a direct influence on regenmed

venturing. These include university TTOs and governmental organisations that support regenmed knowledge transfer, innovation and commercialisation.

For this PhD investigation, data collection took place in Edinburgh, Madison and Moscow between November 2012 and June 2015. The total dataset consists of 47 narratives interviews. This reflects interviews with 15 regenmed entrepreneurs and ventures (E/RMV), 8 regenmed academic scientists (AS) and 24 regenmed support entities (SE). In Edinburgh, 23 narratives were collected in total. The data collected in Madison consisted of 13 narrative interviews. In Moscow, 11 narratives were obtained. A complete list of the informants for this PhD research is highlighted in Table 2.1.

Target informants were identified through a regenmed industry event and via the personal networks of the author. All target informants were e-mailed to confirm their participation in the investigation. The content of the e-mail explained the study, the importance of the study and a request for a confidential interview. Further details of the e-mail content are provided in Appendix A.

Table 2.1. Thesis study informant information

Informant #		Category	Informant role	Organisation type
Edinburgh	1	SE	Executive	Government-backed org. supporting regenmed community.
	2	E/RMV	Founder	Operating in tools/diagnostics, but offering services too.
	3	E/RMV	Manager	Provides regenmed technical support & services.
	4	E/RMV	Founder	Primarily involved in stem cell training & consultancy.
	5	AS	Manager	University academic scientist (Principal Investigator).
	6	SE	Manager	Government-backed org. fostering economic growth.
	7	SE	Executive	Supports academic innovation & commercialisation.
	8	SE	Manager	Supports technology transfer activities & innovation.
	9	AS	Executive	University academic scientist (Principal Investigator).
	10	E/RMV	Founder	Regenmed products & services organisation.
	11	SE	Manager	Supports Scottish life science community & regional growth.
	12	SE	Manager	Supports UK healthcare community & fosters innovation.
	13	E/RMV	Founder	Operates in the RM tools & diagnostics space.
	14	E/RMV	Founder	Biotechnology & stem cell services organisation.
	15	SE	Executive	Creating a cell therapy industry & community.
	16	E/RMV	Executive	Provides products & services to the stem cell sector.
	17	SE	Manager	Encourages innovation & economic development.
	18	SE	Manager	Supports regional economic growth.
	19	E/RMV	Executive	Regenmed diagnostics venture.
	20	SE	Executive	Promotes life science commercialisation & collaboration.
	21	SE	Executive	Promotes technology transfer & venture formation.
	22	AS	Executive	University academic scientist (Principal Investigator).
	23	SE	Executive	Promotes technology transfer & venture formation.
Madison	24	SE	Manager	Promotes technology transfer & venture formation.
	25	E/RMV	Founder	*De novo* regenmed tools & therapeutics venture.
	26	E/RMV	Founder	*De novo* regenmed tools & therapeutics venture.
	27	SE	Manager	Fosters regional economic growth.
	28	SE	Executive	Promotes scientific & technological innovation.
	29	SE	Executive	Supports new venture creation & growth.
	30	E/RMV	Founder	*De novo* regenmed tools, diagnostics & therapeutics venture.
	31	SE	Manager	Promotes technology transfer & innovation.
	32	AS	Executive	University academic scientist (Principal Investigator).
	33	AS	Manager	University academic scientist (Principal Investigator).
	34	SE	Executive	Promotes technology transfer & innovation.
	35	SE	Manager	Supports venture investments.
	36	SE	Manager	Supports venture investments.
Russia	37	E/RMV	Founder	Regenmed therapeutics, tools, diagnostics & services.
	38	AS	Executive	University academic scientist (Principal Investigator).
	39	E/RMV	Manager	*De novo* regenmed tools venture.
	40	SE	Manager	Supports tech. commercialisation & new venture formation.
	41	AS	Executive	University academic scientist (Principal Investigator).
	42	SE	Executive	Supports tech. commercialisation & new venture formation.
	43	SE	Executive	Supports biomed commercialisation & venture development.
	44	AS	Executive	University academic scientist (Principal Investigator).
	45	SE	Manager	Supports licensing & technology transfer.
	46	E/RMV	Founder	Stem cell services venture.
	47	E/RMV	Founder	Regenmed therapeutics, tools, diagnostics & services.

E/RMV = Regenmed entrepreneurs and ventures
AS = Academic scientists
SE = Regenmed/life science support entities
(Source: Author)

2.5. Data collection methods

The principal data collection method across all three essays was the long-form narrative interview (McCraken, 1988). Narrative interviews reflect a qualitative approach to data collection, which is particularly useful for theorising in entrepreneurship (Fletcher, 2007; Larty and Hamilton, 2011) and meaning-making (Bauer, 1996; Boje, 1991). Yet, whilst the principal data collection method for this investigation was qualitative in nature, there was also a quantitative aspect to the investigation. As previously discussed, essay 1 also relied on a small-scale online pilot survey. The survey findings were triangulated against the findings of the narrative interviews in order to confirm the relevance of key constructs.

While the critical realist research philosophy guided the chosen data collection methods for this PhD investigation, other data collection methods were considered. For example, experiments can provide valuable information to help understand whether a change in an independent variable produces a change in another dependant variable (Saunders et al., 2009). In entrepreneurship research, experiments are useful to understand opportunity evaluation and exploitation, and drivers of entrepreneurial choices (Acs et al., 2010). In particular, scholars have studied entrepreneurial cognition and decision-making following various experimental manipulations (Grichnik et al., 2010). Others have investigated entrepreneurial behaviour amidst uncertainty and risk manipulations through experimentation (Sandri et al., 2010).

On the other hand, ethnographic studies enable researchers to immerse themselves for an extended period of time with the actors being studied, allowing for norms, practices and values to aid in the understanding of why these actors construct their social world as it currently is (Rosen, 1991; Watson, 2011). Such studies may be especially useful for investigating entrepreneurial cognition (Zahra et al., 2005) and the role of culture on entrepreneurship (Dana and Dana, 2005).

Large-scale surveys are also useful to test specific hypotheses and move from casual attributions to attributions that are generalizable (Oppenheim, 1992). A wealth of entrepreneurial studies have utilised the Panel Studies of Entrepreneurial Dynamics (PSED) and Global Entrepreneurship Monitor (GEM) to understand individual and country-level entrepreneurship (Levie et al., 2014; Reynolds, 2007).

Narrative interviews were selected over these alternative methods since they are better positioned to reveal novel phenomena. Despite these alternative methods being rejected, each has the potential to contribute to further research in this area and provide an enhanced understanding of entrepreneurial behaviour and ecosystem development at the U-I boundary. This will be discussed in further detail in the *Future Research* section in Part IV of this PhD thesis.

2.5.1. Long-form narrative interviews

For this PhD research, the primary data collection method consisted of a narrative interview approach. The narrative interview is a technique that encourages interviewees to tell a story (Bauer, 1996). Having its origins situated within the linguistics field, management scholars have increasingly applied narratives or stories to study: organisations (Boje, 1991; Czarniawaska, 1998; Garud et al., 2011), strategy (Brown and Thompson, 2013), innovation (Bartel and Garud, 2009; Seidel and O'Mahony, 2014), sensemaking (Humphreys et al., 2011) and entrepreneurship (Gartner, 2007). Narratives have been shown to assist in resource assembly. A well-crafted story that aligns with both stakeholder expectations and industry categories can communicate a coherent identity, which enables resource acquisition and wealth creation (Lounsbury and Glynn, 2001; Martens et al., 2007). A critical requirement for new ventures is establishing venture legitimacy and gaining stakeholder support. Stories that narrate the future projection of a new venture set stakeholder expectations, enabling ventures to gain legitimacy. When uncertainty is high, it is likely that these projected stories deviate. Since this may disappoint stakeholders, entrepreneurs regain legitimacy through revising their initial story (Garud et al., 2014). Since collaborations and networks are important for early stage ventures, entrepreneurial stories build tie portfolios (Phillips et al., 2013). Whilst the focus of entrepreneurial stories and narratives has been on venture creation and success, many entrepreneurial ventures are likely to fail. Narratives of failed venture are also particularly important to help explain how entrepreneurs make sense of failure (Byrne and Shepherd, 2013; Wolfe and Shepherd, 2015).

The narrative interview approach adopted for this PhD research was utilised for three reasons. Firstly, such an approach enables active and reflective meaning-

making (Bauer, 1996; Boje, 1991). Second, a narrative interview approach is especially useful in generating theory within entrepreneurship studies (Fletcher, 2007; Larty and Hamilton, 2011). Finally, given the ethical and legal concerns surrounding regenmed, allowing informants the freedom to guide their own regenmed commercialisation journeys, in which they focus on self-identified areas of interest, assists in reducing staged responses and social desirability bias (Podsakoff et al., 2003).

Informants participating in this study were not supplied with any information prior to the narrative interview, other than an explanation that the study was investigating regenmed commercialisation activity. This ensured that informants did not prepare answers or material prior to the interview. Interviews took place either at the informant's or the interviewer's workplace. To avoid interruptions and ensure informants spoke freely, the interviewer requested that the interview setting must be in a quiet location. Informants were asked to tell their story of their role in the commercialisation of stem cell and/or regenerative medicine innovation. Informants were encouraged to narrate their story in as much detail as possible, without interruption by the interviewer. During this narrative, the interviewer took notes to support coding of the transcripts. When informants had fully completed their story, points of interest that required further explanation were followed up on. All interviews were recorded and later transcribed.

2.5.2. Pilot online survey

Given the scant research on regenmed venturing, a pilot online survey was initiated in order to inform and validate the interview analysis. Survey questions were constructed based on the limited literature on regenmed commercialisation (Giebel, 2005; Ledford, 2008). Question type and order were carefully selected in order to reduce common method bias (Podsakoff et al., 2003), and included both open-ended and closed questions. To ensure clarity of the survey and identify any problems, the survey was pretested by a regenmed industry expert and an academic operating in the stem cell field prior to distribution (Fowler, 2009). Whilst other pretesting methods were considered, including cognitive interviewing and behavioural coding, the method selected was the most cost effective and has a greater

chance of highlighting any problems with the survey over other pretesting choices (Presser and Blair, 1994).

Sampling was a non-probability convenience sample. A list of survey informants was obtained from a regenmed conference at The University of Edinburgh. The contact details of 51 delegates were obtained. Selecting for regenmed entrepreneurs, companies, academics and support entities, revealed 26 useable contacts. While non-probability sampling is a poor method for statistical generalisation, since it introduces biases as a consequence of unknown selection chances, it was perfectly suitable for the desired outcomes of the pilot survey.

The survey was administered to the 26 identified contacts via e-mail. The e-mail explained the study, its importance and details of the survey. In an attempt to increase the sample size, a snowballing method was utilised in which the e-mailed informants were requested to suggest other suitable candidates that fit the informant criteria. The first-wave of e-mails to the 26 contacts generated 15 completed surveys, which represents a 58% success rate. The snowballing method generated 7 additional contacts and 7 completed surveys. Overall, 22 surveys were completed, equating to a 67% success rate.

The benefits of adopting an online distribution method, over a postal survey alternative, were the time and cost advantages. However, there were risks associated with the online choice since it is difficult to manage who is completing the survey. This risk was mitigated by: ensuring that the survey was e-mailed directly to the selected informant (rather than a general business e-mail); requesting informants confirm their job description within the survey; and encouraging informants to provide their full contact details (although this was not a requirement, in order to allow informant anonymity if desired).

2.6. Procedures for data analysis

Analysis of the interview data was informed by grounded theory building (Strauss and Corbin, 1990). This approach is consistent with the critical realist approach to this study (Annells, 1996), the lack of existing research on micro-level cognition and behaviour at the U-I boundary, and the development of entrepreneurial ecosystems.

Grounded theory is a qualitative methodological process to examine and interpret data, elicit meaning and generate empirical knowledge (Corbin and Strauss, 2008). It involves the systematic collection and analysis of data to induce a theory. It involves the production of meaning and concepts, as revealed by the daily realities of social actors and the actor's interpretations of those realities (Gephart, 2004; Glaser and Strauss, 1967). Two critical elements of the grounded theory method are theoretical sampling and the constant comparative method (Glaser, 1978; Strauss and Corbin, 1990). The former determines the collection of further data based on current theory construction. The latter relies on the simultaneous collection and analysis of data. Whilst some scholars have criticised grounded theory for its embellishment of theoretical development (Thomas and James, 2006), this methodological approach is appropriate to aid understanding of processes in which individuals construct meaning out of inter-subjective experience (Suddaby, 2006). This makes it perfectly suited to understand entrepreneurial cognitive processes and their implications for entrepreneurial ecosystem development.

An exploratory analysis (Charmaz, 2006; Locke, 2001; Strauss and Corbin, 1990) of the interview data was utilised in order to reveal phenomena of entrepreneurial behaviour and ecosystem development under uncertainty. This involved reviewing the interview transcripts, field notes and audio files, to allow themes to emerge from the data (Spiggle, 1994). The dataset was open-coded to reveal first-order codes. Through an iterative cycle of inductive and deductive reasoning (Hirschman, 1986; Spiggle, 1994), a structure of second-order categories was generated. During this process, careful consideration was given to preserve the richness of the study narratives, since coding tends to involve reductionism. Once "theoretical saturation" (Glaser and Straus, 1967) had been reached, second-order categories were distilled into theoretical dimensions. This final coding process completed the data structure. The creation of a data structure is an important step in qualitative research because it demonstrates research rigor and illustrates the stages from raw data through to themes (Gioia et al., 2013). The data structure tables are highlighted in each of the three essays.

Throughout the coding process, the constant comparative method (Boeije, 2002; Glaser, 1965) was adopted, which is consistent with a grounded theory

approach. This relied on shifting between the data, coding and constructs in order to extract the relationships between categories and understand their robustness (Charmaz, 2006). During this process, the researcher was mindful of theoretical sensitivity (Glaser, 1978), since this is an important feature of grounded theory building. All coding was performed using NVivo 10 software.

2.6.1. Coding software

NVivo is a data management and analysis tool designed to assist qualitative researchers. It was utilised in this PhD research to assist in the coding of the narrative interviews. The interview transcripts were uploaded into the NVivo software package. Initially, first-order codes (termed "nodes" in NVivo) were created based on reviewing the study transcripts. Following the procedures for data analysis, as previously discussed in this chapter, these first-order "free" nodes were developed into a hierarchal node structure. This consisted of "parent nodes" (which represents theoretical dimensions) and their corresponding "child node" (which represents first- and second-order constructs).

As a computer assisted qualitative data analysis software (CAQDAS) tool, NVivo can enable rapid and efficient organisation and analysis of study data (Schreier, 2012). It facilitates a transparent data analysis process and is a useful tool in providing an accurate overall picture of the data (Morison and Moir, 1998; Richards and Richards, 1994). In addition, it has been suggested to add rigor to qualitative research (Richards and Richards 1991). Yet despite the benefits of CAQDAS, there have been several criticisms. Firstly, the use of CAQDAS has the potential to lose the human interpretation value of the qualitative data, becoming a rigid, automated analysis of text (Kelle, 1995). Second, some have suggested that CAQDAS distances the researcher for the actual physical raw data (Fielding and Lee, 1998; Gilbert, 2002; Hinchcliffe et al., 1997). Third, it has been suggested that CAQDAS guides researchers towards a particular data analysis methodology, rather than basing the data analysis on sound judgement (Lonkila, 1995).

Although other CAQDAS software is available, the decision to use NVivo was driven by several factors. First, the use of NVivo has been highlighted to be useful within grounded theory research (Bringer et al., 2004). Second, in response to

the critics of CAQDAS software, the use of NVivo for this study was solely for the purpose of assisting in the management of the study data, rather than being used for data interpretation; Analysis of the interviews followed a grounded theory approach that preserved the integrity and richness of the data, as previously discussed. Smith and Hesse-Biber (1996) support the view of CAQDAS software being excellent as an organising tool. Third, the researcher had prior experience and familiarity using this coding software.

2.7. Methodological limitations

The methodological approach to this PhD research holds significant strengths. Yet as with all research, there are certain limitations with the collection and analysis of the data for this investigation. The first limitation relates to the cross-sectional design of this PhD research. A longitudinal study would have allowed for the measurement of change over time (Menard, 1991). This has the potential to reveal the rate of ecosystem development. Since uncertainty is time dependent (Kirzner, 1985, 2009; Korsgaard et al., 2015), a longitudinal study would have also enabled changes in entrepreneurial behaviour to be assessed as time progressed and as uncertainty changed. Yet, the time constraints of this PhD investigation resulted in a cross-sectional approach to data collection. A longitudinal study provides a promising area for future research.

Second, there may be limitations to the dataset itself. Whilst the dataset provides a reasonable basis for theory-building, a different field of study such as nanotechnology may have produced slightly different findings. However, as previously discussed, regenmed venturing seems perfectly suited to explore entrepreneurial behaviour and ecosystem development under uncertainty given that it is a sector in its formative stages and one that operates under extremely high levels of uncertainty.

Biases represent the third methodological limitation to consider. In this PhD research, unknown biases may be present as a result of the opportunistic selection of the study informants. Additional biases include method, response and coding biases. Of particular importance in this PhD investigation are response and coding biases. In this PhD research, entrepreneurial behaviour and ecosystem development was

investigated through stories of regenmed participants' involvement in commercialisation activities. In some instances, post-hoc rationalisation and sensemaking has the potential to eliminate or modify information relevant to the study (Loftus and Hoffman, 1989), resulting in errors in respondents' recall of historical events (Glick et al., 1990). This was mitigated in this investigation since respondents were providing narratives of their current involvement in regenmed commercialisation. Thus, they were narrating their present activities in this field, rather than relying on historical events or activities. Another equally important response bias to consider is social desirability bias (Podsakoff et al., 2003). This occurs when respondents respond to questions in a manner that will be viewed favourable by others. As previously discussed, ensuring complete confidentiality to respondents mitigated this. Coding biases occur when aspects of the researcher's personal and political experience, and knowledge, creep into their data analysis and coding, which has been suggested to be extremely difficult to prevent (Becker, 1967; Gouldner, 1973; Hammersley and Gomm, 1997). Despite this challenge, data analysis strove not to lose sight of the intact narratives.

Closely related to these biases are reliability and validity. In qualitative research, reliability refers to the extent that the study can be replicated and the degree of measurement consistency between alternative researchers (Bryman, 2012). Validity represents the truthfulness of findings (Altheide and Johnson, 1994) and whether the data truly reflects reality (Lincoln and Guba, 1985). Unlike quantitative measures, establishing reliability and validity in qualitative research is challenging (Whittemore et al., 2001). Across the scholarly literature there are several common criteria in ensuring reliability and validity. These include: the *credibility* of the data and whether the research findings truly reflect the experience of study participants; the *integrity* of the research and whether it reflects recursive and repetitive checks of validity; and whether the research process demonstrates evidence of *critical appraisal* (Whittemore et al., 2001).

For this PhD research, the dominant criteria in ensuring reliability and validity were the *trustworthiness* and *authenticity* of the data (Guba and Lincoln, 1994; Lincoln and Guba, 1985). To ensure data was both trustworthy and authentic, demonstrating qualitative rigor was at the forefront of the methodological approach

to this PhD investigation (Morse et al., 2002). Procedures set out by Strauss and Corbin (1990) and Gioia et al. (2013) were followed in order to enhance grounded theory development. Additionally, to ensure the trustworthiness and authenticity of the data, replication of the study was a critical consideration. However, replication in the social sciences is problematic (Mezias and Regnier, 2007). Replication goes far beyond the *exact* replication of a particular study utilising the same population. For example, replication also includes: *re-analysis* of a dataset using different measurements and/or analysis; *conceptually extending* the research findings by employing procedures that differ from those in the original study; and *empirical generalisation*, which involves repeating a study on a different population and testing how far the results are generalizable to another population (Tsang and Kwan, 1999).

2.8. Research ethics

As with all research, ethical considerations are an important aspect of the study design, and this study was no exception. While this PhD research did not involve research with vulnerable respondents, which tends to be associated with ethical considerations, it did involve research on a sensitive topic. In considering the ethical aspects of this study, The Economic and Social Research Council (ESRC) guide was initially consulted, since ESRC sponsored this PhD research. Additionally, The University of Edinburgh Business School (UEBS) ethics form was used as a supplementary guide to the ethical considerations of this research.

As previously described, study informants were made aware of the study via e-mail prior to interview or the pilot survey. Informants had the opportunity to discuss the research in further detail both prior to and at the time of the interview. Before the interview was conducted, the interviewer carefully explained the study again to the informant and asked informants to sign an informed consent form (see Appendix B), which highlighted the confidentiality offered to them. While this is ethically desirable, the informed consent form also presents additional benefits. In particular, it offers informants confidentiality and mitigates staged responses by informants. This is especially important when interviewing CEOs or elites, since they are often trained to answer questions in a journalistic manner in which they carefully choose their response in an attempt to avoid the response being directly

attributed to them (Hertz and Imber, 1995). Given the ethical considerations and controversies surrounding regenmed venturing, this was particularly desirable.

To document that the ethical considerations have been carefully reflected upon in this PhD investigation, and in adherence to UEBS ethical requirements, a research ethics statement form was completed. This is shown in Appendix C.

2.9. Part II closing comments

This chapter has reported on the research methodology for this PhD investigation. At the outset, ontological and epistemological views were delineated, since these guide the research philosophy and subsequently the research strategy. The chapter progressed with an outline of the research design, which consisted of a three-study (essay) approach. Both the study context and study data were discussed. Additionally, the data collection procedures were considered. This included a discussion of the long-form narrative interview approach to data collection and the decision to launch an initial online pilot survey. The research findings were informed by grounded theory building, and this chapter explored this particular data analysis procedure. The final sections of this chapter were devoted to the methodological limitations and ethical considerations. Table 2.2. provides an overview of the research design framework. Having considered the methodology and following Table 2.2., this thesis now turns to each of the three research studies (essays).

Table 2.2. Methodological summary

Essay	Research questions	Research philosophy	Research strategy	Research approach	Study context	Unit of analysis	Study data	Data collection	Data analysis
Thesis	**-How does irreducible uncertainty affect entrepreneurial behaviour and the development of entrepreneurial ecosystems at the U-I boundary?**	**Critical realism**	**Retroduction**	**Qualitative (and some basic quantitative)**	**Regenmed ecosystems in Edinburgh, Madison and Moscow**	**Individual ecosystem participant**	**47 regenmed informants**	**Narrative interview (and pilot online survey). Cross-sectional**	**Grounded-theory building (and descriptive statistics)**
1	- How do ecosystem participants make sense of highly uncertain venturing contexts? - What are the unique features of collaborative knowledge development in regenmed venturing?	Critical realism	Retroduction	Qualitative (and some basic quantitative)	Regenmed ecosystem centred on The University of Edinburgh (Scotland, UK)	Individual ecosystem participant	23 regenmed informants	Narrative interview (and pilot online survey). Cross-sectional	Grounded-theory building (and descriptive statistics)
2	- How does micro-level cognition and behaviour differ across ecosystems? - Why do apparently similar entrepreneurial ecosystems develop differently?	Critical realism	Retroduction	Qualitative	Regenmed ecosystems centred on The University of Edinburgh (Scotland, UK) and The University of Wisconsin-Madison (USA)	Individual ecosystem participant	36 regenmed informants	Narrative interview (and pilot online survey). Cross-sectional	Grounded-theory building
3	- What is the role of the university and the tech. transfer process in assisting with the emergence and development of entrepreneurial ecosystems at the U-I boundary? - How does context influence entrepreneurial ecosystem development?	Critical realism	Retroduction	Qualitative	Regenmed ecosystems centred on The University of Edinburgh (Scotland, UK), The University of Wisconsin-Madison (USA) and Skoltech (Moscow, Russia	Individual ecosystem participant	47 regenmed informants	Narrative interview (and pilot online survey). Cross-sectional	Grounded-theory building

(Source: Author)

Part III: The Three Essays

Chapter 3: Essay 1

Coping with uncertainty: Entrepreneurial sensemaking in regenerative medicine venturing

Essay 1 is an empirical study that investigates how regenmed participants make sense of uncertainty during venturing at the U-I boundary. This essay is published as:

> Johnson, D. & Bock, A.J. (2016) Coping with uncertainty: Entrepreneurial sensemaking in regenerative medicine venturing. *The Journal of Technology Transfer,* DOI: 10.1007/s10961-015-9465-0

In accordance to UEBS thesis guidelines, I confirm that the author of this thesis was the main contributor to this co-authored manuscript (essay 1). This included responsibility for the theoretical framework and study design, data collection and analysis, interpretation of the study findings, and writing of the manuscript. The co-author provided valuable reviewing of the manuscript and suggestions for improvement.

Various iterations of this essay have been presented at The Academy of Management Conference, The Technology Transfer Society Conference, The British Academy of Management Conference and during an invited guest seminar at The University of Oslo.

3.1. Introduction

Perceived environmental uncertainty (PEU) places severe limits on entrepreneurial decision-making (Milliken, 1987). When PEU is high, sensemaking helps individuals understand and interpret situations, facilitating action (Maitlis and Christianson, 2014). Sensemaking provides entrepreneurs and managers with a viable narrative (Weick, 1995) that may be communicated to internal and external stakeholders (Cornelissen and Clarke, 2010; Lounsbury and Glynn, 2001). Technology ventures rely on knowledge exchange mechanisms and collaboration to develop deep capabilities needed to exploit unfamiliar and complex opportunities (George et al., 2008; Powell et al., 1996).

This study investigates how uncertainty affects entrepreneurial sensemaking through a situational analysis of regenmed venturing activity. The regenmed sector represents a useful context for studying entrepreneurial activity under uncertainty. The science of regenmed, which emphasises the use of stem cells, is *"the process of creating living, functional tissues to repair or replace tissue or organ function lost due to age, disease, damage or congenital defects"* (NIH, 2006). Regenmed presents unique challenges to venturing activity. Extremely high levels of irreducible uncertainty have hindered the development of regenmed venturing, slowing new firm formation and growth (Ledford, 2008). Irreducible uncertainty is defined as *uncertainty that cannot be reduced by information gathering or analysis, and which reflects an unknown but not an unimaginable future* (Gloria-Palermo, 1999).

Scientific knowledge requirements, regulatory complexity and research capital intensity has led to a limited number of regenmed centres of excellence. Scotland (UK), particularly the capital city Edinburgh, has a long established history of regenmed research. The University of Edinburgh houses the Scottish Centre for Regenerative Medicine (SCRM). This is a world-leading regenmed centre, with the advancement of regenmed research, translation and commercialisation at the very core of the organisation. Yet despite this, venturing activity has been slow. This provides a unique opportunity to investigate an ecosystem in its formative stages.

Informed by a pilot survey and long-form narrative interviews, this study explores how participants make sense of a highly uncertain venturing context. This investigation makes three contributions to the study of entrepreneurship under

uncertainty. First, it highlights the development of coping strategies during the sensemaking process. Findings reveal that regenmed individuals differ in their perceptions of PEU and in their coping responses. The types of coping strategies and the potential implications for venturing behaviour are discussed.

Second, the study extends U-I scholarship by showing an association between university entrepreneurial culture and entrepreneurial coping strategies. A substantial body of literature exists on the entrepreneurial university (e.g. Etzkowitz, 2000; 2003a; Rothaermel et al., 2007). This study extends prior research to propose that coping strategies are tightly linked to entrepreneurial culture at the parent institution. Role-identity conflicts and entrenched hurdles for commercialisation activities are more likely to generate coping strategies that hinder collaborative knowledge development.

Finally, a model of sensemaking under irreducible uncertainty is proposed. This links uncertainty and parent institutional culture to the development of coping strategies, and ultimately the impact of these coping strategies on collaborative knowledge building and perceptions of venture development potential. The interpretations generated in this sensemaking process have direct and important implications for venture growth strategies and resource assembly activities. In particular, findings point towards the importance of entrepreneurial decision-making during ecosystem emergence and development. More specifically, when uncertainty is high, ecosystem emergence requires entrepreneurs to experiment and competently make decisions (Carlson and Eliasson, 2003; Eliasson and Eliasson, 1996; Johansson, 2010).

This study opens new research directions linking entrepreneurial sensemaking to coping strategies and collaborative knowledge development when uncertainty cannot be resolved by information gathering or analysis. Despite important implications for theories of entrepreneurial behaviour and venture development, entrepreneurial coping strategies have received relatively little attention. The study also builds upon recent investigations on selective revealing as an alternative form of entrepreneurial collaboration under uncertainty (Alexy et al., 2013).

3.2. Literature

This study seeks to inform theories of entrepreneurial sensemaking under irreducible uncertainty and the resulting effects on the development of entrepreneurial ecosystems. Focusing on the regenmed sector presents a useful context for investigating these phenomena.

3.2.1. Venturing in the regenerative medicine field

Regenmed venturing is difficult and uncertain. The regenmed industry faces complex political and social forces, uncertain regulatory frameworks, unresolved IP rights issues, and untested production and distribution systems (Hogle, 2014). The investment and infrastructure requirements of regenmed commercialisation have favoured entrepreneurial activities with explicit links to university research programmes. Commercialisation of university-led stem cell innovations is likely to be dependent upon cultural norms and institutional contexts (Walshok et al., 2014; Zahra and Wright, 2011). The dependency on the larger institution may create resource assembly challenges for new technology ventures (Powell et al., 1996). These firms must operate with little or no slack in their resource pool, limiting product-market and business model exploration and testing (Bock et al., 2012; George, 2005). Regenmed business models remain mostly unproven, evolving through a trial-and-error process (Costa and Levie, 2012; Heirman and Clarysse, 2004; Loch et al., 2008). Uncertain business models and the perception of high risk in regenmed venturing hinders investments by VCs and pharmaceutical companies. This has created a knowledge and capabilities gap between regenmed innovation and commercialisation.

Knowledge resources are especially important to new ventures (Grant, 1996; Powel et al., 1996). Ventures commercialising novel innovations may compensate for resource scarcity by accessing social networks to legitimise organisational narratives and access knowledge and financial resources (Aldrich and Martinez, 2001; Lounsbury and Glynn, 2001). The sophisticated technological requirements of regenmed, however, increase these firms' need to explore boundary-spanning resource exchange mechanisms in order to become competitive. In dynamic and complex industries, collaboration and knowledge exchange enable early stage

ventures to develop deep and sophisticated capabilities in order to exploit opportunities (George et al., 2008). At the same time, technical knowledge increases collaboration costs and uncertainty about partner capabilities and intents. The use of selective revealing to reduce the perceived risk of disclosure may induce the external firm to become more similar to the focal firm with respect to the production of knowledge (Alexy et al., 2013).

The regenmed field has suffered from ethical and legal hurdles that have made public or broad disclosure costly. When high amounts of uncertainty and controversy surround a novel technology, legitimisation of this technology becomes essential to resource assembly (Jain and George, 2007). Legitimisation of novel technologies is possible through ventures protecting their technology, widely publicising their technology and influencing key stakeholders (Jain et al., 2009). Entrepreneurs in the field of regenmed have relatively fewer options for either safely testing legitimising narratives or exploring collaborative partnerships, without risking the loss of protecting IP.

Venturing in regenmed will require entrepreneurs to address high levels of irreducible uncertainty. Regenmed entrepreneurs and ventures must rely on risky, costly collaborations and networks to access resources, including knowledge, in order to exploit opportunities. The processes, however, have not been carefully investigated to understand the drivers of such collaboration efforts. As the development of collaboration and knowledge exchange networks are likely important to the formation of the broader ecosystem, studying entrepreneurial cognition in this context offers a window to much larger scale effects under conditions of perceived uncertainty.

3.2.2. The nature of uncertainty

Venture success depends on entrepreneurs recognising and responding to uncertainty (McKelvie et al., 2011). Perceived uncertainty is generally classified as state, effect or response uncertainty (Milliken, 1987). State uncertainty describes environmental unpredictability. Effect uncertainty represents the inability to predict the impact of environmental change. Response uncertainty limits the ability to predict consequences of choice or action. The appropriate responses to uncertainty

lead to growth and firm value (Sirmon et al., 2007). Since uncertainty, in contrast to risk, cannot be resolved via data gathering or analysis (Knight, 1933), entrepreneurs cannot manage uncertainty. They can only be prepared for contingencies and cope with living with the unknown.

Coping with uncertainty is a three-staged process. It involves *primary appraisal* in which individuals evaluate the threats to themselves. *Secondary appraisal* considers the response options available in order to deal with these threats. *Coping* with these threats relies on implementing the response options available and involves the use of two coping functions: a *problem-focused* coping and an *emotion-focused* coping (Lazarus and Folkman, 1984). During stressful situations individuals will utilise both types of coping functions in addressing the particular problem. However, problem-focused coping tends to predominate when individuals perceive that they can address the particular situation and emotion-focused coping prevails when the situation is less controllable (Folkman and Lazarus, 1980). These are fundamentally sensemaking choices. Entrepreneurs make sense of uncertainty by either choosing (consciously or unconsciously) to ignore it, or by attempting to solve unsolvable problems.

3.2.3. Entrepreneurial sensemaking within high uncertainty environments

The cognitive processes of entrepreneurs during venture creation warrant careful study (Forbes, 1999). Prior research has focused primarily on opportunity recognition and decision-making under uncertainty (Haynie et al., 2010; McMullen and Shepherd, 2006). Much remains to be investigated, including the unique role of sensemaking, as entrepreneurs explore unfamiliar opportunity sets or create entirely new markets (Grégoire et al., 2011).

Organisational research on sensemaking generally emphasises how individuals make sense of ambiguity and uncertainty within a broader, stable context (Maitlis, 2005; Maitlis and Christianson, 2014; Weick, 1995; Weick et al., 2005). Even as scholars examine response to chronic pressure or acute crises (Cornelissen, 2012; Maitlis and Sonenshein, 2010; Weick, 1988; Weick, 1993; Weick and Sutcliffe, 2003), the backdrop of a larger institutional framework provides the

overarching norms and expectations of an established organisation or industry. Not surprisingly, research has carefully examined how such institutional contexts influence sensemaking processes (Nigam and Ocasio, 2010).

Sensemaking is critical during venture formation, converting the unfamiliar or unknown to the familiar and understandable (Cornelissen and Clarke, 2010; Hill and Levenhagen, 1995). Entrepreneurs observe and interpret data associated with "known unknowns." Deriving choice sets from vague and limited data rationalises environmental uncertainties, enabling action (Maitlis, 2005). Entrepreneurs use sensemaking to construct stories that legitimise novel ideas (Lounsbury and Glynn, 2001; Martens et al., 2007) and generate metaphors to communicate complex or strange innovations (Cornelissen and Clarke, 2010). Entrepreneurs "give sense" to uncertain exogenous contexts to construct new markets (Santos and Eisenhardt, 2009) and find meaning in the wake of failure (Cardon et al., 2011).

Prior knowledge is particularly valuable in making sense of environmental uncertainty. Entrepreneurs are likely to rely on their prior knowledge as a cognitive resource, which can allow them to recognise opportunities through identifying structural parallels between new information and a relevant context (Grégoire et al., 2010). Prior knowledge, along with learning approaches, has also been shown to be important in entrepreneurial intent to develop and pursue opportunities (Dimov, 2007b).

The underlying mechanisms that activate, influence and enable sensemaking are far less well understood. Only recent research has explored the specific cognitive patterns that connect the search for meaning to entrepreneurial behaviour. Byrne and Shepherd (2013) found entrepreneurs engaging in coping strategies in order to make sense of business failure. In particular, they found that entrepreneurs with more effective cognitive processing of business failure reported higher levels of emotion-focused coping. Yet, the role of affect-based patterns in sensemaking are not well-studied in the entrepreneurial literature (Maitlis et al., 2013).

Despite a growing body of research on sensemaking, particularly its importance in the study of organisations, research remains fragmented (Maitlis and Christianson, 2014; Sandberg and Tsoukas, 2015). A key purpose of this study is to extend prior research on patterns of sensemaking cognition, especially when PEU is

high. Limited information exists on how entrepreneurs make sense of the venturing process under conditions of irreducible uncertainty. It can be expected that institutional factors likely shape individual sensemaking (Nigam and Ocasio, 2010; Weber and Glynn, 2006), but it is unclear how these effects will present when the new venture is relatively distinct from the prior institutional context. Further understanding is required to explain how sensemaking influences entrepreneurial perceptions of the critical functions required for the development of the organisation, including knowledge collaboration.

3.3 Data and Methods

3.3.1. Study context: Uncertainty in the regenmed industry

The UK occupies a world leading position in regenmed research, with stem cell academic centres of excellence located in Edinburgh, Cambridge, London, Oxford and Newcastle.

The UK government is encouraging regenmed translation in a number of ways. It has invested in regenmed infrastructure to help firms and healthcare providers exploit the long-term clinical and economic benefits arising from stem cell research (*Taking Stock of Regenerative Medicine in the UK*, 2011). The governmental funded Technology Strategy Board (TSB) agency has established the Cell Therapy Catapult (CT Catapult). This is charged with ensuring that the UK becomes a global leader in the development, delivery and commercialisation of regenmed. Between 2013-2018, the UK government has allocated £70m of core funding to CT Catapult (*BIA*, 2013). The TSB, in conjunction with the Medical Research Council (MRC), has also established a Biomedical Catalyst Translational Funding Programme, which offers funding to SMEs and academics. Furthermore, the TSB has established knowledge transfer networks (KTN). The Health KTN is tasked with accelerating innovation and technology exploitation through knowledge exchange mechanisms. Moreover, the TSB also offers various individual funding programmes to support SMEs and academics in developing solutions for particular healthcare issues. Governmental funding support has also been utilised in order to form the UK regenmed platform (UKRMP), which seeks to address the technical and

scientific challenges facing regenmed research, and to promote regenmed translation. Additionally, the National Institute for Health Research (NIHR) is supporting regenmed to the sum of £9 million a year. Total UK publicly-funded research in regenmed exceeded £77 million in 2012 (*Regenerative Medicine Report*, 2013).

For stem cell companies and investors, the UK offers a competitive fiscal environment, which includes favourable R&D tax credits, reduced cooperation tax rates and significant non-dilutive grant funding (*BIA*, 2013). At present there are 26 active regenmed companies in the UK, which is the second highest in Europe behind Germany (*House of Lords Scientific Committee Report*, 2013).

Within the UK, Scotland has a long and well-known history in regenmed, popularised by the story of Dolly the Sheep. Dolly was the first cloned mammal from an adult somatic stem cell (Wilmut et al., 1997). Life Science Scotland, a subsidiary of government-run Scottish Enterprise, has focused on encouraging regenmed collaborations, innovations and translation. Within the Scottish life science ecosystem, several organisations support regenmed collaborations and translational activities. These include The National Health Service (NHS) Research Scotland, which provides an outlet for multi-centre clinical studies, and Health Science Scotland, which assists academia and industry collaborations.

The capital city of Scotland, Edinburgh, is home to BioQuarter. This is a £600 million joint venture between Scottish Enterprise, The University of Edinburgh and NHS Scotland. BioQuarter is designed to encourage commercialisation at the U-I boundary. Located at the BioQuarter site is SCRM, which provides state-of-the-art research facilities to advance stem cell and regenmed research. Further details relating to the regenmed ecosystem in Scotland and Edinburgh are shown in Table 3.1.

Table 3.1. General information about the Scottish regenerative medicine ecosystem

Population of Scotland	5 295 000
GDP for Scotland	£150 billion
Capital city of Scotland	Edinburgh
Population of Edinburgh	495 360
Significant local industries	Education, health, finance, insurance, agriculture, tourism and whiskey
VC in region	<5
University of Edinburgh (UoE) student population	30 579
UoE annual research budget	£286 million
University research income	£316 million
UoE College of Medicine faculty	2594
Medical research	Estimated £109 million
UoE TTO activity	TTO founded in 1969. 423 patents filed 2007-2012. £3.5 million license/royalty income in 2011. 160+ active commercial license agreements. 171 spinout/start-ups since 1969.
UoE regenmed patents granted between 2009-2011	9
UoE regenmed publicity	Dolly the Sheep

Note: All data for 2012-2013 unless otherwise noted.
Sources: University of Edinburgh and subsidiary School/College websites and Annual Report, and Scottish Government websites (including UK Intellectual Property Office).
(Source: Author)

Despite the regenmed history and infrastructure in Scotland, venturing in this ecosystem remains in a formative stage. The ecosystem is at the forefront of regenmed research but lags in commercialisation. This provides an opportunity to witness early-stage ecosystem development that would otherwise not be possible in more established regenmed ecosystems such as Boston, San Diego, London or Seoul.

3.3.2. Data

To explore sensemaking and behavioural processes, this study utilises a primarily qualitative approach to better develop insights into socially constructed knowledge and events (Locke, 2001). A small, online pilot survey confirmed the relevance of key constructs, but the primary dataset consists of long-form narrative interviews (McCracken, 1988). Information about the complete set of qualitative informants is provided in Table 3.2.

Table 3.2. Study informant information: Essay 1

#	Informant's role	Category	Organisation type	Location
1	Director of Operations	Support entity	Services	Edinburgh
2	CEO & Founder	Entrepreneur	Tools/Diagnostics	Glasgow
3	Business Development	Regenmed company	Services/Research	Edinburgh
4	CEO & Founder	Entrepreneur	Services/Research	Edinburgh
5	Academic scientist	Academic scientist	Research	Edinburgh
6	Economic Development	Support entity	Services	Edinburgh
7	CEO	Support entity	Services	Edinburgh
8	Business Development	Support entity	Research	Edinburgh
9	Director & Academic	Academic scientist	Research	Edinburgh
10	CEO & Founder	Entrepreneur	Cell Therapy	UK
11	Industry Liaison Manager	Support entity	Services	Glasgow
12	Technology Manager	Support entity	Services	UK wide
13	CEO & Founder	Entrepreneur	Services/Diagnostics	Edinburgh
14	CSO & Founder	Entrepreneur	Services	Glasgow
15	CEO	Support entity	Services/Research	UK wide
16	CEO	Regenmed company	Tools/Diagnostics	UK
17	Outreach Manager	Support entity	Services	Scotland
18	International Executive	Support entity	Services	Scotland
19	Entrepreneur	Entrepreneur	Tools/Diagnostics	Scotland
20	CEO	Support entity	Services/Research	Edinburgh
21	Business Development Head	Support entity	Services/Research	Edinburgh
22	Academic scientist	Academic scientist	Research	Edinburgh
23	Business Creation Head	Support entity	Services/Research	Edinburgh

(Source: Author)

Information on target informants was obtained from BioQuarter. Informants were selected based on direct involvement in the commercialisation of regenmed in one of the following four categories: 1) Regenmed entrepreneurs, 2) Academic scientists, 3) Regenmed/life science support entities, and 4) Regenmed companies/ventures. For-profit third party support firms, such as consultancies, were excluded from the study. Additionally, full-time students, even those with significant entrepreneurial intent, were excluded. This ensured efficient and effective saturation of categories, providing sufficient data to account for all aspects of the phenomenon (Morse et al., 2002). Informants were not provided detailed information about the interview to prevent prejudicial preparation of information or materials.

3.3.3. Long-form narrative interviews

Face-to-face, long-form narrative interviews with informants were conducted between November 2012 and September 2013. Interviews were conducted in private facilities to prevent interruptions and ensure confidentiality. Informants were asked

to *"tell the story of their participation in the commercialisation of regenerative medicine innovation."* Narrative approaches are particularly useful for theory building in entrepreneurship (Fletcher, 2007; Larty and Hamilton, 2011). Informants were given complete freedom to recount their narrative without interruption and with limited or no further direction. This minimises investigator bias, increases informant comfort and encourages informants to recount their own story in their own words and focus on self-identified areas of interest. Legal and ethical controversies associated with regenmed require an especially sensitive approach to the collection of qualitative data. The open-ended, non-directed narrative approach helps to reduce staged responses and social desirability bias (Podsakoff et al., 2003). Informants were encouraged to talk until they felt that they had reached a self-determined conclusion. Following the informant-determined end of the main narrative, some informants were prompted to provide additional details on key areas of interest. Field notes were generated during and immediately after each interview to provide *in situ* interpretation to complement transcript coding. The duration of the interviews ranged from 16 minutes to 111 minutes, with the average length being approximately 60 minutes. The final dataset includes 23 long-form narratives, equating to 151,192 words of textual data.

3.3.4. Online pilot survey

A small-scale, online pilot survey was utilised to confirm the relevance of key constructs and frame the coding of the narrative interviews. The survey was designed to elicit data on informant's perceptions of regenmed venturing. Survey questions included both closed and open-ended questions on facilitative and inhibitive factors to regenmed venturing activity. Question types and order were carefully considered to reduce common method biases (Podsakoff et al., 2003). The survey was pre-tested by administration to a regenmed industry expert and a regenmed academic scientist to ensure clarity of design and relevance of the questions (Fowler, 2009). Survey informants were selected from the regenmed informant target list and e-mailed regarding their participation. In total, 26 individuals were invited to participate in the survey and 15 responses were received, which represents a 58% success rate. Referrals by first-wave respondents to

additional industry participants generated 7 additional responses. Therefore, a total of 22 responses were utilised in the pilot survey analysis.

3.3.5. Procedures

Analysis of the regenmed venturing interview narratives was informed by grounded theory (Strauss and Corbin, 1990). The results of the pilot survey were used solely to inform and validate the qualitative coding process. 1st order codes were generated via open-ended coding of the transcripts and triangulated against the results of the pilot survey to identify overlap and gaps. 2nd order groupings of the 1st order codes were identified via a cycle of inductive and deductive reasoning. Finally, the 2nd order groupings were organised into aggregate theoretical dimensions based on reviews of the transcripts and the broader narratives described by the informants. All coding was performed using NVivo software.

3.4. Findings

The findings of the online pilot survey are presented first. The narrative interview findings are then discussed.

3.4.1. Online pilot survey findings

As the pilot survey data was used solely to inform the qualitative interview coding, simple descriptive statistics are reported only. Key findings from the pilot survey are presented in Table 3.3. Key summary findings that informed the qualitative analysis are noted. First, most respondents agreed that regenmed venturing is challenging due to entrepreneurial resource constraints. The majority of respondents suggested that collaborations with universities and national-level funders, government entities or national healthcare providers are required to overcome these deficiencies. Most agreed that collaborations enabled knowledge exchange, access to resources and the development of valuable organisational capabilities. There was also agreement that unrealistic commercialisation timeframes have been set for regenmed commercialisation. Respondents further noted that commercialisation was inhibited by uncertainties surrounding regenmed regulation, manufacturing, distribution and scale-up. Despite these challenges, most respondents

disagreed that regenmed collaborations were difficult to manage. Most disagreed that collaborations with large pharmaceutical firms were required for regenmed commercialisation. Respondents were split on whether VC funding was reasonably accessible for regenmed commercialisation or whether collaborations were costly and failed to deliver.

The results of the pilot survey clearly confirm some of the challenges of regenmed venturing, but provide first indications of the sensemaking mechanisms that entrepreneurs use to justify continued venturing activity. These results were utilised to inform the qualitative coding procedure since the study was particularly interested in the potential for cognitive and sensemaking processes.

Table 3.3. Summary of pilot survey findings

Survey statements	Key findings – participants' response to statement
Regenerative medicine commercialisation is challenging due to the resource constraints faced by organisations	45% agreed 32% strongly agreed
Collaborations are required for regenerative medicine commercialisation	45% agreed 32% strongly agreed
Governmental funding can be accessed for regenerative medicine commercialisation	32% agreed 23% strongly agreed 18% disagreed
Unresolved regulatory issues are affecting regenerative medicine commercialisation	64% agreed
Knowledge is exchanged during collaborations	55% agreed 36% strongly agreed
Collaboration with hospitals is necessary for regenerative medicine commercialisation	41% agreed 36% strongly agreed
Unrealistic timeframes are set for regenerative medicine commercialisation	41% agreed 27% strongly agreed 18% neither agreed or disagreed
Collaborations with academic institutions are necessary for regenerative medicine commercialisation	45% agreed 27% strongly agreed
Venture capital funding can be accessed for regenerative medicine commercialisation	32% disagreed 32% agreed 23% neither agreed or disagreed
Regenerative medicine collaborations often fail to deliver	36% disagreed 32% neither agreed or disagreed 23% agreed
Collaborations can provide early stage regenerative medicine ventures access to resources	45% agreed 27% strongly agreed
Collaboration with "big pharma" is necessary for regenerative medicine commercialisation	50% disagreed 18% neither agreed or disagreed
Manufacturing, distribution and scale-up uncertainties are affecting regenerative medicine commercialisation	36% agreed 23% neither agreed or disagreed 18% strongly agreed
Regenerative medicine collaborations are difficult to manage	41% disagreed 23% agreed 18% neither agreed or disagreed
Regenerative medicine collaborations are costly	27% neither agreed or disagreed 27% agreed 18% strongly agreed
Regenerative medicine business models are unknown and unproven	32% strongly agreed 32% don't know
Collaborations enable regenerative medicine organisations to acquire capabilities	64% agreed

(Source: Author)

3.4.2. Narrative interview findings

The results of the interview coding are presented in Table 3.4. utilising a multi-level data structure (Walsh and Bartunek, 2011). The first column of the table shows the prevalence (%) of 1st order codes within the total (T) 23 interviews. The table also highlights the prevalence (%) of 1st order codes for each informant

category, which includes interviews with 6 entrepreneurs (E), interviews with 3 academics (A), interviews with 12 support entities (SE) and interviews with 2 regenmed companies (RC).

Table 3.4. Data structure: Essay 1

Prevalence in study sample (%)*					1st Order Codes	2nd Oder Codes	Theoretical Dimensions
T	E	A	SE	RC			
61	83	67	50	50	Risk	Types of uncertainty	Perceived environmental uncertainty (PEU)
74	100	67	58	100	Funding issues		
43	33	67	42	50	Mfg, scale-up and distribution uncertainty		
39	50	0	42	50	Regulatory uncertainty		
17	17	33	17	0	Scientific uncertainty		
17	33	0	8	50	Ethics		
13	17	0	17	0	Reimbursement uncertainty		
39	17	33	58	0	Academic conflicts	Inventing entrepreneurs	University entrepreneurial culture
39	17	67	50	0	Academic motivations		
30	0	67	42	0	Academic metrics		
35	17	0	58	0	TTO goals and activities	TTO goals and activities	
91	83	67	100	100	Collaborations with industry	Collaborative partners	Coping strategies
74	33	100	83	100	Collaborations with academia		
39	17	33	50	50	Collaborations with NHS		
35	0	33	50	50	Collaborations with support entities		
39	67	67	17	50	Collaboration for sharing of resources	Collaborative outcomes	
30	17	33	25	100	Collaboration for process improvement		
22	0	67	25	0	Collaboration for funding purposes		
9	17	33	0	0	Collaboration costs		
4	17	0	0	0	Collaboration for legitimacy building		
61	83	67	58	0	Legitimacy building	Legitimacy building	
57	67	0	67	50	Knowledge transfer	Resource exchange mechanisms	Collaborative knowledge
70	50	100	75	50	Communication		
22	50	33	0	50	Learning		
26	17	33	33	0	Language differences		
57	50	33	75	0	Regenmed and scientific communities	Networks	
87	83	67	92	100	Governmental funding	Funding sources	Narratives of venture potential
61	83	33	58	50	VC funding		
35	0	100	33	50	"Big pharma" funding		
65	50	67	75	50	Spinout venture formation	Spinout venture formation	
61	83	67	58	0	Legitimacy building	Trial and error business models	
57	100	33	33	100	Business models		
9	33	0	0	0	Integrated business model		
78	83	100	75	50	Resources	Existing resources	
30	17	33	33	50	Innovation	Economic development	
30	0	0	58	0	Regional investment and growth		
65	67	67	58	100	Commercialisation timeframes	Future scenarios	
9	17	33	0	0	Potential industry structure		

* Does not account for multiple occurrences within a single interview. T = Total sample; E = Entrepreneur, A = Academic; SE = Support entity; RC = Regenerative medicine company
(Source: Author)

The theoretical dimensions revealed by the study data are discussed in turn. To support the findings and highlight their relevance and significance, illustrative examples of 1st and 2nd order codes are provided.

Perceived environmental uncertainty (PEU). The data shows high levels of PEU surrounding regenmed venturing. Informants consistently reported high levels of funding uncertainties: *"Yeah, if you can imagine taking a drug to market, only large pharmaceutical companies can really afford to do that…you need GMP manufacturing, you need clinical trials, you need safety assays…it's a very expensive deal. In Scotland we don't have that level and the amount of money required."* (Informant #13)

Regenmed venturing requires bridging this funding gap between stem cell innovations and translation. Achieving this is highly uncertain since regenmed commercialisation activities generally exceed investor timeframes and investment limits. High levels of uncertainty also surround manufacturing, scale-up and distribution: *"…so you have all sorts of problems as to how you scale out and manufacture…"* (Informant #2)

Regenmed ventures also face high levels of regulatory uncertainty, especially unresolved IP rights issues: *"Not only is the regulatory path as expensive as a pharmaceutical with a potentially smaller market, it's also got a huge amount of uncertainty."* (Informant #10) Legislative changes regarding the use of human ESCs has resulted in the shift to iPSC but has required ventures to adapt their business model as a consequence. iPSC are seen as more ethically acceptable, but ethical uncertainties still surround the regenmed sector. Furthermore, scientific shifts are likely because stem cell science is still in its infancy.

Many of the uncertainties discussed within the dataset are consistent with previous research (Plagnol et al., 2009). Some ventures are not fully committing to this sector, deploying limited resources until uncertainty (and risk) is reduced. Therefore, if the sector is to see advancements in regenmed venturing, these uncertainties must be addressed. To achieve this, regenmed ventures are engaging in collaborations, legitimacy building and knowledge exchange mechanisms.

University entrepreneurial culture. University academic scientists may be expected to participate in commercialisation activities. This requires the inventing entrepreneur to modify their role-identity, shifting from a scientific orientation to a more market-driven approach (George and Bock, 2008; Jain et al., 2009). However, this often creates conflicting pressures as academics are measured on research papers and grants, not commercialisation outcomes: *"…there's a tension here isn't there? Academics are judged by their papers and their grants…Spinouts take a lot of time and a huge amount of work…group leaders find that extremely difficult because that's time that they're not doing their academic work and ultimately they will be judged with the current metrics much more on their academic work than they will on their commercialisation work."* (Informant #9) This tension could impact their motivation for commercialisation (Etzkowitz, 1998; Ndonzuau et al., 2002).

TTOs play an important role in encouraging an entrepreneurial culture for academics (Lerner, 2005). The business development capabilities of TTO staff can also influence commercialisation (Lockett and Wright, 2005; Thursby and Kemp, 2002). Some staff may lack the technical and entrepreneurial understanding that is required to commercialise stem cell science (Lockett et al., 2005): *"I guess again that comes down to their tech transfer department to do that. Again, will they necessarily understand? I don't think so?"* (Informant #1) Regenmed venturing will, therefore, ultimately depend on universities deinstitutionalising their traditional academic culture and adopting a more commercially oriented and entrepreneurial one (Dacin et al., 2002; Scott, 2001).

Coping strategies. In order to address high levels of PEU, entrepreneurs or ventures will be required to engage in coping strategies (Milliken, 1987). Study findings show entrepreneurs and ventures engaging in collaborations and legitimacy building, in order to address the high levels of PEU.

The majority of collaborations are taking place for resource assembly purposes: *"…so we have access to the cell lines, or at least some of them, from [company name]. That's a collaboration"* (Informant #3), and improving particular processes: *"…the idea is that we can work with them and take some of the processes and tune them up for proper manufacturing."* (Informant #15) Collaborations also

provide access to funding and can build the legitimacy of a particular venture. Collaborations with industry and academia appear to be the most dominant types of collaboration within the dataset. Collaborations with the NHS are also vitally important for regenmed venturing, as they enable access to clinicians. However, gaining access to the NHS and forming a collaborative partnership is currently challenging: *"Access to the NHS is very challenging in Scotland…it's just something that's not happened in Scotland."* (Informant #11) Collaborations involving support entities provide ventures with access to executives with expertise in new venture development. They also facilitate in connecting ventures with investment communities. However, despite the benefits of collaborations, costs associated with collaborations were evident.

In addition to the role of collaboration in addressing the high levels of PEU, uncertainty reduction is also possible as a consequence of legitimacy building. Entrepreneurial stories were evident within the dataset as a means of legitimacy building and serving to reduce uncertainty: *"…we had been talking to him, and talking to him, and talking to him. And he didn't, at first, believe that our technology did what it said it did because it is a paradigm shift for stem cell technology…and we get a lot of people who don't believe it, although less and less. We are able to show people stuff now that makes them realise that's it's the real deal…"* (Informant #2) Protection of stem cell research, publicising regenmed technology through raising awareness, and influencing key stakeholders was also evident within the dataset as a means of legitimisation.

Collaborative knowledge. Coping strategies can enable access to knowledge for venture formation and growth. The study findings highlight the exchange of knowledge and communication between the various actors operating within the regenmed sector. Knowledge is accessed through collaborations: *"I'm working with [name of collaborator] and we are developing techniques which hopefully will have commercial applications in the future. So it's kind of using my communication skills and knowledge of embryology and his knowledge of transgenics and how that works."* (Informant #4)

Networks are also important for knowledge access: *"…we got them to meet some companies through our network…to find out what they're doing, swap information, so that kind of activity, I mean, knowledge transfer, it's community building, access to funding and access to partners for collaboration would be the strap line."* (Informant #12) Knowledge access is especially valuable because it can enable capability development: *"…we had a knowledge transfer partnership with the university… and really that was used to sort of develop our capability in creating cell lines that basically took on the form of hepatocytes."* (Informant #7) However, informants did discuss the difficulties in exchanging knowledge due to the language differences between the various actors within the sector and due to the tacitness of regenmed knowledge.

Social networks have been suggested to be an important mechanism for the assembly of resources and in the creation and exchange of knowledge (Aldrich and Martinez, 2001; Ardichvili et al., 2002). Within the regenmed sector there are several life science communities that have been established, with the aim of ensuring successful regenmed venturing. For example, The Health KTN organises events and workshops where regenmed industry actors can meet in order to share ideas and gain access to potential collaborators. This network also acts as a facilitator for the identification of new sources of funding.

Narratives of venture potential. Accessing resources, including knowledge, through collaborations and networks can enable regenmed ventures to form and grow. During this venture development period, ventures may continue to engage in coping strategies resulting in additional collaborative knowledge. However, regenmed venture development is challenged due to a lack of slack resources, especially financial resources. Governmental funding appears to be available for basic scientific regenmed research and to progress regenmed research to phase I/II studies. However, access to funding for clinical stage research and to deliver this research to the market is currently challenging: *"…because at the moment people in regenerative medicine talk about a funding gap and you'll hear this from many people, but preclinical stuff...is great, it's all academic. You then sort of do proof of concept stuff which is fundable because it's fairly cheap, but then there's this clinical*

development which is extremely expensive and small companies can't afford it, universities certainly can't afford it." (Informant #3) At present, entrepreneurs and early stage regenmed ventures are required to match governmental funding with their existing financial resources, which is difficult.

Business model evolution through trial-and-error was exemplified within the dataset. When complexity and uncertainty are high, ventures may run multiple parallel business models and select the best performing one (Loch et al., 2008): *"The other part to it which actually never really materialised…we also thought there was the opportunity of people actually utilising our facilities to undertake that work. In reality that bluntly didn't happen for whatever reasons…what we did, to some extent, is move away from a company that was almost a service company to one that would eventually have product or products based on IP in one form or another, whether patented or not, that we could then market."* (Informant #7)

Informants also discussed uncertainty surrounding their own business model, in some cases discussing business model failure or changes to their current business model due to a lack of market demand. This highlights that regenmed business models cannot be predicted *ex ante*. Entrepreneurs discussed their desire to become players in the regenmed therapeutics market, but due to the high uncertainties and costs of being involved in this market, all were prevented from operating in this space. Therefore, it appears from the dataset that regenmed ventures focusing on tools or diagnostics may have a clearer path to a viable business model than those focusing on therapeutics. This is because the financial resources required for commercialisation of tools or diagnostics is significantly lower than the financial resources required to commercialise therapeutics. However, given the current uncertainty within the regenmed sector, young regenmed tools or diagnostic ventures are likely to face downstream uncertainties such as reimbursement uncertainties.

University-led regenmed venturing has the potential to result in significant economic gains. However, it should not be forgotten that failure is an unavoidable aspect of any entrepreneurial venture and even if universities are successful in transferring their technology, they should not always expect the economic gains to accrue to their local area (Miner et al., 2001). Informants, especially regenmed support entities, were concerned with regenmed venturing positively impacting the

local economic environment. However, there was some concern as to whether the local environment could retain this innovation.

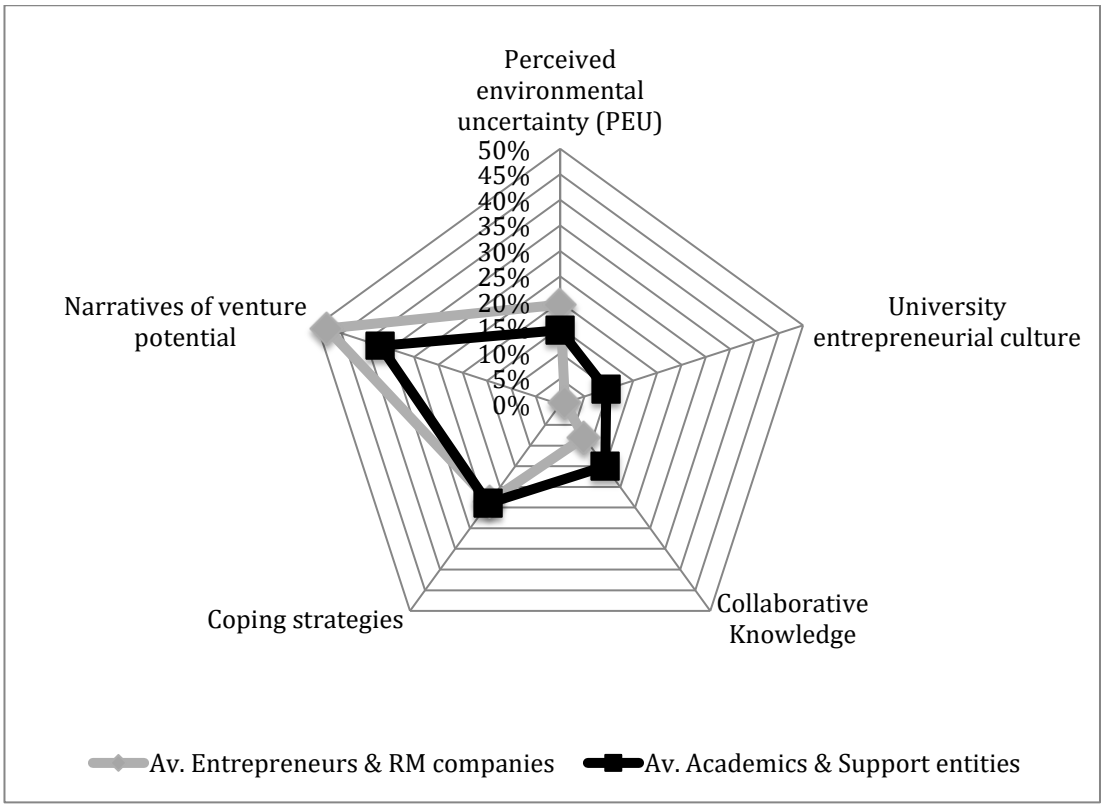
Despite the high uncertainty surrounding regenmed venturing, suggestions by informants for the trajectory of the market were forthcoming. Informants also discussed the timeframes involved for regenmed scientific progression and widespread venturing. The expected timeframes for taking regenmed science to market differs amongst the actors operating within the sector. VCs, SMEs and the UK government do not understand the timeframes involved in taking regenmed science to market, according to entrepreneurs and regenmed support entities. VCs, SMEs and the UK government expect a much quicker return on investment and as a consequence, this has serious implications for regenmed funding and, ultimately, commercialisation: *"…the time horizons of a VC investment just don't fit the time horizons of a development of a therapeutic…so the VCs intending to sell it either to other VCs or to trade sale it…I really don't like that model, it just doesn't fit."* (Informant #10)

The data also highlights differences in how each category of informant addresses uncertainty and regenmed venturing. Findings suggest the relevance of two role-based sensemaking lenses, which likely influence or complement the coping strategies in use. The two role-based lenses are illustrated in Figure 3.1.

Lens 1 consists of the average occurrence of each theoretical dimension for academics and support entities. Both place a higher emphasis on university entrepreneurial culture and collaborations. The purpose of these collaborations is to progress scientific developments and improve current regenmed processes.

In contrast, lens 2 consists of the average occurrence of each theoretical dimension for regenmed entrepreneurs and regenmed companies. Both approach venturing in a comparable way and have similar perceptions of uncertainty, including the significance and effect of uncertainty. They also both face the same concerns in relation to funding uncertainties. Regenmed entrepreneurs and companies both lack slack resources and place more emphasis on narratives of venture potential.

Figure 3.1. Revealed significance of uncertainty and venturing



(Source: Author)

3.5. Discussion

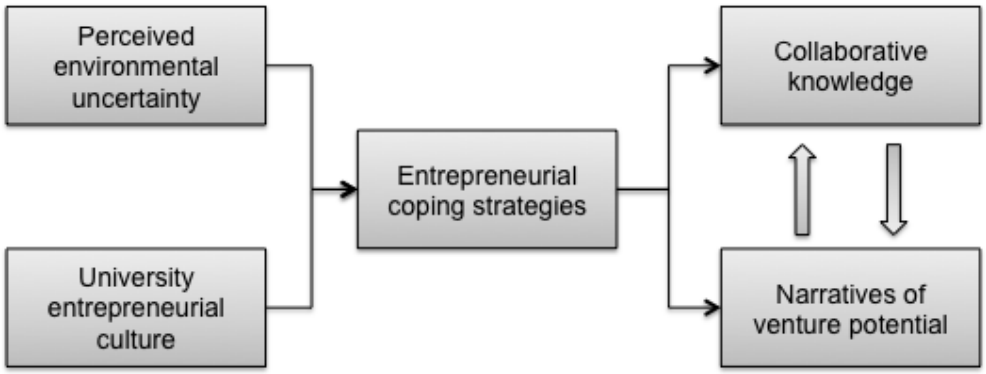
The qualitative findings suggest a model of sensemaking under irreducible uncertainty. The emergence of different coping strategies, which reflect the situational understanding of regenmed ecosystem participants during venturing, are considered. Coping strategies affect collaborative knowledge development and the resulting narratives of venture formation and growth. Alternative approaches to collaboration are considered and a typology of sensemaking under uncertainty is generated. The effect of uncertainty on institutional culture is also discussed.

3.5.1. Sensemaking in regenmed venturing

The theoretical dimensions generated by the qualitative analysis reveal a model of sensemaking in regenmed venturing, shown in Figure 3.2. PEU and institutional entrepreneurial culture affect the individual's preferred coping strategy. The chosen coping strategy then influences both the generation of venture narratives

as well as collaboration efforts. A key purpose of venture narrative is the legitimisation of the firm's innovation or business model. It can, therefore, be expected that venture narratives and knowledge collaboration efforts interact. Since this study is not longitudinal, it is not possible to consider how this interaction shapes the actual growth, development or success of a given venture.

Figure 3.2. A model of sensemaking process in regenerative medicine venturing



(Source: Author)

3.5.2. Coping with high PEU

By definition, PEU is a subjectively determined assessment of uncertainty. Informants described a variety of relevant uncertainties, including funding issues; manufacturing, scale-up and distribution uncertainties; regulatory uncertainties; scientific uncertainties; ethics; and reimbursement uncertainties. These are consistent with prior analysis of the industry (Ledford, 2008). At a fundamental level, PEU describes environmental unpredictability (Buchko, 1994; Milliken, 1987). Freel (2005) discusses three separate dimensions of PEU, which involves uncertainties related to the firm's resources/environment, the firm's industrial/market environment and the firm's economic environment. According to this categorisation, funding issues would, therefore, belong to the firm's resources/environment PEU dimension. Thus, coping strategies appear to be part of the cognitive mechanism associated with incorporating the uncertainty into the organisational development strategy.

This study has shown coping strategies to include collaborations and legitimacy building. These depend on culture and uncertainty, and affect collaborative knowledge development and the resulting narratives of venture formation and growth. Coping includes problem-focused and emotion-focused coping. Several forms of problem-focused coping have been identified, such as *specific interpersonal efforts to alter the stressful situation* or the *seeking of social support* (Folkman et al., 1986b). The specific problem-focused coping form implemented by entrepreneurs is likely to have differing effects on resource assembly and collaborative knowledge development. For example, regenmed entrepreneurs implementing problem-focused coping, in which they seek social support, may find that they are unable to assemble resources and develop collaborative knowledge. Seeking social support relies on entrepreneurs obtaining external advice, assistance or knowledge. Yet, if support is sought from regenmed individuals who have coping strategies linked to venture failure, resource assembly and collaborative knowledge development will be challenged.

Emotion-focused coping strategies enable entrepreneurs to manage their emotions in relation to the uncertainty and are most suited to uncontrollable situations. Therefore, they are especially valuable to entrepreneurs and ventures during regenmed venturing due to the high levels of irreducible uncertainty surrounding regenmed. Several forms of emotion-focused coping strategies exist, which can facilitate or inhibit problem-focused coping. These include: *denial*, *wishful thinking*, *distancing*, *emphasising the positive*, *self-blame*, *tension-reduction* and *self-isolation* (Folkman et al., 1986a). Again, we can expect resource assembly and collaborative knowledge development to proceed differently depending on which form of emotion-focused coping is adopted. For example, entrepreneurs relying on wishful thinking may fail to see potential flaws in their business model or regenmed technology. If they then collaborate for resource assembly and knowledge development purposes, homophily effects suggest that the collaborating firm will also fail to see the potential flaws. This will have serious consequences on venture formation and growth. Therefore, this study proposes that:

> **Proposition 1**: Under high levels of PEU, coping strategies relying on wishful thinking or denial are associated with reduced knowledge

collaboration and venture narratives that emphasise the venture's current innovation as the key component of a successful business model.

Proposition 2: Under high levels of PEU, coping strategies relying on problem-solving or exploration are associated with increased knowledge collaboration and venture narratives that emphasise addressing a specific market need as the key component of a successful business model.

Findings have confirmed that individuals differ in their perceptions of uncertainty (Duncan, 1972) and in their coping responses (Carver et al., 1989). This study has revealed that entrepreneurs rely less on coping strategies for venture development than any of the other regenmed participants in our study. The UK government's commitment to regenmed commercialisation has encouraged a wide range of support entities, which have been shown to rely heavily on collaborations as a coping strategy to the high levels of PEU. In some instances, support entities are measured on the number of collaborations that they establish. Therefore, regenmed support entities actively encourage regenmed firms and entrepreneurs to engage in collaborations. Yet, this situational analysis reveals that this conflicts with how regenmed entrepreneurs deal with high levels of PEU. Conflicts towards the best commercialisation pathway may prove to be detrimental to regenmed venture formation and growth. Irreducible uncertainty and variations in the best commercialisation paths, could lead to the grouping of regenmed informants based on homophily effects. This may have serious implications for venture outcome, as groups will either randomly all succeed or fail based on whether their interpretation of the best commercialisation path was accurate or not (Miner et al., 1999). Thus, support entities that are at odds with entrepreneurs' coping strategies are unlikely to provide useful support, unless they are in fact converting entrepreneurs to coping strategies that are linked more to success.

3.5.3. Collaboration under irreducible uncertainty

The study findings indicate that entrepreneurs rely on coping strategies less than any other category. Findings also indicate that costs exist during collaborations

and that there are unwilling collaborators. In addition, given the high levels of PEU, high partner uncertainty is expected. Under conditions of high collaboration costs, unwilling collaborators and high partner uncertainty, it is possible that regenmed entrepreneurs and new ventures rely on selective revealing as an alternative strategic mechanism to known collaboration mechanisms (Alexy et al., 2013). However, the use of selective revealing strategies in regenmed venturing may be problematic. If the focal firm is associated with coping strategies that are linked to venture failure, then this study proposes that collaborative networks of ignorance will be created, since the external firm also becomes associated with coping strategies linked to venture failure. This will have serious implications for the development of collaborative knowledge, since opportunity recognition depends on individuals mentally comparing new information with prior knowledge through a cognitive process of structural alignment (Grégoire et al., 2010). Therefore, it can be expected that:

> **Proposition 3**: Coping strategies, which rely on selective revealing during collaboration, are associated with partnering that favours firms with similar business models as the focal firm.

3.5.4. Institutional culture

Regenmed venturing is driven by university-led stem cell research. The embedded institutional culture and processes at the university and TTO are likely to have an imprinting effect on the structure and characteristics of regenmed ventures which emanate from the university (Kimberly, 1975; Stinchcombe, 1965). At founding, new ventures are determined by the specific technological, economic, political and cultural resources that are available to them (Johnson, 2007). To ensure their survival and growth, they must follow strategies that are rewarded by their external environment (Kriauciunas and Kale, 2006). However, since regenmed ventures operate under extended periods of high levels of uncertainty, it is reasonable to suggest that imprinting effects will have unintended outcomes on the survival of young regenmed ventures. Therefore, imprinting effects, and the inventing academic-entrepreneur's prior role-identity conflicts, presents significant challenges to regenmed venturing. With this in mind, this study suggests that:

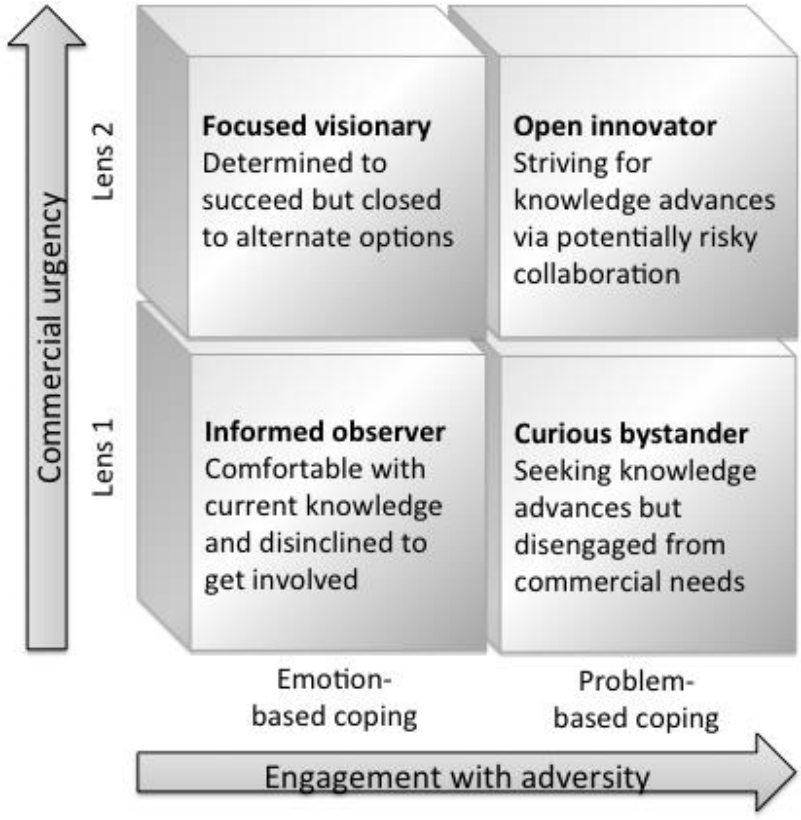
Proposition 4: A weak entrepreneurial culture in the parent institution is associated with emotion-based coping strategies in its spinoff ventures.

Proposition 5: A strong entrepreneurial culture in the parent institution is associated with problem-based coping strategies in its spinoff ventures.

3.5.5. A typology of knowledge collaboration during venturing under high uncertainty

Combining the role-based lenses with the coping strategies generates a typology of sensemaking profiles under uncertainty. The generation of archetypal sensemaking approaches to inherently uncertain activities presents a useful tool for entrepreneurs, research institutions, and policymakers to better understand and potentially influence the evolution of an entrepreneurial ecosystem. The typology is shown in Figure 3.3.

Figure 3.3. Sensemaking types in uncertain entrepreneurial ecosystems



(Source: Author)

Focused visionaries are participants in the regenmed ecosystem that have settled on a key innovation or business model and plan to see it through regardless of the development of alternative innovations or collaborative opportunities.

Informed observers have similarly determined a relatively set position with regard to technology or innovation but are not actively engaged in commercialisation.

Open innovators are individuals engaged in commercialisation activity based on a primary technology, but are willing to take the risk of collaboration in order to best address a given market problem.

Curious bystanders are not directly involved in commercialisation, but have specific market problems or industry needs in mind and encourage collaboration for the sake of improving the knowledge of the ecosystem as a whole.

At this time, it is unclear whether ecosystems benefit more from some sensemaking profiles than others, or whether a specific mix or blend of sensemaking profiles is somehow advantageous. This study speculates, however, that the level of uncertainty in regenmed has differential effects on individuals, firms and the ecosystem based on sensemaking profiles. For example, small ecosystems with relatively limited capital and knowledge resources likely reward focused visionaries over open innovators, because they present a more compelling narrative to legitimise the venture and its business model. By contrast, curious bystanders may be favoured in nascent ecosystems because they enable trusted exchange of information without extensive and costly contracting requirements. Larger ecosystems still operating under significant uncertainty might favour the opposite profiles. Open innovators, that emphasise clear market opportunities, may ultimately attract more venture capital through venturing development activities that emphasise capability development rather than narrow technological testing. Similarly, the presence of larger networks of service and financial experts may obviate the need for curious bystanders, increasing the relative value of informed observers who are aware of untapped innovations that can be tested with minimal resource combinations.

3.6. Limitations and directions for future research

As this is an exploratory study, the sensemaking model should be tested via empirical analysis. The derived theories of regenmed venturing proposed in this study also require further testing, refinement and development through further empirical research. The dataset is limited primarily to regenmed venturing informants in Scotland. Similarities in regenmed sector development across western geographies suggest that findings have broader relevance, but caution should be exercised beyond early stage regenmed ecosystems in western economies. The dataset over represents regenmed support entities, therefore, further data collection should focus on pre-venture academic entrepreneurs and *de novo* regenmed firms.

Despite these limitations, the research findings emphasise the importance of research linking entrepreneurial cognition and decision-making to venture process, especially under high levels of uncertainty. This study opens pathways for future research to reveal the full nature of individual and organisational coping responses during opportunity exploitation and under high levels of PEU. This may distinguish which coping strategies are linked to success or failure in context. From this, this can enable a deeper understanding of coping strategies for the assembly of resources, the development of collaborative knowledge and venture outcomes. Further research in this area also has strong potential to clarify the characteristics of mind-sets that distinguish academic entrepreneurs from industry entrepreneurs. This investigation calls upon further research on the existence and role of selective revealing in regenmed venturing, particularly the drivers and outcomes of this alternative form of collaboration mechanism. This is consistent with further research calls from Alexy et al. (2013). Finally, these study findings also encourage further studies to understand the effects of prolonged periods of PEU to environmental imprinting and the survival of young regenmed ventures.

3.7. Policy implications

This study points towards specific policy implications regarding entrepreneurial training, ecosystem development and university entrepreneurial culture.

First, many universities have begun offering entrepreneurial training to academics that self-select for potential commercialisation of their research-based innovations. In knowledge-intensive fields that operate under high levels of uncertainty, the merits of such training may be difficult to measure. In addition to developing traditional business skills, academic entrepreneurs report needing to adjust their mind-set to operating within an entrepreneurial framework (George and Bock, 2008). In fields requiring significant scientific capabilities, such as regenmed, fostering effective academic entrepreneurship may require investing in experiential training that directly addresses coping with failure and collaborative knowledge development.

Second, the role of government in technology ecosystem development requires careful consideration. The state has an important role to play in developing novel university-based technologies whose potential is not yet understood by the business community (Etzkowitz, 2003b; Mazzucato, 2013). The nature of policies that support ecosystem development in nascent technology sectors, however, has not been broadly tested. Government support for the growth of an extant, healthy ecosystem is primarily one of addressing market failures, such as lack of growth capital and access to markets. In nascent, high-uncertainty ecosystems, such as regenmed, downstream markets may not yet exist and supplemental growth capital would likely go unused or be lost in purely speculative ventures. The development of entrepreneurial ecosystems depends on more than environmental conditions and institutional policy (Bock and Johnson, 2016).

Third, universities must consider entrepreneurial culture as well as commercialisation policy. The proposed sensemaking model highlights the role of institutional culture on the development of an individual's preferred coping strategy. Entrepreneurs are adept at finding, adapting and exploiting undervalued resources, often through novel, unexpected, or even counter-institutional processes (Anderson and Warren 2011). The academic entrepreneurs most likely to succeed will do so by exploiting supportive policies and side-stepping inhibitive restrictions. In other words, universities may need to be less concerned about policies that support successful entrepreneurial action, and more concerned about fostering an environment and culture that encourages entrepreneurial action in the first place.

3.8. Conclusions

This study investigated entrepreneurial activity within regenmed venturing, which is a sector characterised by unusually high levels of uncertainty. The investigation advances theories of sensemaking under irreducible uncertainty by proposing a model linking uncertainty, sensemaking, coping and collaborative knowledge development. Findings present a novel picture of organisational coping under high levels of uncertainty. Entrepreneurs and new ventures will be required to adopt coping strategies in response to the high levels of PEU, which can result in the development of collaborative knowledge and venture development. Those entrepreneurs and new ventures that fail to adhere to this, may find themselves unable to develop their business model.

This study has also progressed the understanding of U-I scholarship by showing an association between university culture and venture coping strategies. Therefore, these findings are especially useful to TTOs. Universities and TTOs, which expect to commercialise their stem cell research, will need to consider balancing their academic and commercialisation culture.

This study also has implications to UK government policymakers, who are not only charged with ensuring that the UK remains at the forefront of regenmed research, but also with the commercialisation of this research.

Chapter 4: Essay 2

A comparative study of ecosystem development in regenerative medicine

Essay 2 is a cross-national investigation of entrepreneurial ecosystem development at the U-I boundary. This essay is published as:

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In accordance to UEBS thesis guidelines, I confirm that the author of this thesis was the main contributor to this co-authored manuscript. This included responsibility for the theoretical framework and study design, data collection and analysis, interpretation of the study findings, and writing of the manuscript. The co-author provided valuable reviewing of the manuscript and suggestions for improvement.

Various working forms of this essay have been presented at The Academy of Management Conference, The Technology Transfer Society Conference, and during an invited guest seminar at The University of Oslo.

4.1. Introduction

Many technology-based entrepreneurial ecosystems bridge academic institutions, industry and government. As universities have been spotlighted as potential engines for high-value economic development, these ecosystems have received significantly more research and policy attention (Etzkowitz, 2003b). Entrepreneurial ecosystems are complex, often poorly defined clusters of economic activity whose participants are linked variously by field, technology, geographic proximity or parent institution. It is not surprising that the innovation and commercialisation outcomes of these systems are contingent on a variety of factors, including entrepreneurial behaviour, cultural norms and the context of the originating university (Walshok et al., 2014; Zahra and Wright, 2011).

Universities drive regional economic outcomes via basic research, teaching, knowledge transfer, policy developments, economic initiatives and other activities (Breznitz and Feldman, 2012). Although the regional economic benefits of university technology transfer are not consistent (Miner et al., 2001), universities clearly contribute to the formation of industry and innovation clusters (Porter, 1998). One important university activity that contributes to cluster development is the generation of *de novo* ventures.

Venture development at the U-I boundary is difficult and uncertain. Entrepreneurs, often academics with limited business training or experience, must acquire scarce resources, capabilities and partners (Alvarez and Barney, 2005). The experiences of academic entrepreneurs are highly idiosyncratic, and the outcomes of any given university spinout is difficult to predict from either endogenous or exogenous factors (Festel, 2013; Wright et al., 2012a; Yosuf and Jain, 2010). At the same time, characteristic and structural patterns suggest that the underlying venturing processes are similar across ecosystems (George and Bock, 2008).

The regenmed industry provides a useful setting to study entrepreneurial behaviour and ecosystem development at the U-I boundary. The regenmed field presents unusually high levels of uncertainty associated with complex and unresolved regulatory and IP frameworks (Ledford, 2008). This limits entrepreneurial planning, hinders the identification of key capabilities and prevents *ex ante* validation of stem cell-based business models (George and Bock, 2012;

Heirman and Clarysse, 2004). In this context, regenmed ventures must simultaneously explore unfamiliar territory and acquire the knowledge resources to navigate that territory.

In robust clusters, new ventures acquire and create knowledge through spillovers and human capital (Saxenian, 1996; Zucker et al., 1998). Human capital, such as prior venture experience of the entrepreneur, can enable greater network ties and more diverse social networks (Mosey and Wright, 2007). Across ecosystems, specific resource assembly challenges and entrepreneurial behaviour differ (Clarysse et al., 2011). In the regenmed space, valuable knowledge, capabilities and IP are extremely sophisticated, scarce and tightly contested. This study uses the backdrop of the complex and uncertain regenmed field to explore micro-level dynamics of entrepreneurial ecosystems in the context of knowledge acquisition. First, this study investigates entrepreneurial attributions across apparently similar regenmed ecosystems. Second, it considers how entrepreneurial ecosystems develop differently, with specific emphasis on imprinting effects of the parent institution.

The study reports on a cross-national investigation of regenmed venturing in Edinburgh (Scotland, UK) and Madison (Wisconsin, United States) to explore entrepreneurial behaviour and ecosystem development. Findings emphasise how entrepreneurial coping strategies may be partly driven by university culture. The data shows apparently similar ecosystems at different stages and points towards the dynamic and evolving nature of entrepreneurial ecosystems. Based on the situational context presented in the data, a model of entrepreneurial ecosystem development is proposed.

4.2. Entrepreneurial ecosystems

Broadly speaking, business clusters embody the co-evolution of firms around particular innovations, technologies or markets. The industrial-organisational literature specifically defines a cluster as *"a geographically proximate group of interconnected companies and associated institutions"* (Porter, 2000). These firms interact cooperatively and competitively to generate new products, meet market needs and stimulate further innovations (Moore, 1993). Clustered ventures benefit from reduced transaction costs, specialised pools of labour and improved access to

resources and knowledge, particularly through collaborating and competing with other cluster members (Bell et al., 2009).

An entrepreneurial ecosystem is a specialised type of organisational-industrial cluster, which develops over time within a specific geographic region and is replenished or expanded by new ventures (Cohen, 2006). Ecosystem participants are connected by venture formation and growth activities, potentially spanning otherwise disparate technology fields and capability sets. The ecosystem generates incentives for entrepreneurial activity, linking potentially surplus resources to extant ecosystem participants and opportunity-oriented individuals outside the system (Spilling, 1996). Participants in an entrepreneurial ecosystem may or may not be closely connected. Spinouts from the same university laboratory may share fundamental technology capabilities and human capital. For example, Cellular Dynamics International, Inc. and Stem Cell Products, Inc., were both spun out of The University of Wisconsin-Madison based on stem cell innovations associated with research by Professor James Thomson. These firms even shared physical facilities and certain executive managers.[1] Other ecosystem participants may be connected only by formative links to the parent university or by relationships to other specialised businesses in the ecosystem, such as IP law firms.

Networks are especially important to the development and performance of these ecosystems. Network content, connections and structures affect resource assembly practices and outcomes (Hoang and Antoncic, 2003). This is especially relevant for access to resources and the creation and exchange of knowledge (Aldrich and Martinez, 2001; Ardichvili et al., 2002). As entrepreneurial ecosystems commonly span otherwise disparate industrial sectors, social networks play an important role in venture formation and development (Birley, 1985; Jack, 2010). These social networks are influenced by differences in human capital (Mosey and Wright, 2007). Entrepreneurs must invest in operating and managing networks for venture formation and growth (Nijkamp, 2003). Such networks enable entrepreneurs and ventures to interact (directly and indirectly) with economic and social organisations and institutions. These interactions are mediated by cultural norms within the wider ecosystem (Johannisson et al., 2002).

[1] The firms were, in fact, ultimately merged in 2008.

When social networks facilitate knowledge acquisition, ventures are often better placed to exploit knowledge for competitive advantage (Yli-Renko et al., 2001). Under uncertainty, particularly in emerging or nascent markets, ventures are likely to benefit from a diverse network and the ability to form ties with a wide range of networked partners (De Vaan, 2014; Meyskens and Carsrud, 2013). When uncertainty is high, network openness improves ecosystem performance by accepting new participants, supporting diversity and facilitating tie-formation to other ecosystems. Networks enable the spillover of knowledge, which further promotes clustering between ventures in similar industries (Audretsch and Feldman, 1996; Hayter, 2013).

There is clear evidence of the importance of context and institutional forces in ecosystem formation and development. Considering ecosystem development from a range of contextual frameworks, such as technological, institutional, social and spatial contexts, is important to gain a richer understanding of ecosystems (Autio et al., 2014). Networks thus play a critical role in the outcomes of individual ventures and the overall ecosystem (Eisingerich et al., 2010). Yet, research has not generally been directed at the impact of the central institution (university) on the participants in the ecosystem and their entrepreneurial decision-making.

4.2.1. University-centric ecosystems

Research universities often anchor entrepreneurial ecosystems in knowledge-intensive fields. Since many technology-intensive firms have potential high-growth profiles, special emphasis is commonly placed on the role of university spinouts in regional economic growth (Etzkowitz, 2003b). Although the actual economic impact of university-based entrepreneurship is overshadowed by media focus on outlier successes, universities and TTOs are commonly identified as important engines of economic growth (Bock, 2012; Miner et al., 2001). The dynamics of entrepreneurial ecosystems at the U-I boundary are poorly understood. On the one hand, universities may foster entrepreneurial activity and subsequent interaction between ecosystem participants (Swamidass, 2013). Many universities and civic-minded entities support subject-specific research, translational resources and practices, access to seed funding and venture capital, investments in human capital, and even subsidised

professional services. Yet geographic, economic, socio-demographic and other factors beyond the control of the university or any ecosystem participant are also relevant. Policy differences across ecosystems result in variations in spinout activity and performance (Goldfarb and Henrekson, 2003; Mustar and Wright, 2010). Innovation and economic outcomes may derive from initial configurations and path dependencies, limiting the influence of policymakers (Zacharakis et al., 2003).

In particular, venture formation at the U-I boundary has received a great deal of attention (c.f. Djokovic and Souitaris, 2008; O'Shea et al., 2004). Venturing activity is informed and influenced by institutional norms and culture. The motivation for technology transfer, and the choice of transfer instrument, are driven by ecosystem norms and university-based incentive structures (Decter et al., 2007; Henrekson and Rosenberg, 2001).

Venturing at the U-I boundary is challenging. Academic entrepreneurs usually lack resources and commercialisation expertise. Spinouts face significant uncertainties related to proving technologies, market needs and value creation potential (Doganova and Eyquem-Renault, 2009; Lehoux et al., 2014; Vohora et al., 2004). Resource access and configurations are highly dependent on exogenous factors outside the entrepreneur's control (Clarysse et al., 2011). New ventures generated at the U-I boundary may require entirely new business models specific to the innovation (Pries and Guild, 2011).

4.2.2. Knowledge spillover and creation

Universities play an important role in knowledge creation within ecosystems. The spillover of knowledge from universities is important for innovation and ultimately ecosystem development and economic growth (Acs et al., 1994; Audretsch and Feldman, 1996). New knowledge generated within the university can spill over to the surrounding ecosystem, which is facilitated by the entrepreneurial culture at the focal university (Audretsch, 2014). External ecosystem actors are able to exploit and benefit from this spillover of knowledge (Agarwal et al., 2010), which is often tacit in nature (Agarwal and Shah, 2014). When there are greater levels of university-based knowledge spillovers, there are likely to be higher levels of new venture start-ups located around the university (Audretsch and Lehmann, 2005). The

highly sophisticated, technological requirements of regenmed venturing indicate that new regenmed ventures are most likely to locate themselves around the university in order to capitalise on localised university knowledge spillovers (Acosta et al., 2011; Audretsch et al., 2005). By being in close proximity to the university, regenmed ventures may benefit from smoother transmission of tacit knowledge (Kolympiris and Kalaitzandonakes, 2013). Spatially, university ventures spun out to university-linked science parks, in contrast those spun out within the wider ecosystem, may be better placed to overcome resource scarcity and uncertainty (Lofsten and Lindelof, 2003). The generation of new knowledge in ecosystems, and the subsequent spillover of this knowledge, drives entrepreneurial opportunities (Audretsch and Belitski, 2013). Exploiting these opportunities requires absorptive capacity to understand, recognise and commercialise this knowledge (Qian and Acs, 2013). Entrepreneurs must find ways to distinguish partnerships that create exploitable knowledge, rather than expropriate otherwise protected knowledge assets (Hernandez et al., 2015; Katila et al., 2008).

4.2.3. Regenerative medicine ecosystems: Venturing under irreducible uncertainty

Regenmed venturing is a complex and resource intensive process. Individual and institutional tensions are driven by conflicting motivations at the U-I boundary, as well as business model uncertainty in the marketplace (Ledford, 2008). Regenmed spinouts are generally capital intensive yet capability-poor. They face field-specific challenges in manufacturing scale-up, distribution logistics and exit uncertainty. Regenmed ventures must operate with little or no slack in their resource pool, limiting product-market and business model exploration and testing (Bock et al., 2012; George, 2005). This capabilities gap between university regenmed innovation and regenmed entrepreneurial activity requires new ventures to partner for critical industry knowledge and deep capabilities, in order to explore regenmed opportunities (George et al., 2008).

The development of a regenmed ecosystem ultimately depends heavily on the actions of individual entrepreneurs (Feldman, 2014; Wright et al., 2012b). The decision to become an inventing entrepreneur in the regenmed field may be

controversial, difficult and uncertain (George and Bock, 2008). Academic scientists participating in commercialisation activities will be required to modify their role-identity (Jain et al., 2009). Shifting from a scientific orientation to a more market-driven approach creates tensions for the individual, university and the venture. The deeply embedded culture within academic institutions preferentially focuses on research and publications at the expense of patent and commercialisation activities and is, therefore, at odds with an entrepreneurial approach (Decter et al., 2007).

Despite the noted research on entrepreneurial ecosystems, numerous questions require further attention. Broadly speaking, the full effects of university-based translational and commercial activity on local ecosystems and regional economies remains uncertain (Audretsch et al., 2013; Audretsch et al., 2014; Wright, 2013). More specifically, we know relatively little about the emergence of these ecosystems or the institutional characteristics that influence their development (Autio et al., 2014; Thomas and Autio, 2014). The impact of university policy, practice and culture on micro-level entrepreneurial cognition and behaviour also requires more attention (Jennings et al., 2013). Specifically, there is a need for a deeper understanding of how different contexts affect entrepreneurial coping, especially under uncertainty (Autio et al., 2014). From a field perspective, venturing in regenmed has not been rigorously studied. It presents an edge case, highly specific to university-centric entrepreneurial ecosystems, in which uncertainty limits the value of strategic planning. Venturing activity in the regenmed field offers clues to the emergence and dynamics of entrepreneurial ecosystems.

4.3. Methods

Since this study is primarily focused on the sensemaking and behaviour of ecosystem participants, a qualitative approach to data collection is utilised (Locke, 2001). Ecosystem participants were interviewed following long-form interview procedures (McCracken, 1988). To explore entrepreneurial processes and ecosystem elements in regenmed venturing, a study of activity in two distinct but similar areas was initiated. The ecosystems studied and the procedures for analysis are now discussed.

4.3.1. Entrepreneurial ecosystems under investigation

Regenmed venturing centred on The University of Edinburgh (Edinburgh, Scotland, UK) and The University of Wisconsin-Madison (Madison, Wisconsin, United States) was investigated. These ecosystems present useful and surprisingly similar contexts to explore the development of a regenmed ecosystem at the U-I boundary.

The University of Edinburgh and The University of Wisconsin-Madison are large research institutions with long-standing regenmed programmes. Regenmed research at The University of Edinburgh has been popularised by media attention to Dolly the Sheep. Research led by Professor Sir Ian Wilmut led to the first cloned mammal from an adult somatic stem cell. The University of Edinburgh houses SCRM. This world leading research centre employs more than 230 research scientists and clinicians, and was specifically commissioned to translate stem cell research to the clinic and industry. In addition, the Scottish government has a key focus on regenmed translation and the development of a viable regenmed ecosystem.

The University of Wisconsin-Madison also has an established history of regenmed research, with Professor James Thomson deriving the first primate and human ESC lines and the first human iPSC lines. The SCRMC at The University of Wisconsin-Madison is focused on being a world leader in stem cell and regenmed research and translation. WARF, the TTO for The University of Wisconsin-Madison, is generally recognised as holding the world's most foundational patent portfolio covering stem cell technology (Bergman and Graff, 2007).

Comparative information between the institutions and relative economic context is provided in Table 4.1. to demonstrate the surface similarities of the venturing context. The areas present strong similarities across a variety of measures. Both represent large research institutions in Tier 2 metropolitan areas. Additional similarities include the university size, socio-geographical context and relative dearth of local VC. Both ecosystems remain relatively small, providing a conducive context for investigation. The pairing is preferable to comparisons against more established and significantly larger regenmed ecosystems, such as San Diego (metro population 3.1 million), Boston (metro population 4.5 million), London (metro population 15 million) and Seoul (metro population 25.6 million). The similarities between the two

ecosystems under investigation allowed for a more controlled exploration of variation in entrepreneurial cognition and behaviour. While no two metropolitan or regional ecosystems will present enough similarity to warrant fully controlled investigation of target variables, the Scotland-Wisconsin parallel was (perhaps unusually) sufficiently similar to justify comparison over many other possible ecosystem choices.

Table 4.1. Institution and regional economic data: Edinburgh and Madison

	University of Edinburgh / Edinburgh / Scotland	**University of Wisconsin-Madison / Madison / Wisconsin**
University student population	30 579	43 275
Annual research budget	$458 million	$1 billion
Metropolitan population	Edinburgh: 495 360	Madison: 240 323
City status	Capital of Scotland	Capital of Wisconsin
State/Region population	Scotland: 5 295 000	Wisconsin: 5 726 000
GDP for region	Scotland: $216 billion	Wisconsin: $261 billion
Significant local industries	Finance, insurance, health, education, agriculture, tourism, whiskey	Insurance, health, education, agriculture, tourism, machinery
VC in region	<5	<5
School/College of Medicine research and academic faculty #	2594	4447
University research income	$506 million	N/A
University research expenditures	N/A	$1.2 billion
Medical research expenditures	Estimated $175 million	$333 million
TTO activity (funding, patents)	TTO founded in 1969. 423 patents filed 2007-2012. $5.6 million license/royalty income in 2011.	TTO founded in 1928. 2300 patents granted. $57.7 million license/royalty income in 2011.
License/spinouts	Currently maintains 160+ commercial license agreements. 171 spinout/start-ups since 1969.	Currently maintains 380+ commercial license agreements. 280+ spinout start-ups since founding.
Regenmed patents granted between 2009-2011	9	15
Regenmed publicity	Dolly the Sheep	Jamie Thomson, WARF

Note: All data for 2012-2013 unless otherwise noted.
Sources: University of Wisconsin-Madison and subsidiary School/College websites; University of Edinburgh and subsidiary School/College websites and Annual Report; Scottish and Wisconsin Government websites (including UK Intellectual Property Office); and Milwaukee Journal-Sentinel.
(Source: Author)

4.3.2. Long interview

Target informants were purposefully selected (Morse et al., 2002) according to their involvement in regenmed commercialisation. To capture full aspects of the phenomena being examined, several categories of informants from Edinburgh and Madison were interviewed. Categories included, regenmed entrepreneurs and firms (n=10), academic scientists (n=4) and regenmed/life science support entities (n=16). Regenmed/life science support entities were defined as organisations that supported regenmed venturing processes. They included TTOs, agencies that supported life science innovation and governmental bodies concerned with economic development in the life sciences.

Interviews in Edinburgh were conducted between November 2012 and September 2013. Interviews in Madison were conducted between March and May 2014. A narrative interview approach was adopted, in which informants were asked to describe their participation in the commercialisation of regenmed innovation. Such an approach is especially useful for theory generation within entrepreneurship studies (Fletcher, 2007; Larty and Hamilton, 2011). Beyond this initial narrative request, informants were not provided with any further direction. When appropriate, the interviewer requested additional information about specific topics of interest. Consistent with long interview practices (McCracken 1988), the interviewer encouraged the informant to discuss whatever topics, personal stories and opinions seemed relevant. Allowing informants to freely discuss areas of interest to them helps alleviate possible socially desirability bias (Podsakoff et al., 2003).

To limit participant bias and prejudicial preparation of information or materials, informants were not provided detailed information about the interview in advance. Interviews ranged from 14 minutes to 85 minutes in duration. Additional field notes were generated during and immediately after the interviews to support data analysis. All interviews were recorded and transcribed. Information on the interview informants is provided in Table 4.2.

Table 4.2. Study informant and organisation information: Essay 2

Informant #		Category	Informant role	Organisation type
Edinburgh	1	SE	Executive	Provides support to the regenmed community. Government-backed initiative.
	2	E/RMF	Founder	Main operations are in tools/diagnostics. Also, offer services to other organisations and are actively developing in the cell therapy space.
	3	E/RMF	Manager	Involved in providing stem cell technical support and services to other organisations.
	4	E/ RMF	Founder	Primarily involved in providing stem cell training and consultancy to other organisations.
	5	AS	Manager	University academic scientist (Principal Investigator).
	6	SE	Manager	Governmental organisation to encourage economic growth in Edinburgh.
	7	SE	Executive	Supports academic innovation and commercialisation.
	8	SE	Manager	Supports technology transfer and innovation.
	9	AS	Executive	University academic scientist (Principal Investigator).
	10	E/ RMF	Founder	Operates in regenmed products and services.
	11	SE	Manager	Generate economic growth for Scotland through supporting a life science community.
	12	SE	Manager	Supports a healthcare community and enable innovation.
	13	E/RMF	Founder	Operates in the regenmed tools and diagnostics space.
	14	E/RMF	Founder	Biotechnology and stem cell services organisation.
	15	SE	Executive	Establishing a cell therapy industry and community.
	16	E/RMF	Executive	Products and services organisation with operations in stem cell space.
	17	SE	Manager	Supports innovation and economic development in Scotland.
	18	SE	Manager	Supports economic growth in Edinburgh and Scotland.
Madison	19	SE	Manager	Supports technology transfer and company formation.
	20	E/RMF	Founder	Operates in the regenmed tools space with therapeutic potential.
	21	E/RMF	Founder	Operates in the regenmed tools space with therapeutic potential.
	22	SE	Manager	Supports regional economic growth.
	23	SE	Executive	Supports scientific and technological innovation.
	24	SE	Executive	Supports new venture creation and growth.
	25	E/RMF	Founder	Operates in the tools and diagnostics space. Also, developing stem cell therapeutics.
	26	SE	Manager	Supports technology transfer and innovation.
	27	AS	Executive	University academic scientist (Principal Investigator).
	28	AS	Manager	University academic scientist (Principal Investigator).
	29	SE	Executive	Supports technology transfer and innovation.
	30	SE	Senior Manager	Supports company investments.

E/RMF = Regenmed entrepreneurs and firms
AS = Academic scientists
SE = Regenmed/life science support entities
(Source: Author)

4.3.3. Procedures

Analysis of the narrative interviews was guided by grounded-theory building (Strauss and Corbin, 1990). The Edinburgh interviews were open-coded to generate first-order codes. This was guided by findings from an initial pilot survey. Following the open coding, theoretical categories and dimensions were developed through inductive and deductive reasoning. To ensure theoretical sensitivity and a deep understanding of the relationships between categories, there was constant shifting between the data, coding and constructs during the analysis (Charmaz, 2006; Glaser, 1965). Transcripts were reviewed at the semantic level, seeking out the meaning of phrases, sentences and short passages. All coding was performed using NVivo software.

The Madison data was coded using the same data structure. The author was sensitive to the possibility of entirely new codings in the Madison data. Although some new constructs were observed in the Madison data, the author chose to emphasise consistent, comparative analysis for three reasons. First, the prevalence of novel constructs in the Madison data was low. Second, re-coding the Edinburgh data with the novel constructs would not have been possible in a *tabula rasa* framework. Third, the Madison dataset was slightly smaller than the Edinburgh dataset, with a slightly different ratio of informant roles. For the sake of parsimony, the author focused on the extant data structure, though the author strove to remain open to novel or unexpected phenomena.

4.4. Findings

In this section, the findings from the data coding are reported. The theoretical dimensions revealed by the data are explained and how these differ within and across ecosystems are considered. Examples from the interview transcripts are provided, in order to illustrate the results of the coding analysis and emphasise key findings.

The multi-level data structure based on the interview coding is presented in Table 4.3. to highlight the relative prevalence of codes in each dataset (Walsh and Bartunek, 2011). The first column in the table shows the prevalence (%) of codes for a) all informants, b) informants in the Edinburgh ecosystem (ED) and c) informants in the Madison ecosystem (MSN).

Table 4.3. Data structure: Essay 2

Prevalence in study sample (%)*			First-Order Codes	Theoretical Categories	Theoretical Dimensions
TOTAL	**ED**	**MSN**			
57	61	50	Risk	Types of uncertainty	**Perceived environmental uncertainty (PEU)**
77	67	92	Funding issues		
30	44	8	Manufacturing, scale-up and distribution uncertainty		
47	44	50	Regulatory uncertainty		
30	28	33	Scientific uncertainty		
27	28	25	Ethics		
13	17	8	Reimbursement uncertainty		
33	28	42	Academic conflicts	Inventing entrepreneurs	**University entrepreneurial culture**
40	28	58	Academic motivations		
23	22	25	Academic metrics		
30	17	50	TTO business models and processes	TTO business models and processes	
73	89	50	Collaborations with industry	Collaborative partners	**Coping strategies**
63	72	50	Collaborations with academia		
30	44	8	Collaborations with hospitals		
37	44	25	Collaborations with support entities		
33	44	17	Collaboration for sharing of resources	Collaborative outcomes	
20	28	8	Collaboration for process improvement		
13	11	17	Collaboration for funding purposes		
7	11	0	Collaboration costs		
3	6	0	Collaboration for legitimacy building		
47	56	33	Legitimacy building	Legitimacy building	
60	56	67	Knowledge transfer	Resource exchange mechanisms	**Collaborative knowledge**
63	61	67	Communication		
33	22	50	Learning		
23	28	17	Language differences		
60	61	58	RM and scientific communities	Networks	
73	89	50	Governmental funding	Funding sources	**Venture development**
47	44	50	Angel/VC funding		
23	28	17	"Big pharma" funding		
60	67	50	Spinout venture formation	Spinout venture formation	
47	33	33	Business models	Business models	
87	78	100	Resources	Existing resources	
17	28	0	Innovation	Economic development	**Outcomes**
27	28	25	Regional investment and growth		
67	83	42	Commercialisation timeframes	Future scenarios	
10	11	8	Potential industry structure		

* Does not account for multiple occurrences within a single interview.
(Source: Author)

4.4.1. Ecosystem and informant role comparisons

Comparisons across ecosystems and informant role highlight several differences. These are presented in Table 4.4. The data presented compares normalised code frequency to account for differences in interview length and informant speaking styles. The values for each ecosystem (and informant role) are calculated by dividing the total number of references for each theoretical dimension by the total number of all references across all theoretical dimensions.

Table 4.4. Ecosystem and informant role comparisons

	ED	**MSN**	**Entrepreneurs/ Regenmed firms**	**Academic scientists**	**Support entities**
PEU	18%	15%	19%	19%	14%
University entrepreneurial culture	5%	18%	4%	15%	12%
Coping strategies	21%	14%	20%	19%	18%
Collaborative knowledge	13%	19%	9%	13%	21%
Venture development	32%	29%	43%	23%	25%
Outcomes	11%	5%	5%	11%	10%
Total (%)	**100**	**100**	**100**	**100**	**100**

(Source: Author)

4.4.2. Differences across ecosystems

The data shows much higher reference to *university entrepreneurial culture* in Madison than Edinburgh. Both ecosystems highlight the conflicts faced by academic scientists looking to commercialise their stem cell innovations, since commercialisation activities are at odds with traditional academic culture: *"[A]cademics are judged by their papers and their grants…Spinouts take a lot of time and a huge amount of work…group leaders find that extremely difficult because that's time that they're not doing their academic work and ultimately they will be judged with the current metrics much more on their academic work than they will on their commercialisation work."* (Informant #9) Other informants placed blame on the larger academic context: *"That's the way that our scientific environment is structured. We publish papers and get proposals funded without pushing toward the edges of the spectrum…we can't have impact."* (Informant #28)

Informants from Madison highlight stronger motivation towards venture formation at the U-I boundary. In Edinburgh there are perceptions that licensing, rather than spinout formation, is the preferred method of technology transfer:

"…[U]niversities don't do spinout companies, I know it sounds a bit daft, but conceptually that's not… they tend to do licensing deals and spinouts are not something they want to get involved with." (Informant #7)

There is a greater emphasis in Madison on the TTO policies that encourage commercialisation and the resources available at the TTO to enable entrepreneurial activities. WARF has a long history of technology commercialisation. It is one of the oldest and most successful TTOs in the world and has particular expertise with regenmed technologies, stemming from the early seminal research and discoveries by Professor James Thomson.

The business development capabilities of TTO personnel have been shown to influence venturing activity (Lockett and Wright, 2005). Academic scientists disclosing their innovations at The University of Wisconsin-Madison have access to a diverse team within the TTO. This includes Licensing Managers, IP Managers, Legal Counsel, and Patent and Market Intelligence Analysts. The University of Edinburgh has fewer resources allocated to this type of pre-commercialisation activity.

Across ecosystems there are differences in *collaborative knowledge*, with greater emphasis on this in Madison. There is higher reference to knowledge transfer during regenmed venturing activities in Madison: "*So we'll be in constant communication with the inventors and communication with our outside patent counsel and work with them to build a strong patent portfolio that we can market."* (Informant #30)

The flow of knowledge within networks results in specialised knowledge being created, transferred or recombined, which results in learning (Dyer and Nobeoka, 2000). Findings from Madison highlight greater perceptions of learning taking place during the venturing process. Some emphasised lessons related to their institutional role: *"What I've learned over time is that you have to be published in peer reviewed journals."* (Informant #25) Others emphasised learning specifically about venturing: *"There were just a lot of dynamics in the process that were tremendous learning experiences."* (Informant #28)

Ecosystem comparisons illustrate a greater emphasis on *coping strategies* in Edinburgh compared to Madison. To overcome the high levels of PEU (Milliken,

1987), the dataset highlights the implementation of coping strategies. These include collaboration and legitimacy building. Collaborations can provide access to critical resources. Legitimacy building is especially useful when uncertainty and controversy surround a novel technology. The findings show support entities in Edinburgh building legitimacy in order to promote their offerings to regenmed ventures: "*…we've become active internationally as a mechanism of trying to demonstrate that the UK is an attractive place to do this sort of work in and then we'll partner with potential inward investors to either set up manufacturing, get clinical trials done, being the entry point into the European arena through the UK."* (Informant #15)

Findings also highlight differences in the emphasis and preference for *outcomes* between ecosystems. Edinburgh placed a greater emphasis on *outcomes* in comparison to Madison. In particular, informants in Edinburgh discussed regional economic development and innovation expectations arising from regenmed venturing activity: "*…make sure that the innovation coming out of Scotland is developed in Scotland, is manufactured in Scotland…that we have the economic benefit and we have the wealth gain and the health gain…it's to try and help developments stay in Scotland."* (Informant #11)

Informants in Edinburgh particularly focus on the timeframes involved in regenmed venturing. Some noted the conflict with policy expectations: *"…I think linked to the lack of understanding of the science, often the timescales for these end games are just not understood at all."* (Informant #1) Others noted the potential mismatch with investor expectations: *"…[the] time horizons of a VC investment just don't fit the time horizons of a development of a therapeutic…"* (Informant #10)

4.4.3. Differences between informant roles

Entrepreneurs and regenmed firms place a greater significance on *venture development* than academic scientists and support entities. Regenmed venture development relies on the availability of resources and the regenmed business model. Findings show entrepreneurs and regenmed firms extensively discussing the availability of financial resources. Informants reported that funding is accessible for regenmed research and development. Some funding is clearly linked to venture development: *"We've found that for this early stage activity, the Technology Strategy*

Board [UK government funding board] has been critical, they are a very good source of funding…the amounts of money are suitable for these early stage activities." (Informant #16) The perception of funding accessibility may directly drive venture formation: *"And there was money available for seed funding to get started. And so that's how we ended up starting the company."* (Informant #25) Again, the link to scale-up funding, however, is less clear: "*... only large pharmaceutical companies can really afford to [bring a therapeutic to market]… it's a very expensive deal…we don't have that level and the amount of money required."* (Informant #13)

New ventures at the U-I boundary require sufficient human capital. This is seen as a key driver to the growth of high-technology start-ups (Colombo et al., 2010). The academic founder may not possess the appropriate skills and capabilities necessary for commercialisation (Venkataraman et al., 1992). Academics are also likely to lack the commercial experience that investors seek (Franklin et al., 2001), which suggests that new ventures need access to management with proven commercialisation experience. However, there was strong support between informants in Madison that attracting the appropriate management team was problematic: *"…And so that is the challenge…. finding talented people to get us off the ground who are willing to take a risk…we have moved people here before and that can be harder. If they have no Midwestern ties, it's very hard to recruit to here."* (Informant #25)

Entrepreneurs and regenmed firms are clearly concerned with the assembly of resources in the venturing process. As a result, they place less emphasis on *university entrepreneurial culture* and *outcomes* than support entities and academic scientists. Since support entities play an important role in establishing networks for regenmed venturing, they place greater emphasis on *collaborative knowledge* than regenmed entrepreneurs and firms and academic scientists.

4.4.4. Differences between informant roles across ecosystems

Comparisons of informant roles across the two ecosystems are shown in Table 4.5. Again, values are normalised and calculated as previously reported.

Table 4.5. Informant role across ecosystem comparisons

	Entrepreneurs / Regenmed firms		Academic scientists		Support entities	
	Ed	**Msn**	**Ed**	**Msn**	**Ed**	**Msn**
PEU	21%	14%	19%	20%	15%	13%
University entrepreneurial culture	0%	19%	10%	20%	9%	17%
Coping strategies	21%	18%	23%	16%	21%	12%
Collaborative knowledge	7%	16%	10%	16%	20%	22%
Venture development	46%	31%	23%	24%	21%	30%
Outcomes	5%	2%	15%	4%	14%	6%
Total (%)	**100**	**100**	**100**	**100**	**100**	**100**

(Source: Author)

Findings highlight less reference to *PEU* by entrepreneurs and regenmed firms in Madison than Edinburgh. Whilst funding uncertainties are highlighted in both ecosystems, Edinburgh faces particular challenges in acquiring angel and VC funding: "*We're too small for VC's but we're too big for angels."* (Informant #2)

Results show a greater reference to *university entrepreneurial culture* for entrepreneurs and regenmed firms in Madison. This may be explained by the discrepancy in informant roles across the datasets. Two entrepreneur informants in Madison had been academic scientists prior to starting the new venture. Academic scientists and support entities in Madison also make greater reference to *university entrepreneurial culture* in contrast to Edinburgh. Academic scientists in Madison appear to show stronger motivations towards venturing activity at the U-I boundary.

The findings show less reference to *coping strategies* but more emphasis on *collaborative knowledge* across all informant roles in Madison than Edinburgh. In particular, findings emphasise the individual learning that has taken place: "*So, I'm kind of learning myself… My hope is that interacting with people like you and talking to other people that I learn something."* (Informant #20)

Entrepreneurs and regenmed firms refer less to *venture development* in Madison than Edinburgh. In contrast, support entities and to some extent academic scientists in Madison place a greater emphasis on *venture development*. Across all informant roles in Madison, there is less discussion of *outcomes* in comparison to Edinburgh, particularly for academic scientists and support entities.

4.5. Discussion

This cross-national comparative study contributes to research on entrepreneurial behaviour, technology transfer and ecosystem development. These are discussed to emphasise both the key findings from this study as well as opportunities for further research.

4.5.1. Entrepreneurial coping strategies and institutional culture

Entrepreneurial behaviour is driven by a variety of factors (Aldrich and Martinez, 2001; Alvarez and Barney, 2005). Entrepreneurs translating innovations from the university to industry experience significant changes in the role-identity profile that drives their beliefs and goals (George and Bock, 2008). The cultural context from which entrepreneurs emerge directly affects the cognitive framework and interpretation of information used to make decisions under uncertainty. The culture of the "parent" institution thus directly shapes the individual traits that drive entrepreneurial behaviour (Hofstede, 1980; Mueller and Thomas, 2001).

A significant amount of university technology transfer takes place in fields with high levels of technological sophistication and correspondingly high levels of uncertainty. This is especially so for innovations in regenmed. Faced with irreducible uncertainty, participants in regenmed entrepreneurial ecosystems must utilise coping strategies to continue to make decisions without viable risk-reward calculations. Entrepreneurial coping strategies are the behavioural patterns entrepreneurs employ to contextualise or make sense of non-resolvable venturing problems (Johnson and Bock, 2016).

Prior research shows that entrepreneurs utilise both problem-focused coping and emotion-focused coping responses (Carver et al., 1989; Lazarus and Folkman, 1984). Problem-focused coping is associated with internal locus of control and the entrepreneur's perception that further information gathering and analysis will resolve uncertainties or mitigate their impact. By contrast, emotion-focused coping is associated with external locus of control and the belief that some or all aspects of the situation are either out of the entrepreneur's control or at least not amenable to influence via the entrepreneur's efforts. This distinction is especially important in

regenmed, where entrepreneurs often rely on collaboration and partnerships to access knowledge and develop key capabilities.

The cross-national comparison suggests that the profile of dominant coping strategies may vary across similar entrepreneurial ecosystems. Since coping strategies are driven by persistent beliefs and assumptions about the nature of the technology transfer process, the most likely driver of coping strategy profiles is the culture of the originating institution. Prior research has emphasised the critical role of context and originating culture to entrepreneurial behaviour and sensemaking (e.g. Autio et al., 2014; Jennings et al., 2013). These study findings reveal differences between the dominance of originating university entrepreneurial culture and the application of coping strategies. As such, the following proposition is made:

> **Proposition 6**: Entrepreneurial culture at the originating institution is associated with coping strategies in the entrepreneurial ecosystem.

The ecosystem around Edinburgh presents higher levels of PEU, lower institutional entrepreneurial culture and a higher reliance on coping strategies. Participants in this ecosystem appear to rely more on emotion-focused coping than participants in the Wisconsin ecosystem. This has important implications for theories of entrepreneurial behaviour at the U-I boundary, including the prevalence of residual effects of institutional culture on the broader ecosystem. This relationship is further specified:

> **Proposition 7a**: The level of entrepreneurial culture at the originating institution is negatively associated with the prevalence of emotion-focused coping strategies in the entrepreneurial ecosystem.

> **Proposition 7b**: The level of entrepreneurial culture at the originating institution is positively associated with the prevalence of problem-focused coping strategies in the entrepreneurial ecosystem.

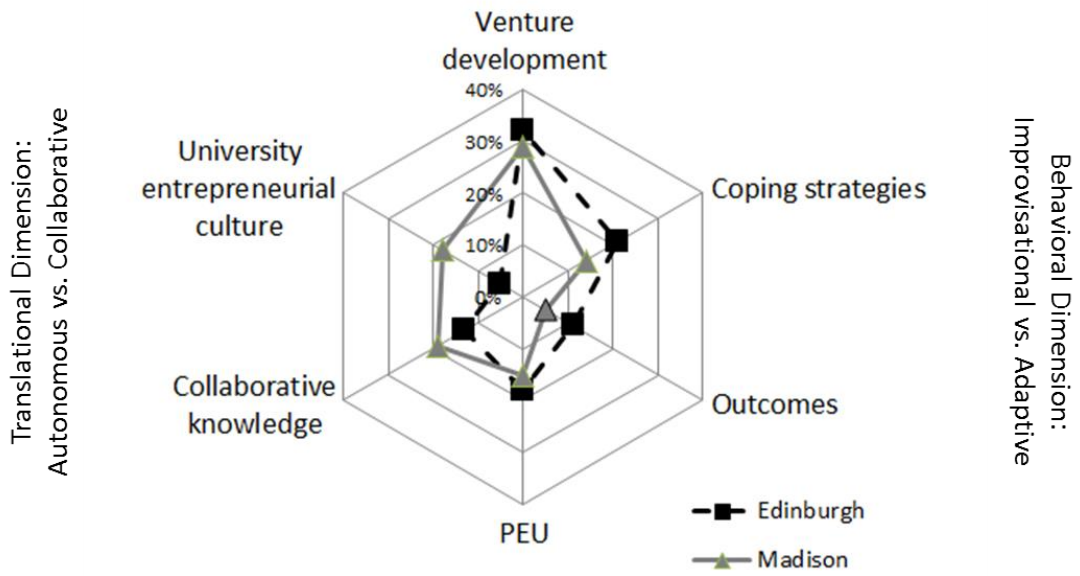
4.5.2. Entrepreneurial ecosystem characteristics

Ecosystem development is a multi-dimensional and idiosyncratic process. The structure and content of a given ecosystem emerges from a series of non-path-

deterministic events and exogenous circumstances. These study findings suggest disparate paths for the observed ecosystems.

Distinctions between micro-level sensemaking and behaviour across the ecosystems are clearly shown in Figure 4.1. The ecosystem around The University of Wisconsin-Madison demonstrates a stronger entrepreneurial culture associated with the university as well as an emphasis on collaborative knowledge development in the venturing process. By contrast, the ecosystem around The University of Edinburgh presents a stronger emphasis on coping strategies and venturing outcomes. These reflect important differences in underlying dimensions of behavioural norms and translational approaches to technology commercialisation and venture development.

Figure 4.1. Comparison of micro-level factors across ecosystems



(Source: Author)

Regenmed venturing is disproportionately driven by individuals that are trained in academic institutions and that experience significant transitions when engaging in commercialisation. While broad patterns for these transitions are consistent across institutions and ecosystems, the translational approach adopted by participants clearly varies across ecosystems. It is, therefore, proposed:

Proposition 8: The dominant translational approach of an entrepreneurial ecosystem is associated with the entrepreneurial culture of the originating institution and the utilisation of collaborative knowledge development.

In the case of the regenmed ecosystem around The University of Wisconsin-Madison, the ecosystem combines a relatively strong entrepreneurial culture extant within the university with collaborative knowledge development. In other words, this ecosystem values a collaborative and opportunistic approach to translational activity. The ecosystem around The University of Wisconsin-Madison presents much lower levels of coping strategies and outcome emphasis. This is indicative of an improvisational approach, with less emphasis on behavioural change in the service of achieving specific goals. It is, therefore, proposed:

Proposition 9a: Improvisational entrepreneurial ecosystems are associated with higher levels of entrepreneurial culture in the originating institution and increased utilisation of collaborative knowledge development.

By contrast, the ecosystem around The University of Edinburgh is lower on entrepreneurial university culture and collaborative knowledge development. Entrepreneurs and other ecosystem participants rely on a more autonomous and focused approach to translating technologies across the U-I boundary. The ecosystem around The University of Edinburgh emphasises coping strategies and venturing outcomes. This suggests a reactive practice to addressing uncertainty:

Proposition 9b: Focused entrepreneurial ecosystems are associated with lower levels of entrepreneurial culture in the originating institution and decreased utilisation of collaborative knowledge development.

4.5.3. The development paths of entrepreneurial ecosystems

This study does not address performance outcomes at any level; no conclusions can be drawn at this time regarding whether specific translational or behavioural ecosystem profiles are correlated with the probability of success of entrepreneurs, TTOs, or ecosystems. At the same time, prior research on venturing,

learning, industry and cluster development suggest implications for profile differences as well as opportunities for future research.

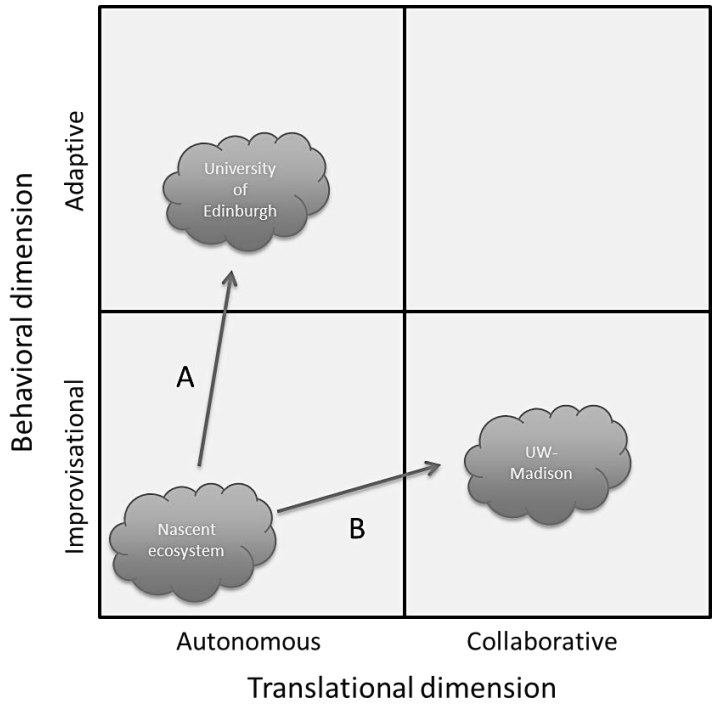
Generally speaking, knowledge creation and collaborative learning are associated with more rapidly developing ventures and clusters (Porter, 1998). As learning is time-dependent, a translational preference for autonomous learning may unintentionally delay the development of dynamic capabilities that underpin firm and ecosystem development (Jantunen et al., 2012; Teece, et al., 1997). Further, highly uncertain environments may necessitate trial-and-error learning in venture development (Loch et al., 2008; Sosna et al., 2010). Research on absorptive capacity also suggests that the sophisticated requirements of life science entrepreneurship make it unlikely that new ventures will possess adequate internal knowledge (Cohen and Levinthal, 1990; Zahra and George, 2002). The greater emphasis on knowledge exchange and entrepreneurial culture within The University of Wisconsin-Madison, linked to a more improvisational and collaborative ecosystem, may suggest long-term venture growth and success.

On the behavioural side, the ecosystem around Edinburgh presents an apparently more adaptive approach to regenmed venturing activity. While improvisation may be effective in some entrepreneurial contexts (Moorman and Miner, 1998), especially under uncertainty, firms must implement consistent structures, routines and predictive systems to manage risks and scale value creation activities (Baker and Nelson, 2005). Greater reliance on coping strategies may be explained by the perception of greater uncertainty within the ecosystem. Although specific coping strategies differ across individuals (Carver et al., 1989), coping responses can be effective in reducing, acknowledging and suppressing uncertainty (Lipshitz and Strauss, 1997).

A dynamic model of ecosystem development represents an important step forward in the understanding of technology transfer and translation of innovation (Autio et al., 2014; Thomas and Autio, 2014). Based on the comparison of characteristics, a two-dimensional model of entrepreneurial ecosystem development is proposed. Although an ecosystem may be described by a variety of characteristics, these appear to have direct relevance to venturing activity at the U-I boundary.

Figure 4.2. shows the model, incorporating Translation and Behavioural dimensions of ecosystems.

Figure 4.2. Model of regenerative medicine venturing ecosystem development



(Source: Author)

To address the dynamics of ecosystem development, it is presumed that an entrepreneurial ecosystem centred on a university must be initiated with a relatively autonomous approach to translation and an improvisational approach to behaviour. At the very earliest stages of university-based ecosystem formation in a sector that relies on long-term research, the innovations at the core of the nascent ecosystem originate within the university. While scientists and university or TTO administrators may be well-attuned to market factors and industry dynamics, early activities will necessarily require researchers with potentially commercialisable activities to operate independently. This is because there will be little to no comparable entrepreneurial culture or activity related to that type of innovation. The entrepreneurial culture at the university must be strong enough to manifest at the departmental level (Rasmussen et al., 2014). Since there will be little or no extant infrastructure to

support translational activities for a specific innovation type, either within or outside the university, the inventing entrepreneur's behaviour is likely to be primarily improvisational. Again, either the university or the regional technology cluster may provide a context for adaptive behaviour through mentoring schemes, support entities and prior success stories. At the same time, when innovations are novel and uncertainty high, identifying proven behaviours and processes becomes more difficult. This is precisely the situation in regenmed.

The ecosystem around Madison has developed more collaborative translational approaches, while the ecosystem around Edinburgh has developed more adaptive behavioural norms. It is important to emphasise that this picture of ecosystem development does not reflect a purely linear process or a specific rate of development. On the other hand, the relative novelty of regenmed research and commercialisation activity (see Table 4.1. for the relatively low number of regenmed patents compared to the overall portfolio of the TTOs) reinforces that these ecosystems are still relatively early-stage.

Despite significant surface-level similarities between the industrial-geographic regions around the universities, key differences should be noted. Collaborative effects in the Wisconsin ecosystem may benefit from WARF's extensive technology transfer history and the prior experience of numerous life science spinouts with exit events (e.g. Nimblegen/Roche, Tomotherapy/Accuray, Lunar/GE, BoneCare/Genzyme and others) in the area. Although both areas have relatively limited VC resources (compared to other life science venturing hubs), numerous life science ventures in the Madison ecosystem have obtained mid- and late-stage investments from VC firms in California and the U.S. East Coast.

This model suggests that entrepreneurial ecosystem development at the U-I boundary is a dynamic and path independent process. The development of the ecosystem is both a driver and outcome of the nature and type of entrepreneurial coping strategies prevalent within the ecosystem. Coping responses are particularly important to *de novo* ventures, especially at start-up, as they assist in resource and knowledge identification and access. Since cultural artefacts and ecosystem specific factors affect coping responses, similar ecosystems may generate significantly different behaviours for knowledge and learning. It is not sufficient to characterise an

ecosystem's configuration of resources and prior history to understand how the ecosystem is likely to develop further. The interplay of the central university's entrepreneurial culture and the dominant coping strategy profile of the ecosystem will be tightly linked to the ecosystem's locus of attention and collaborative knowledge emphasis.

Study findings have important theoretical and practical implications. They advance theories of U-I technology transfer by presenting cross-national findings on the characteristics and dynamics of entrepreneurial ecosystem development under irreducible uncertainty. They further inform institutional entrepreneurship and technology transfer literature by developing specific propositions linking originating culture to resulting characteristics of the ecosystem.

This study also extends research linking entrepreneurial cognition and sensemaking to ecosystem development (Wright et al., 2012b). Findings highlight individual-level coping responses to institutional culture and high levels of uncertainty. It has been shown that coping strategies are important for resource and knowledge acquisition and assembly. All of these factors are implicated in the process and outcome of new venture development at the U-I boundary. These findings further emphasise the importance of the entrepreneur and entrepreneurial cognition in ecosystem development and competiveness. This is consistent with prior research (Feldman, 2014) but presents entirely new directions for further study of coping strategies and collaborative activities. In particular, findings help identify the specific mechanisms that drive entrepreneurial decision-making in fields of high uncertainty, emphasising that university policy and culture plays a critical role in ecosystem outcomes (Audretsch et al., 2013; Audretsch et al., 2014; Wright, 2013).

4.6. Limitations and research directions

Certain limitations in this study must be kept in mind in the interpretation of the study. First, the datasets are relatively small and may not effectively capture the situational perspective of the entire ecosystems. Second, open coding has specific limitations, including the potential for biasing effects of prior researcher knowledge. Third, the datasets were coded asynchronously. It is possible that synchronous coding of the datasets in a randomised order might have generated a slightly different

data structure. Since the data is not longitudinal or time-synchronised, the study cannot address potential differential rates of ecosystem development between ecosystems.

The inductive, theory-driven approach was suitable for the development of novel phenomena. At the same time, findings should be tested empirically to identify the strength of relationships and impact in context. This study has shown how cognition and behaviour of ecosystem participants is important for ecosystem development, with potentially long-term effects on firm and ecosystem competitiveness. Further large-scale, quantitative research that tests for the cognitive and behavioural characteristics in entrepreneurial ecosystems, as well as ecosystem development processes, are warranted.

Findings report on entrepreneurial ecosystem development of two similar but distinct ecosystems. While Edinburgh and Madison present close similarity, the difference in TTO activity between these two ecosystems warrants further analysis, since this will be implicated in ecosystem development. Given that this study could not control all target variables between ecosystems, additional research could extend to other similar ecosystems. It would also be interesting for future research to investigate more established ecosystems in other industries and regenmed ecosystems in larger and more well-resourced industrial-geographic or non-western regions, in order to reveal differences in ecosystem development.

4.7. Conclusion

This study presents a cross-national analysis of ecosystem development under irreducible uncertainty. The results suggest that university culture and PEU impact the characteristics and development path of entrepreneurial ecosystems. The findings point towards important new theories of entrepreneurial ecosystem development and micro-level entrepreneurial behaviour at the U-I boundary.

Chapter 5: Essay 3

The emergence of entrepreneurial ecosystems and the importance of context in regenerative medicine commercialisation

Essay 3 investigates technology transfer and contextual factors across three regenmed ecosystems to reveal the emergence of entrepreneurial ecosystems at the U-I boundary. This essay is under "revise and resubmit" at *Strategic Entrepreneurship Journal* as:

> Johnson, D., Harrison, R.T. & Bock, A.J. The emergence of entrepreneurial ecosystems and the importance of context in regenerative medicine commercialisation.

In accordance to UEBS thesis guidelines, I confirm that the author of this thesis was the main contributor to this co-authored manuscript. This included responsibility for the theoretical framework and study design, data collection and analysis, interpretation of the study findings, and writing of the manuscript. The co-authors provided valuable reviewing of the manuscript and suggestions for improvement.

5.1. Introduction

Entrepreneurial ecosystems are a key policy concern in both developed and emerging economies (Etzkowitz and Leydesdorff, 2000; Graham 2014). Driven primarily by concerns about innovation outcomes (Adner, 2006), ecosystem research has focused on geographical clustering, competitive advantage (Porter, 1998; Saxenian, 1996), and dynamics between constituents and structures (Bahrami and Evans, 1995; Spilling, 1996). Particular emphasis has been placed on the role of academic institutions and knowledge spillovers (Audretsch and Feldman, 1996; Audretsch et al., 2014; Guerrero et al., 2015). Comparatively few efforts, however, link the actual entrepreneurs to the emergence of entrepreneurial ecosystems (Thomas and Autio, 2014).

In knowledge intensive fields, opportunity creation and managerial decisions about place (Jennings et al., 2013; Nambisan and Baron, 2013) drive ecosystem development. Venture founding and development decisions depend heavily on the presence of extant organisations, including the academic institutions central to knowledge creation (Audretsch et al., 2014; Wright, 2013). Micro-level cognition and institutional characteristics have not, however, received attention in the emergence and development of entrepreneurial ecosystems. In this study, these effects are explored at the U-I boundary to take advantage of centralised and field-specific ecosystem characteristics.

University technology transfer activities facilitate entrepreneurial ecosystem development (Audretsch et al., 2014). Most ventures formed at the U-I boundary, however, are typically small lifestyle ventures (Harrison and Leitch, 2010), which add little to the ecosystem as a whole. This raises the question of how do institutional and entrepreneurial characteristics impact the development of sustainable ecosystems? With this in mind, this study utilises theories of EOE and competence blocs (Eliasson and Eliasson, 1996) to explore the critical links between entrepreneurial cognition, institutional culture and organisational knowledge creation in ecosystem formation. In particular, developing economies offer important comparative contexts for investigations of knowledge-intensive ecosystems (Bruton et al., 2013; McCarthy and Puffer, 2013; Morris et al., 2013). To the author's knowledge, this is the first transnational, multi-level study to explore entrepreneurial

ecosystems within an EOE/competence bloc theory framework. The emergence of entrepreneurial ecosystems at the U-I boundary is likely determined by how individuals make venturing decisions under uncertainty. Given this uncertainty, experimentation is likely and requires a specific set of competencies. Thus, the EOE/competence bloc theory framework is particularly suited to assist in understanding how entrepreneurial ecosystems emerge and develop.

This study investigates entrepreneurial activity at the U-I boundary in the field of stem cell-based regenmed to assist understanding of comparative entrepreneurial ecosystems. Regenmed ecosystems are studied across three cities in three countries: Edinburgh (Scotland, United Kingdom), Madison (Wisconsin, USA), and Moscow (Russia). The focus of the investigation in Edinburgh is on The University of Edinburgh. In Madison, the regenmed ecosystem centred on The University of Wisconsin-Madison is investigated. In Moscow, Skoltech is studied. Applying competence bloc theory, this study explores entrepreneurial ecosystems at the U-I boundary by addressing two research questions. First, what is the role of the university and the technology transfer process in assisting with the emergence and development of entrepreneurial ecosystems at the university-industry boundary? Second, how does context influence entrepreneurial ecosystem development? Relying on 47 narrative interviews across the three sites, a framework for entrepreneurial ecosystem emergence at the U-I boundary and how this differs within distinctive contextual settings is revealed. Additionally, a typology of spinout ventures at the U-I boundary is suggested. This research makes important contributions to the entrepreneurial ecosystem literature, as well as contributing to research emphasising context in entrepreneurship. Findings have important policy implications for entrepreneurs, technology transfer managers and policy makers responsible for fostering entrepreneurial ecosystems.

5.2. Theoretical framework

5.2.1. Entrepreneurial ecosystems and competence blocs

Despite the importance of entrepreneurial ecosystems, research in this area remains limited (Thomas and Autio, 2014). Stam (2015) defines an entrepreneurial

ecosystem as *"a set of independent actors and factors coordinated in such a way that they enable productive entrepreneurship."* This study applies EOE and competence bloc theory to study entrepreneurial ecosystems at the U-I boundary. The EOE reflects an experimental nature to economic growth. Since actors will not have perfect information, venturing decisions are essentially experiments (Johansson, 2010). Ecosystem growth is achieved through capturing winning experiments but at the same time removing losing projects (Carlsson and Eliasson, 2003). Thus, a thriving entrepreneurial ecosystem will minimise the loss of winners and the duration that losers remain in the ecosystem (Eliasson and Eliasson, 2006). These losing firms are particularly important for ecosystem economics since they serve as a source of resources to the growing firms within the ecosystem. Minimising the error of losing winners and retaining losers requires ecosystem participants within the ecosystem to be competently guided, which is the foundation of competence bloc theory (Eliasson and Eliasson, 2006).

A competence bloc is defined as *"the total infrastructure needed to create (innovation), select (entrepreneurship), recognise (venture capital provision), diffuse (spillovers), and commercially exploit (receiver competence) new ideas in clusters of firms. The competence bloc is dominated by human-embodied competence capital that determines the efficiency characteristics of all other factors of production, including the organisation of all economic activities that constitute the competence bloc"* (Eliasson and Eliasson, 1996: p.14). Knowledge is a particularly important aspect of the competence bloc, particularly the spillover of this knowledge (Eliasson, 1996b). Nowhere is more evident than in high-technology industries (Eliasson and Eliasson, 1996; Eliasson and Eliasson, 2006), where knowledge can drive ecosystem emergence (Krafft et al., 2014).

Networks are an important feature of knowledge resources and spillovers (Audretsch and Feldman, 1996; Wang et al., 2014). Additionally, networks serve as conduits to human capital (Bozeman et al., 2013), social capital (Birley, 1985) and even as a means to seek legitimacy (Stuart et al., 1999). Similarly, collaborations must also function within the ecosystem, especially in knowledge-intensive fields where firms likely lack adequate internal knowledge and capabilities (George et al.,

2008). U-I collaborations are well placed to assist with access to resources and spinout venture development (Lee, 2010).

In this study, an entrepreneurial ecosystem at the U-I boundary is defined as *a set of interdependent and competent actors and infrastructure capable of selecting, recognising, diffusing, and commercially exploiting opportunities in such a way that they support productive entrepreneurship.* The emergence and development of these ecosystems at the U-I boundary requires: 1) entrepreneurs (including academic entrepreneurs) that are able to identify novel and profitable innovations, 2) innovators that can combine technologies in novel ways, 3) supporting organisations and individuals that have the ability to recognise, finance and commercially progress novel opportunities, 4) an institutional culture supportive of entrepreneurship, and 5) exit markets (Eliasson and Eliasson, 1996; Eliasson and Eliasson, 2006).

5.2.2. University technology transfer

The role of the university is an important feature within entrepreneurial ecosystems (Audretsch, 2014; Guerrero et al., 2015). Acting as a source of human and knowledge capital, universities can assist commercialisation activities at the U-I boundary. Whilst teaching and research has dominated the traditional university mission, universities have gradually been shifting towards the so-called entrepreneurial university model, which serves as a driver of entrepreneurial activities (Grimaldi et al., 2011). Universities, which promote a culture for entrepreneurship as a core mission, increasingly foster commercialisation activities (Huyghe and Knockaert, 2015). However, an understanding of the links between micro-level cognition and university characteristics on ecosystem emergence and development remains limited (Audretsch et al., 2014; Jennings et al., 2013; Wright, 2013).

The transfer of technology at the U-I boundary can occur via various channels, such as spinout venture creation (O'Shea et al., 2008; Rothaermel et al., 2007). Yet, this depends upon the culture for entrepreneurship at the research institution (Huyghe and Knockaert, 2015) and the ability of academic entrepreneurs to engage in commercialisation activities in combination with their teaching and research duties (George and Bock, 2008). Additionally, access to venture capital is

often a significant challenge for university spinouts (Wright et al., 2006), particularly those in high-technology fields such as regenmed (Mason and Harrison, 2004).

Regenmed technology transfer at the U-I boundary is particularly challenging. In this field, unique uncertainties have hindered commercialisation activities and the development of effective business models (Ledford, 2008). Venturing and the emergence of entrepreneurial ecosystems in this field will depend on how regenmed entrepreneurs make sense of uncertainties (Bock and Johnson, 2016; Johnson and Bock, 2016). A key aspect of ecosystem development in this nascent sector will be dependent on legitimising strategies (Aldrich and Fiol, 1994). Narratives may be an important legitimising mechanism (Lounsbury and Glynn, 2001) and sensemaking device (Weick, 1995). As a form of storytelling (Fisher, 1994), narratives are key instruments in venture formation (Downing, 2005; Gartner, 2007).

The decision to investigate regenmed venturing, in order to explore entrepreneurial ecosystems at the U-I boundary, was driven by several factors. First, since regenmed research is predominantly situated within the university setting, venturing at the U-I boundary can be directly observed. Second, regenmed is a nascent industry, which is still in the early stages of development. This provides the opportunity to witness the emergence of an ecosystem at the U-I boundary. Third, the distinctive venturing uncertainties surrounding regenmed enables the study of the unique features of technology transfer when uncertainty is high.

5.2.3. The importance of context

Institutional and national contexts, including regional contexts, have important implications for venturing at the U-I boundary (Nelson, 2014; Saxenian, 1996). Studies emphasising context have helped explain why entrepreneurship varies between countries as a consequence of culture and cognition (Hayton and Cacciotti, 2013; Manolova et al., 2008). A focus on cultural contexts and micro-level cognition can help explain differences in venturing across nations (Autio et al., 2013; Stephan and Uhlaner, 2010).

Entrepreneurial activities are context specific (Aldrich and Fiol, 1994; Welter, 2011). Entrepreneurial ecosystem development is no exception. Institutional

context drives entrepreneurial activities and ecosystem characteristics (Autio et al., 2013; Bowen and De Clercq, 2008). Little attention has been directed, however, towards the connections between knowledge creation entities and opportunity creation processes, especially across national contexts (Autio et al., 2014; Levie et al., 2014; Zahra and Wright, 2011; Zahra et al., 2014). With this in mind, this cross-national investigation of regenmed venturing at the U-I boundary helps explain how institutional contexts shape entrepreneurial behaviour and cognition (Nelson, 2014).

The triple helix model of university-industry-government was established in the context of a developed economy. As such, this model is insufficient to explain entrepreneurial ecosystem development within an emerging economy such as Russia. In the Russian context, it has been suggested that a fourth component be added to the triple helix model – the unique Russian culture (McCarthy et al., 2014). While Russia has historically lagged in the commercialisation of new technologies, partly due to a lack of institutional infrastructure, it is attempting to turn this around through establishing economic supporting agencies (including a state-backed venture capital fund) and reforming Russian universities (including the creation of Skoltech) (McCarthy et al., 2014). While there is optimism regarding Russia's economic future, and although Russian ventures are becoming particularly important in the global marketplace, the declining human capital as a result of the exodus of promising scientists, engineers and entrepreneurs, casts doubts on innovation and growth (Michailova et al., 2013).

Venturing in Russia is characterised by high levels of uncertainty (Puffer et al., 1998). For example, the constrained and underdeveloped institutional environment within the Russian economy limits strategic choices (Puffer et al., 2010). Russian ventures face significant challenges in the availability of slack resources, particularly technical resources and human capital, which has limited international activities (Shirokova and McDougall, 2012). *De novo* ventures operating within nascent markets lack sufficient internal knowledge. In emerging economies this is problematic, requiring ventures to look towards internationalisation to developed economies (Yamakawa et al., 2013). Under these conditions, collaboration and knowledge exchanges at the U-I boundary are critical for Russian regenmed ventures to remain competitive. However, the socio-cultural norms in

Russia have generally not been conducive to knowledge exchanges (May and Stewart, 2013). For example, cultural differences, in addition to collaboration history, incompatible goals and trust, have all been cited as challenges to international collaboration and knowledge exchanges within Russia (Trifilova et al., 2013).

The ability to develop an entrepreneurial culture and mind-set is critical if Russian ventures are to both innovate and grow (Shirokova et al., 2013). Russia's formal institutional void has forced ventures to rely on informal cultural-cognitive institutions, such as social networks, during venturing (Puffer and McCarthy, 2011). Extant social networks are particularly favoured by Russian ventures during knowledge exchanges (May and Stewart, 2013). Yet, while social networks are important for internationalisation, the negative image and distrust towards Russian ventures generally held by foreigners, often limits a reliance on social networks during the venturing process (Shirokova and McDougall, 2012).

Empirical research on entrepreneurial ecosystems in the context of an emerging market is rather limited. Focusing on regenmed venturing in Russia presents the opportunity to theorise over the influence of a unique socio-cultural context on ecosystem emergence. This is particularly important, precisely because theories of entrepreneurial ecosystem emergence in developed economies are not sufficient to explain entrepreneurial ecosystems within the unique institutional and cultural Russian context (Elenkov, 1998). Since Edinburgh and Madison both have an established history of regenmed innovation, studying regenmed venturing in Russia can help explain the idiosyncrasies of entrepreneurial ecosystems in an emerging economy. Research that advances our understanding of institutions and culture in the context of Russian venturing, especially cross-national comparison studies to Westernised economies, is especially timely (Puffer et al., 2010).

5.3. Methodology

To understand entrepreneurial ecosystems at the U-I boundary, regenmed venturing at three research institutions across three separate countries is studied. This study explores the ecosystems surrounding: 1) The University of Edinburgh (Edinburgh, UK), 2) The University of Wisconsin-Madison (Wisconsin, USA), and

3) Skoltech (Moscow, Russia). The selection of the three cross-national ecosystems was driven by three principal motivations. First, all ecosystems are actively pursuing stem cell research and focused on translational activities. Second, the ecosystems are in their formative stages, allowing for investigation of ecosystem emergence and development. Third, the Skoltech ecosystem provides a suitable setting to investigate entrepreneurial ecosystem emergence within a unique, socio-cultural context.

This study relied on 47 long-form narrative interviews with participants directly involved in regenmed commercialisation activities. A preliminary online survey was implemented at the start of the investigation, but since this was solely utilised to support analysis of the interview findings, the survey results are not reported for this particular study. The ecosystems under investigation, the data and the procedures for data analysis are now discussed in turn.

5.3.1. The University of Edinburgh

The University of Edinburgh is a UK institution established in 1583, making it one of the oldest universities in the UK. The University has a particularly strong reputation in life science research and has a long history in stem cell research, which is conducted at the University's stem cell research institute – SCRM.

Stem cell commercialisation activities fall under the remit of the University's TTO, ERI, and BioQuarter. The Edinburgh BioQuarter represents a recent $925 million investment designed to accelerate life science research and translation through business creation, industry collaboration and inward investments. ERI is structured and functions as a typical university TTO. It was one of the first TTOs to be established in the UK. Since founding in 1969, ERI has generated 171 spinout/start-up ventures. Between 2007 and 2009 it filed 423 patents, and in 2011 license/royalty income reached $5.6 million.

5.3.2. The University of Wisconsin-Madison

As a research-intensive institution, The University of Wisconsin-Madison has strong similarities to The University of Edinburgh. Founded in 1848, and being one of the largest research universities in the United States, it too has an established history in life science and stem cell research. SCRMC within the University is

responsible for progressing stem cell research and translation. Supporting this translation is both WID and the University's TTO – WARF.

WID's responsibilities are to promote scientific research, industry collaboration and commercialisation activities. WARF assists the transfer of university-based technologies at The University of Wisconsin-Madison. It was founded in 1925 and is often credited as being one of the world's most successful TTOs, having granted 2300 patents. Since founding, WARF has established in excess of 280 spinout/start-up ventures, and in 2011 generated $57.7 million in license/royalty income.

5.3.3. Skolkovo Institute of Science and Technology

Skoltech is a private research university located on the outskirts of Moscow, Russia, and has been labelled as Russia's 'Silicon Valley.' Established in 2011, in collaboration with MIT, a critical mission of Skoltech is to foster an entrepreneurial ecosystem, driven through innovation and technology transfer. Stem cell research and translation has been identified as a priority area in assisting with this ecosystem development.

The SCSCR was created in collaboration with The European Institute for the Biology of Aging (Netherlands) and The Hubrech Institute (Netherlands). SCSCR is one of fifteen CREI. The notion of the CREIs is to provide world-class educational training and generate research that can assist in driving innovation and entrepreneurial activities at Skoltech and within the Russian economy.

At the heart of ensuring Skoltech becomes an innovation and entrepreneurial powerhouse is the CEI. It is responsible for providing entrepreneurial support to scientists at Skoltech; assisting them with taking their innovations towards licensing or spinout venture formation. CEI closely follows the technology transfer policies at MIT and has close ties with The Deshpande Center for Technological Innovation at MIT.

5.3.4. Narrative interviews

To explore entrepreneurial ecosystem emergence at the U-I boundary, long-form narrative interviews (McCraken, 1988) were relied upon. Selection of

informants was purpose-based (Morse et al., 2002), focusing on informants that were directly involved in regenmed commercialisation activities. This resulted in three categories of informants, which included: 1) regenmed entrepreneurs or ventures, 2) regenmed academic scientists, and 3) regenmed supporting entities that are involved in technology transfer activities or activities to progress life science innovation. All informants were e-mailed to request their participation in the study. Interviews with 23 regenmed informants took place in Edinburgh between November 2012 and September 2013. In Madison, 13 interviews were conducted between March and May 2014. Interviews with 11 regenmed informants took place in Moscow during May 2015. The total dataset represents 47 narratives, which consists of interviews with 15 regenmed entrepreneurs and ventures, 8 regenmed academic scientists, and 24 regenmed supporting entities. A full list of informants is reported in Table 5.1.

The author of this thesis conducted all 47 interviews. Consistent with a narrative interview approach, target informants were asked to *"describe your role in regenerative medicine commercialisation activity."* Informants were given complete freedom in their discussion, without any interruption by the interviewer. Upon completion of the informant narrative, the interviewer followed up on areas of interest or areas that required further explanation. Interviews lasted between 15 and 85 minutes. All interviews were recorded and field notes were taken during the interview to assist with data analysis. The interviews were transcribed, with the total combined transcriptions containing a total word count of 236,003.

A narrative interview approach was particularly suited to this study since it enabled reflective meaning-making (Bauer, 1996; Boje, 1991) and deeper theorising (Fletcher, 2007; Larty and Hamilton, 2011). It also helps circumvent social desirable responses (Podsakoff et al., 2003), which are possible due to the high levels of ethical controversies surrounding regenmed commercialisation.

Table 5.1. Informant information: Essay 3

Informant #		Category	Informant role	Organisation type
Edinburgh	1	SE	Executive	Government-backed org. supporting regenmed community.
	2	E/RMV	Founder	Operating in tools/diagnostics, but offering services too.
	3	E/RMV	Manager	Provides regenmed technical support & services.
	4	E/RMV	Founder	Primarily involved in stem cell training & consultancy.
	5	AS	Manager	University academic scientist (Principal Investigator).
	6	SE	Manager	Government-backed org. fostering economic growth.
	7	SE	Executive	Supports academic innovation & commercialisation.
	8	SE	Manager	Supports technology transfer activities & innovation.
	9	AS	Executive	University academic scientist (Principal Investigator).
	10	E/RMV	Founder	Regenmed products & services organisation.
	11	SE	Manager	Supports Scottish life science community & regional growth.
	12	SE	Manager	Supports UK healthcare community & fosters innovation.
	13	E/RMV	Founder	Operates in the regenmed tools & diagnostics space.
	14	E/RMV	Founder	Biotechnology & stem cell services organisation.
	15	SE	Executive	Creating a cell therapy industry & community.
	16	E/RMV	Executive	Provides products & services to the stem cell sector.
	17	SE	Manager	Encourages innovation & economic development.
	18	SE	Manager	Supports regional economic growth.
	19	E/RMV	Executive	Regenmed diagnostics venture.
	20	SE	Executive	Promotes life science commercialisation & collaboration.
	21	SE	Executive	Promotes technology transfer & venture formation.
	22	AS	Executive	University academic scientist (Principal Investigator).
	23	SE	Executive	Promotes technology transfer & venture formation.
Madison	24	SE	Manager	Promotes technology transfer & venture formation.
	25	E/RMV	Founder	*De novo* regenmed tools & therapeutics venture.
	26	E/RMV	Founder	*De novo* regenmed tools & therapeutics venture.
	27	SE	Manager	Fosters regional economic growth.
	28	SE	Executive	Promotes scientific & technological innovation.
	29	SE	Executive	Supports new venture creation & growth.
	30	E/RMV	Founder	*De novo* regenmed tools, diagnostics & therapeutics venture.
	31	SE	Manager	Promotes technology transfer & innovation.
	32	AS	Executive	University academic scientist (Principal Investigator).
	33	AS	Manager	University academic scientist (Principal Investigator).
	34	SE	Executive	Promotes technology transfer & innovation.
	35	SE	Manager	Supports venture investments.
	36	SE	Manager	Supports venture investments.
Russia	37	E/RMV	Founder	Regenmed therapeutics, tools, diagnostics & services.
	38	AS	Executive	University academic scientist (Principal Investigator).
	39	E/RMV	Manager	*De novo* regenmed tools venture.
	40	SE	Manager	Supports tech. commercialisation & new venture formation.
	41	AS	Executive	University academic scientist (Principal Investigator).
	42	SE	Executive	Supports tech. commercialisation & new venture formation.
	43	SE	Executive	Supports biomed commercialisation & venture development.
	44	AS	Executive	University academic scientist (Principal Investigator).
	45	SE	Manager	Supports licensing & technology transfer.
	46	E/RMV	Founder	Stem cell services venture.
	47	E/RMV	Founder	Regenmed therapeutics, tools, diagnostics & services.

E/RMV = regenmed entrepreneurs and ventures
AS = Academic scientists
SE = Regenmed/life science support entities
(Source: Author)

5.3.5. Data analysis procedures

The data analysis began with a fine-grained review of the transcripts. The analysis involved three major steps, which relied on retroductive analysis (Charmaz, 2006; Locke, 2001; Strauss and Corbin, 1990) and supplemented with a more general narrative analytical approach (Riessman, 2008). All coding was performed using NVivo software.

Phase I: Initial data coding. Analysis began by carefully reviewing the transcripts, along with the field notes and pilot survey findings. Initially, the data was open-coded, developing first-order codes (Strauss and Corbin, 1990). As themes emerged, they were compared both within and across the transcripts, and with the field notes. From this initial coding stage, an understanding of how ecosystem participants approach regenmed venturing at the U-I boundary, and the implications for entrepreneurial ecosystem emergence, emerged. Throughout this process, the author was careful not to lose sight of the intact narratives and strove to preserve the depth and richness of the narratives by staying close to informants' interpretations.

Phase II: Second-order themes. Phase II progressed with axial-coding. This involved structuring the first-order codes into second-order themes, which relied on searching for relationships between codes and grouping them into common themes (Corley and Gioia, 2004; Strauss and Corbin, 1990). Moving back and forth between the data and the extant theory enabled the development of themes that were grounded in the data but expanded upon with the help of existing concepts. During this process, the constant comparative method (Glaser, 1965) was employed.

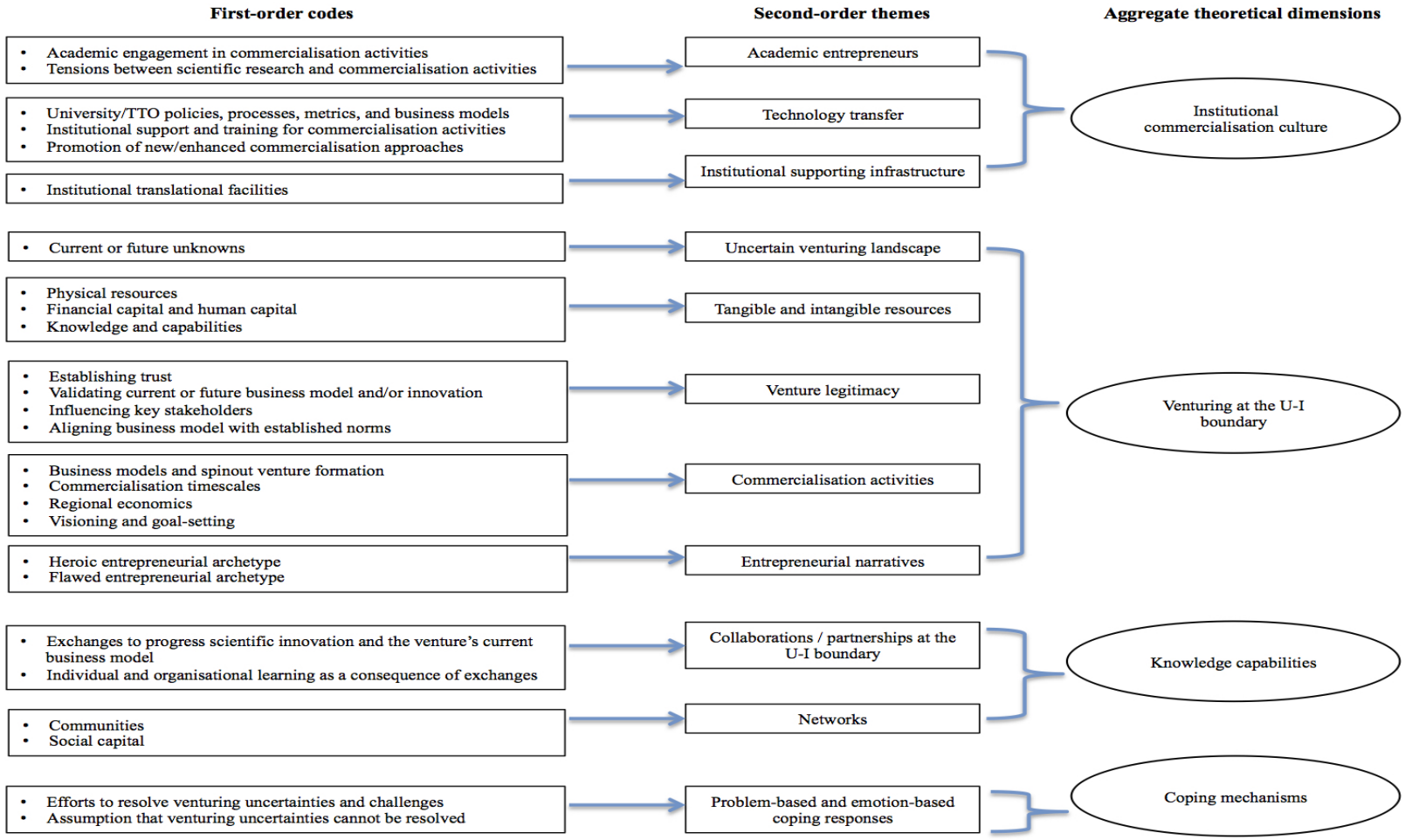
Phase III: Aggregate theoretical dimensions. The final stage of data analysis involved the identification of aggregate theoretical dimensions from the second-order themes. In developing these dimensions, the author engaged in inductive and deductive reasoning, connecting inductive codes and themes with extant concepts and frameworks (Walsh and Bartunek, 2011).

To ensure the trustworthiness of the analysis, the author triangulated coding of the interviews with both the higher-level themes embedded in the narratives (Miles and Huberman, 1994) and with the findings from the pilot online survey.

5.4. Findings

The data structure table emerging from the analysis of the narrative interviews is illustrated in Figure 5.1. To provide further context to the data structure table, Table 5.2 shows representative quotes from the interview narratives that led to the development of the second-order themes and aggregate dimensions. Following this, each of the aggregate theoretical dimensions are discussed and additional illustrative examples provided in order to support the findings.

Figure 5.1. Data structure: Essay 3



(Source: Author)

Table 5.2. Representative quotations from ecosystem participants

Theoretical dimensions	*Second-order themes*	*Representative quotations*
Institutional commercialisation culture	Academic entrepreneurs	*"I joined the University of Wisconsin in Madison as a faculty member. And at that time, the world was kind of opening up for me…And that's why I think my entrepreneurial days really started in those early formative years."* (Informant #23)
	Technology transfer	*"So in terms of regenerative medicine…that's where I would come in and work at getting translational funding for them from whatever's about at the moment...the idea would be to get funding to move it to a stage where we can license it or spin out, or whatever. At the same time, my role would be to look at the patentability of the product/the research and decide, if it's suitable, we would want to file a patent, but decide when to do it. And then at the same time you'd be looking at the commercial exit strategy; talking to commercial partners."* (Informant #8)
	Institutional supporting infrastructure	*"So the cluster itself is responsible to find new projects, which need some support. So if I take as the example, let's say pharmaceutical project, I mean, drug development/drug discovery projects. We are picking up the project somewhere in the stage of late preclinical studies and we can support it up to the phase of clinical studies. Later it's already industry role there, earlier it's more like scientific part, classical science. What I'm saying about support: that means we first evaluate the project, expertise it, we use internal expertise of the cluster on the first stages of the evaluation. Later on, we evaluate it with the support of external blind expert panel. And when the project get through the expertise, the project can get the status of the Skolkovo resident, enjoy the tax benefits and that's very high level of tax benefits we provide here. Also access to machinery, lab equipment…"* (Informant #41)
Venturing at the U-I boundary	Uncertain venturing landscape	*"If you can imagine taking a drug to market, only large pharmaceutical companies can really afford to do that…and it is absolutely no different with cellular therapeutics."* (Informant #13)
	Tangible and intangible resources	*"And there was money available for seed funding to get started. And so that's how we ended up starting the company."* (Informant #28)
	Venture legitimacy	*"So they published the results in two scientific journals, in two Russian journals. We didn't find anything matching globally, it was quite a premier application in the world…We went deeper in publications, in Pubmed, about what's happening in this field in the world…So just recently, at the end of 2014, another important milestone is this publication – a highly respectable publication…"* (Informant #45)
	Commercialisation activities	*"We have a dream to treat kidney, it's our dream because we understand that it's one of the biggest problems…we didn't think about pharmaceutical market, we didn't think about some test systems, we*

		think about human organ itself. It's our driver. This way we start to invest in this company, we invite people from different countries, we have a very international team…" (Informant #37)
	Entrepreneurial narratives	*"We don't have any product for sale connected to stem cells but we have a very huge cryobank of embryos, which are not belonging to any patient now…I think this is very valuable material for future investigation…I know that in our country there are two types of operators in stem cells: state/governmental institutions and private companies. They do not come to us to ask for these embryos…so I just wait…I believe that there are many such partners but I'm overloaded and I don't have time to look for them…This field is very risky. I don't want to invest any money in this field…"* (Informant #44) [Example of a flawed-entrepreneurial narrative]
Knowledge capabilities	Collaborations / partnerships at the U-I boundary	*"The other things that we're doing are looking at improving the 3-D culture of the cells that we can make. So that's stem cells being turned into liver cells and using new growth matrices, which should allow the cells to grow in 3-D…That's a collaboration with a university."* (Informant #3)
	Networks	*"Our Wisconsin Innovation Network is designed to connect entrepreneurs and others through a variety of programmes in and around the State… Those companies have a profile within their community, they help make it possible for others like them to continue and to spur that process of innovation in tech transfer."* (Informant #26)
Coping mechanisms	Problem-based and emotion-based coping responses	*"So it just... it's broke, so you've got a broken regulatory system strapped onto a broken venture capital system… you can imagine some new system coming out – I don't know what it is yet… But there are systems out there; we're trying to work this out now and we're trying to develop a partnership with a hospital, cause I think that's the critical bit, you need the clinicians as part of this game really."* (Informant #10) [Example of a problem-based coping response]

(Source: Author)

Institutional commercialisation culture

The commercialisation culture at the research institution is important for commercialisation activities at the U-I boundary. Whilst all of the ecosystems under investigation emphasised an institutional commercialisation culture, idiosyncrasies across each of the ecosystems were witnessed. The Madison ecosystem emphasised a greater commercialisation culture than Moscow, which in turn emphasised a greater commercialisation culture than Edinburgh. The higher culture in Madison may simply be a reflection of WARF's long established history of venturing activities.

For Skoltech, the high commercialisation culture may reflect Skoltech's core mission of developing an institution with entrepreneurship and innovation at the forefront.

Within each ecosystem, the TTO and institutional translational facilities are responsible for regenmed commercialisation activities. Numerous entrepreneurial training and educational programmes were in place across the ecosystems:

> *"…the business school has a business clinic. They provide training in developing business, not business plans so much, but market assessments and looking at the strategic feasibility. We have a law clinic that looks at the legal side. We have a mentor group that's outside of the university officially but pretty much tied in with access to the university. WARF has a number of training programmes and things…so we have quite a diversity of things."* (Informant #24)

Additionally, each institution offers various platforms to support commercialisation activities:

> *"...trying to provide a kind of a comfortable area where people can register their start up, get certain benefits and feel more protected from various risks that appear…run a so called translational research and innovation programme…and in fact it's kind of a proof of concept programme. Our task is to identify which research teams inside the institute have gotten to the level where they would like to make an impact, to bring their development to the use of society, maybe to license it for the company, or use the knowledge that they created in their lab…and then we select these teams."* (Informant #38)

Despite this, and consistent with prior literature, tensions amongst the academics towards commercialisation activities were observed:

> *"Academics are judged by their papers and grants…spinouts take a lot of time and a huge amount of work…group leaders find that extremely difficult because that's time that they're not doing their academic work and ultimately they will be judged with the current metrics much more on their academic work than they will on their commercialisation work."* (Informant #9)

Commercialisation activities at the U-I boundary differed across the three ecosystems according to the TTO policies. The Madison ecosystem favours spinout venture activity at the U-I boundary:

> *"We believe that investing in start-up companies based on WARF license technology is good business…we've had a number of very successful companies that have been formed with WARF support and have cashed out, have exited and made a nice profit for us, which we can use to support the university."* (Informant #19)

Edinburgh emphasises licensing:

> *"…Universities don't do spinout companies, I know it sounds a bit daft, but conceptually that's not… they tend to do licensing deals and spinouts are not something they want to get involved with."* (Informant #7)

In Moscow, neither spinout nor licensing dominates; instead there is an emphasis on culture change:

> *"I would say we don't have a preference on licensing or spinouts yet cause we're fairly young, the whole university is like three and a half years old and for us any instance of commercialisation is good enough..."* (Informant #40)

Venturing at the U-I boundary

High levels of uncertainty surround regenmed venturing at the U-I boundary. In Edinburgh and Madison, findings are consistent with this, with Edinburgh demonstrating greater perceptions of uncertainty across all of the ecosystems under investigation. Surprisingly, however, the study shows limited reference to commercialisation challenges or uncertainties in Moscow. Only when probed did informants reveal two key commercialisation challenges. Firstly, informants discussed challenges relating to the political situation in Russia:

> *"And definitely we have some activities of international VCs here, it's slowed down due to the present political situation."* (Informant #41)

Second, regulatory uncertainties were also an important concern amongst informants:

> *"Well, I would say that in Russia, the biggest challenge is the law, the regulations that do not exist but were promised decades ago… I'm not going to discuss this federal law that was prepared by the Minister of Health because it's really disgusting [laugh] and I think after this all stem cell technologies will be terminated or at least slowed down. Nevertheless, what we have, however, at the same time there's still a lot of illegal use of stem-cell-like supporting technology, or approved technology that's still illegal - they're all commercialised because people pay money for this."* (Informant #42)

Findings highlight the importance of slack resources for regenmed venturing. Across each of the ecosystems, slack resources differ. All ecosystems face significant financial capital constraints, but Madison appears to leverage financial resources from out-with the immediate ecosystem:

"We've still done a lot of great deals recently in Madison with Midwest syndicates or a blend of Midwest and coastal syndicates [Boston and Palo Alto VC/private equity firms]" (Informant #34)

Human capital is severely constrained in Moscow. In particular, findings reveal the necessity to attract international human capital in order to truly enable the emergence of a thriving ecosystem:

"To have good results in our organisation we need to combine just few components, one of them is people...we tried to find leading people in different countries and ask if they have the possibility to work in Russia. We go to States, to Germany, to Holland…we collaborate with different leading companies, for example, when we built our printer we co-operate with guys from Vienna University who have experience to make smallest, normal 3D printer...we collaborate with these guys to have some advantage in this technology." (Informant #37)

Across the ecosystems, our findings illustrate informants discussing both current and future business models. Legitimising these business models was clearly important within the study dataset. In the excerpt below, a venture founder describes the necessary steps to legitimise her venture. This included publishing within academic journals and even employing an experienced member of the team, who she believes will be required take over as CEO in order for the venture to truly progress:

"…It was just the confluence of lots of things to consider. So, the science, the business, was there a viable business plan here? Convincing investors that there was one, finding talented people to get us off the ground who are willing to take a risk…So, those have been important partners to get us where we are and continue to be, from the standpoint of credibility…You have to be published in peer reviewed journals. You need to speak at all the meetings all around the world. And we have now been published three times and we speak at meetings all the time. And when we were at Society of Toxicology meeting week before last. It's like our home…everyone stops by the both, and you know, they all know us. And it just took time to build that…One of the things that we did just the last 10 weeks, I hired someone to be the head of diagnostics. For the company he is a gentleman who has worked at a technology company. He's raised 170 million dollars in venture capital. He's taken one [venture] public and got another one acquired. He just has a different pedigree than I have…he is probably the right person to lead the company in the next section of our lifetime. Not to say that I'm leaving, I will just move into a different seat. But what we do is recognise when we have to have a different set of talents, you know, in the lead seat." (Informant #28)

The interview narratives reflected visioning and goal setting. In some instances, narratives portrayed the archetypical heroic entrepreneur. For example, one founder described how he overcame the odds of failure in order for the venture to survive:

> *"Ok, so we sat down and talked about it. We had enough money for about another 6 months or something in the bank and we said we've got two choices; we can go find another processing partner, we can repair the issue with this processing partner, which was only beginning to unfold at the time, or we can do this ourselves, which we always wanted to do but were scared of the cost, the implications, weren't sure if we'd get regulatory approval so that we could commission a lab and try and raise money to do that. It's very difficult...it's all a catch 22, raising money is a whole big catch 22…So we took a decision to throw all the money at building a facility and doing it ourselves… We had spent 3 months before then coming back and forth to here looking at the labs, choosing the spaces, working out what we needed to do to make it work, how much money we were going to need etc. And then we set about raising small amount of money from our investors and we commissioned our lab. So yeah, so that is how we got to where we are now…OK, so it's been a long journey, but we're ramping it up again…"* (Informant #2)

Other narratives emphasised aspects of flawed entrepreneurship, where despite efforts to progress, failure was highly likely:

> *"I've done all sorts of things this year but things are not progressing very well. If things don't start picking up, I really need to think about perhaps doing something else."* (Informant #4)

These entrepreneurial narratives were clearly an important aspect of venturing at the U-I boundary.

Knowledge capabilities

Life science venturing, especially in nascent markets, requires ventures to leverage knowledge capabilities. Findings reveal the importance of collaborations and partnerships as a necessary requirement for ecosystem development across each of the ecosystems under investigation. Again, across each of the ecosystems differences exist. Madison and Moscow strongly favour collaboration during regenmed commercialisation activities. More specifically, cross-national collaborations in Moscow are deemed to be essential for ecosystem emergence:

> *"And next our activity was the collaboration with two teams, one in Germany, the other in the United Kingdom…We have collaborations with the US, with different scientists to develop our drug in US."* (Informant #35)

Whilst Edinburgh does value collaboration, regenmed venturing at the U-I boundary reflects a more independent approach.

Findings also revealed the importance of networks in the development of the ecosystems. In Edinburgh and Madison, these are a common feature of knowledge exchanges:

> *"Our Wisconsin Innovation Network is designed to connect entrepreneurs and others through a variety of programmes in and around the State...we brought all those people to the table, including outsiders who are not university related, who'll hear about what's going on… And that's going to help, at least in an indirect way, further that notion of tech transfer."* (Informant #26)

In Moscow, social networks were deemed to be essential in developing the entrepreneurial ecosystem:

> *"It's especially important inside Russia because what we realise is that people who are doing innovations here they feel quite alone, they still don't have strong networks…We're trying to invite people from outside, but the community was not large…So now we have both a community of mentors from US and other countries, this is a kind of international mentors, and then we have local mentors."* (Informant #38)

Coping mechanisms

Since ecosystem participants must manage uncertainty, findings revealed both problem-based and emotion-based coping mechanisms. With a problem-based approach to addressing uncertainty, individuals attempt to resolve venturing uncertainties or challenges. The following example describes how an academic entrepreneur with no prior entrepreneurial experiences overcame venturing challenges by directly addressing the problems to hand, in order to ensure survival of the venture. This included raising financial capital, partnering at the U-I boundary, networking with VCs, testing and changing the venture business model, and realising when experienced human capital was required:

> *"But when the company started it was entirely novel…there were some business plans, but they weren't very mature…when the company launched, we immediately began a much more mature fundraising effort. We incorporated the company and turned into something significant. And not long after, we ended up raising initial Series A venture financing and we were off and running…we're exploring now interactions with strategic partners…we had interactions early on with venture capital folks that were asking fundamental*

questions...we had to identify the initial technical staff, we had to determine what the focus of the company was going to be, what were we going to effectively do with the initial venture financing? How were we going to explore, how were we going to develop a company focus? We had a really exciting platform that could do many things, but we didn't have a story, we didn't know the market that we were going to identify and target…So we continued to develop the technology…we found out very quickly what the risks were…it turned out that spine went from being a really hot space for these kinds of devices to just getting killed because there were some cautionary tales that made the space appear negative to venture capital and to potential strategic partners. And so our initial focus on spine shifted around the time that we were interested in raising Series B. At that time we also hired a new CEO, very seasoned medical device CEO, and who had started multiple companies prior. His initial goal was to establish a product focus that would be differentiating for the company. So that resulted in a spine focus company, pivoting toward cranium exofacial applications…And we went from being not a lifestyle company, but also not a product discipline company, to becoming a laser-focused-product discipline company. So that was a big transition…And the challenge in raising funds was that we were going to need to raise about $20 million…Instead of raising the $20 million, we ended up doing a much smaller raise and changing the business plan, such that the company's focus now is not on becoming a self-sustaining medical device company that has a long-term goal of generating multiple products, but instead focusing on establishing connections to strategic partners that can take that next step. So that's where we currently are, and we've raised enough to keep the company alive for another couple of years and we have collaborations now established with strategic partners that are building toward potential acquisition over the next year or two." (Informant #31)

In contrast, emotion-based coping assumes that venturing uncertainties or challenges cannot be resolved via information gather or analysis. In the excerpt below, a venture founder is fully aware of the challenges facing their venture, but despite the real chance of the venture failing, the founder explicitly chooses not to address the issues to hand:

"...it's really quite difficult for a company like mine, most of it's consulting to actually get money to do any research… And as I say, that's the problem at the moment, because people are kinda looking at their budgets and, as I say, it does sometimes appear that what I do is quite expensive. Although, I would have to say that I would expect that I could actually save them a considerable amount of money both by going and actually doing the work with them and showing them on their own equipment, and just because my knowledge is a little bit greater of all sorts of different techniques…but there's not really any money coming in from most of this, so that's going to be something that's going to close the company if I don't find something soon." (Informant #10)

In Edinburgh, findings emphasised a greater reliance on emotion-based coping responses. The Madison ecosystem places a greater reliance on problem-based coping mechanisms. Since Moscow highlighted little reference to venturing uncertainties or challenges, this was reflected in a reduced emphasis on coping mechanisms. Since coping is an important mechanism for venturing at the U-I boundary, coping is discussed in further detail in the Discussion.

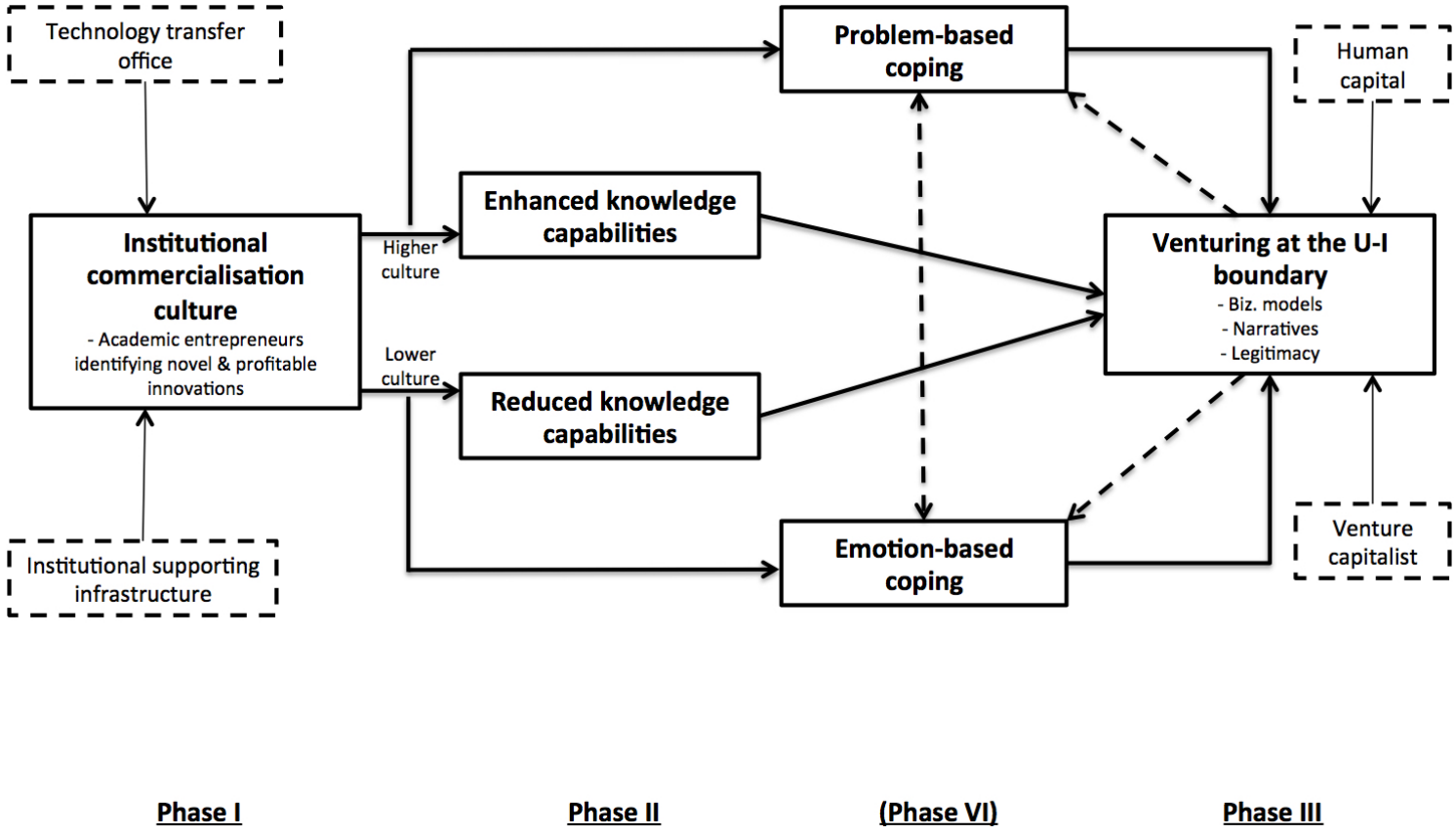
5.5. Discussion

Universities play an important role in the emergence of entrepreneurial ecosystems. Based on the study findings and drawing on EOE/competence bloc theory, a dynamic model illustrating the critical attributes for the emergence and development of entrepreneurial ecosystems at the U-I boundary is proposed. Additionally, the findings reveal a typology of spinout ventures formed at the U-I boundary amidst uncertainty. In the context of an emerging economy, the idiosyncrasies of entrepreneurial ecosystem emergence are highlighted. The Discussion is structured around the research questions articulated in the Introduction to essay 3.

5.5.1. The emergence of entrepreneurial ecosystems at the university-industry boundary

Entrepreneurial ecosystem emergence at the U-I boundary is a complex, context-specific phenomenon. Findings reveal the necessary attributes required for the emergence and development of entrepreneurial ecosystems. Following Corley and Gioia (2011), the previously discussed themes and aggregate dimensions are further built upon to propose a framework for entrepreneurial ecosystem emergence at the U-I boundary (see Figure 5.2).

Figure 5.2. Framework of entrepreneurial ecosystem emergence at the U-I boundary



(Source: Author)

Entrepreneurial ecosystems at the U-I boundary have received little attention (Audretsch et al., 2014; Thomas and Autio, 2014). This proposed framework represents an important effort to show the relationship between entrepreneurial cognition, institutional culture and organisational knowledge creation in the emergence of entrepreneurial ecosystems.

Phase I: This first phase relies on the university adopting a strong culture for entrepreneurship. This requires academic entrepreneurs to engage in commercialisation activities and competently recognise novel and profitable innovations (Eliasson and Eliasson, 1996). Phase I also requires a TTO that promotes spinout venture formation. For example, TTOs with clearer policies are better placed to support commercialisation activities at the U-I boundary (Lockett et al., 2003). Those TTOs that incentivise commercialisation activities support venturing at the U-I boundary (Macho-Stadler and Pérez-Castrillo, 2010). The institutional supporting infrastructure is important too, especially in nascent, high-technology sectors (Woolley, 2013).

Phase II: Entrepreneurial ecosystem emergence requires exchanges at the U-I boundary to enable the development of knowledge capabilities. Findings reveal that when universities promote a culture that is supportive of commercialisation activities, which is associated with an emphasis on problem-based coping mechanisms, increased knowledge exchanges occur at the U-I boundary. During the emergence of an ecosystem this is particularly encouraging since U-I knowledge exchanges support enhanced knowledge capabilities, which are associated with start-up activity and entrepreneurial ecosystems (Acs et al., 2013).

In contrast, when the culture for entrepreneurship is low at the research institution, which is associated with emotion-based coping mechanisms, reduced knowledge capabilities within the ecosystem are observed. Since knowledge is a key requirement for entrepreneurial ecosystems, this situation is likely to be problematic, especially in nascent, high-technological sectors operating under high uncertainty. Despite the importance of knowledge exchanges at the U-I boundary, successful ecosystem emergence requires the recipient to have the competence to utilise the exchanged knowledge (Eliasson and Eliasson, 1996).

Phase III: As the university looks towards venturing at the U-I boundary, certain criteria must be met. High levels of venturing uncertainty dominate this phase. Entrepreneurs must leverage both tangible and intangible resources. High-technology firms face challenges accessing financial capital and, therefore, VC firms at the U-I boundary are important for spinout ventures (Wright et al., 2006). Similarly, university-managed capital funds are becoming increasingly important in assisting venture development at the U-I boundary (Croce et al., 2014). The adopted business model will determine venturing at the U-I boundary. In particular, the configuration of the structural elements of the venture's business model will determine how ventures pursue the entrepreneurial opportunity (George and Bock, 2011).

When uncertainty is high and the decision-making abilities of entrepreneurs challenged, entrepreneurial ecosystem emergence requires ventures to experiment (Johansson, 2010). For example, university spinout ventures that follow multiple business models at the same time may be better placed to innovate (Clausen and Rasmussen, 2013). However, selecting the most appropriate business model is often challenging (Pries and Guild, 2011), especially in regenmed where proven business models are unknown. A critical element during this phase is that thriving business models are retained and rewarded, and the support for non-sustainable business models ceased.

Entrepreneurial narratives are an important mechanism to establish venture legitimacy (Garud et al., 2014). A compelling story can assist ventures in resource acquisition (Lounsbury and Glynn, 2001) and establishing partnerships (Phillips et al., 2013). When uncertainty is high, stories represent an important sensemaking device (Cornelissen, 2012). For example, narratives of failure reflect coping and sensemaking at entrepreneurial firms (Byrne and Shepherd, 2013). Heroic narratives reflect legitimacy, and individual and organisational sensemaking (Anderson and Warren, 2011; Nicholls, 2010).

Phase IV: Phases I, II, and III operate within a highly uncertain landscape. Study findings have revealed a fundamental condition for the emergence and development of entrepreneurial ecosystems at the U-I boundary. When uncertainty is high, entrepreneurs must engage in coping mechanisms to ensure venturing at the U-

I boundary. This is an important step forward in our understanding of entrepreneurial ecosystems.

Coping is an individual's behavioural and cognitive efforts to stressful situations (Folkman and Lazarus, 1980), enabling them to manage uncertainty (Lipshitz and Strauss, 1997). Individuals engage in two types of coping strategies: problem-based and emotion-based coping (Lazarus and Folkman, 1984). The former, which is a type of active coping, relies on addressing the uncertainty directly in an attempt to alter the stressful situation. The latter, which may be viewed as avoidance coping, relies on disengaging from or avoiding the stressful situation (Carver et al., 1989; Lazarus and Folkman, 1984; Uy et al., 2013). Coping strategies have been shown to differ across individuals (Carver et al., 1989) and may depend on prior experience. For example, Uy et al. (2013) found prior start-up experience to be a source of learning that enabled entrepreneurs to cope with *de novo* venturing uncertainties. Individuals utilise both types of coping strategies when dealing with uncertainties (Folkman and Moskowitz, 2004). While there is no clear consensus on the most effective coping mechanism (Aldwin and Revenson, 1987), an emphasis on emotion-based coping is likely to be insufficient to address the uncertainties inherent to high-technology industries that are faced with rapid change (Derfus et al., 2008).

When considering responses to venturing uncertainty, the coping context is important (Mattlin et al., 1990; Patzelt and Shepherd, 2011). Across the three ecosystems studied, differences in coping responses were observed. Study findings reveal coping mechanisms at the U-I boundary to be determined by the culture for entrepreneurship at the research institution. In turn, this determines whether individuals chose to collaborate or partner at the U-I boundary, and the development of knowledge capabilities. This relationship is further specified in the section that follows.

The proposed framework supports a regional competence bloc (Eliasson and Eliasson, 1996). More specifically, it highlights the ecosystem infrastructure, which includes institutional commercialisation culture, coping mechanisms and knowledge capabilities, to successfully innovate and exploit entrepreneurial opportunities. At the centre of this competence bloc is micro-level competence and cognition. Thus, it is proposed here that:

Proposition 10: In nascent ecosystems, human embodied competence assists in entrepreneurial ecosystem emergence and regional competency.

Human embodied competence reflects the characteristics described in Table 1.3 and also reflects individual or team tacit knowledge (Bjuggren and Mueller, 2009).

5.5.2. Technology transfer amidst uncertainty

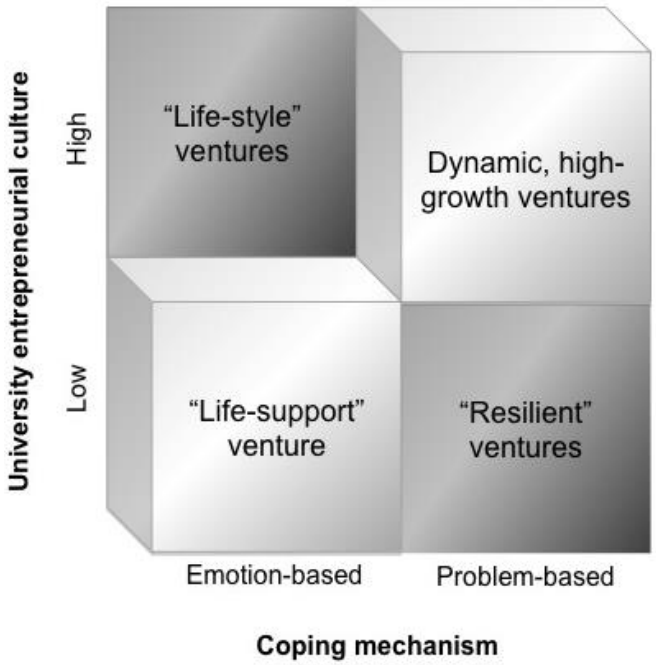
University technology transfer is an idiosyncratic and uncertain process. This study investigated regenmed commercialisation activities at the U-I boundary, which is dominated by high levels of uncertainty. Findings reveal a link between the institutional entrepreneurial culture, technology transfer, collaboration efforts and coping mechanisms. Findings highlighted university translational activities to be driven by the entrepreneurial culture within the research institution. Not surprisingly, higher levels of entrepreneurial culture are reflected in a greater emphasis on technology transfer and commercialisation activities. In contrast, lower levels of entrepreneurial culture reflect a reduced emphasis on technology transfer and commercialisation activities. Yet, interesting phenomena are observed amidst the backdrop of high uncertainty.

When the university emphasises a strong entrepreneurial culture, greater collaboration efforts and the development of knowledge capabilities are witnessed. Interestingly, it is this precise situation that a greater emphasis on problem-based coping mechanisms is observed. The Madison ecosystem was representative of this particular scenario. In situations of reduced university entrepreneurial culture, findings reveal limited collaboration efforts. This was reflected in reduced knowledge exchanges at the U-I boundary and a reduction in knowledge capabilities. In this situation, findings reveal a dominance of emotion-based coping mechanisms within the ecosystem. This is precisely the scenario in Edinburgh. Surprisingly, the Moscow ecosystem exhibited limited problem-based and emotion-based coping mechanisms. This is elaborated on in greater detail in the discussion of context, in Section 5.5.3. of this particular study.

Since the study findings reveal entrepreneurial coping responses to uncertainty to be culturally determined, in Figure 5.3 a range of potential university

spinout venture types that may operate within entrepreneurial ecosystems are depicted.

Figure 5.3. Spinout venture types in entrepreneurial ecosystems



(Source: Author)

Dynamic, high growth ventures at the U-I boundary reflect an ecosystem that emphasises high levels of university entrepreneurial culture and a problem-based approach to uncertainty reduction. In this particular ecosystem, exchanges at the U-I boundary are common, leading to enhanced knowledge capabilities that are particularly important during venturing under uncertainty. Rapidly developing ecosystems are associated with collaborative learning and knowledge capabilities (Porter, 1998). Entrepreneurial ecosystem emergence and development at the U-I boundary is clearly determined and driven by the very presence of these dynamic, high growth ventures.

Life-support ventures reflect a low entrepreneurial culture and emotion-based coping. The low culture for entrepreneurship means that these ventures focus on the internal resources to hand. Low collaboration efforts result in limited knowledge

capabilities. Since ventures do not directly address uncertainty, they attempt to mitigate the downside of missing knowledge. While this cohort of ventures would appear to be detrimental to ecosystem economics, they actually have the potential to contribute to entrepreneurial ecosystems. Since these ventures are likely to fail relatively rapidly, they provide perfect sources of recycled human capital and other resources (Eliasson and Eliasson, 2006).

Life-style ventures are the problem children of entrepreneurial ecosystems and are characterised by high institutional entrepreneurial culture and emotion-based coping. The high entrepreneurial culture at the research institution favours collaboration efforts. However, since these ventures adopt an emotion-based response to dealing with uncertainty, two potential hazards are possible. First, the high entrepreneurial culture is indicative of U-I boundary knowledge exchanges. As a result, ventures are likely to partner with similar firms as a consequence of homophily effects (McPherson et al., 2001; Phillips et al., 2013). In this situation, since both ventures assume that uncertainty cannot be resolved, there is a high possibility that both ventures follow a flawed route towards commercialisation. This is suggestive of a high venture failure rate and the demise of the entrepreneurial ecosystem. Second, the high entrepreneurial culture suggests increased levels of institutional support. While this may appear useful, it is in fact reducing the availability of slack resources necessary for the high-growth ventures.

Resilient ventures face significant challenges within the ecosystem. The low culture for entrepreneurship at the research institution is counter-intuitive to collaboration efforts and, therefore, the development of knowledge capabilities. In nascent markets, this is particularly problematic (George et al., 2008). Yet, the problem-based approach to addressing venturing uncertainties sees entrepreneurs seeking information and responding to challenges by whatever means possible. Here, entrepreneurs are constructing their venture narrative in real time (George and Bock, 2012). The heroic entrepreneurial archetype (Anderson and Warren, 2011) is especially fitting to this scenario.

Findings reveal how institutional culture shapes individual responses to uncertainty and the subsequent implications on entrepreneurial ecosystems. This directly responds to requests for further research on the influence of institutional

contexts and culture on micro-level cognition (Jennings et al., 2013; Nelson, 2014), and the effect(s) on entrepreneurial ecosystems (Autio et al., 2014). A key aspect supporting the emergence and development of entrepreneurial ecosystems at the U-I boundary will be the support of dynamic, high-growth ventures and resilient ventures. In contrast, ecosystem participants must recognise life-style and life-support ventures, and limit the support offered to them.

This typology of spinout ventures is encouraging, since it integrates theories of uncertainty, sensemaking, collaborative knowledge development, entrepreneurial ecosystem emergence and competency blocs. More specifically, it illustrates that entrepreneurial coping responses to uncertainty and the dominant institutional culture drive the specific structure and type of spinout ventures at the U-I boundary. In turn, this affects both the emergence and development of entrepreneurial ecosystems, and is contingent upon the competency within the specific ecosystem.

Unlike industrial clusters, which grow by outcompeting other clusters, entrepreneurial ecosystems grow via the exploitation of new technologies, business models, market opportunities, and subsequent venture formation and growth. Whilst a mix of all venture types presented in Figure 5.3 are likely beneficial to the ecosystem, an over emphasis on any one types suggests high failure rates. In the EOE, mid-level organisational choices and outcomes depend on human-embodied competence (Johansson, 2010). These competencies bear close relation to dynamic capabilities, reflecting entrepreneurs' ability to manage venturing uncertainties and take appropriate risks, while efficiently identifying and correcting commercialisation mistakes (Bjuggren and Mueller, 2009; Eliasson, 1996b; Eliasson, 1990). Such capabilities are often primarily tacit, relying on prior experience rather than strategic planning or environmental analysis. Human-embodied competence functions within a system that responds to experimental project creation and selection by capturing winning projects/ventures and removing losers (Carlsson and Eliasson, 2003).

The EOE assumes that there are numerous permutations for combining production factors within a venture. Some combinations are superior to others; some combinations may remain undiscovered. The EOE, therefore, provides a useful way to analyse entrepreneurial ecosystems. It explicitly recognises that actors cannot possess perfect information. Limitations on resources and knowable information

result in experimentation to seek locally-optimal configurations (Eliasson, 1996b; Johansson, 2010). Thus, critical to the emergence and development of entrepreneurial ecosystems at the U-I boundary is the competency of individual entrepreneurs (and the wider ecosystem participants) in selecting and removing the appropriate mix of spinout venture types.

5.5.3. The importance of context in entrepreneurial ecosystems

An important aspect of this study is to develop an understanding of the importance of context in entrepreneurial ecosystems. This is a critical step towards advancing contextual influences on entrepreneurial activities (Autio et al., 2014; Zahra and Wright, 2011; Zahra et al., 2014). This study explores ecosystem emergence across three separate countries. While Edinburgh and Madison represent similar contexts in terms of their history in regenmed research activities, Moscow reflects a unique and novel context to examine regenmed commercialisation activity at the U-I boundary.

The analysis of this unique contextual setting suggests new directions for the emergence of entrepreneurial ecosystems. Across each ecosystem, stem cell science and the underlying institutional structures are similar. Therefore, it can be expected that ecosystem emergence in Russia will proceed in a similar manner to Edinburgh and Madison. Yet, a striking phenomenon is observed in the Russian context. Despite the high levels of uncertainty surrounding regenmed venturing and the uncertainties inherent to venturing within emerging economies, this study revealed limited reference to venturing uncertainties in Russia. As a consequence, ecosystem emergence in Russia appears to place a reduced emphasis on coping mechanisms. This is peculiar and may reflect the entrepreneurial cognition of Russian entrepreneurs. For example, prior studies have shown Russian entrepreneurs to be more adept at managing uncertainty and exhibiting a more opportunistic approach during venturing in comparison to their more Western counterparts. It has also been suggested that the Russian cultural tendency is to have unrealistic expectations, even to the extent of believing in miracles (Puffer et al., 2001). Thus, in the context of this nascent, emerging economy, the entrepreneur and more specifically the

entrepreneurial traits appear to be central to the early stages of ecosystem emergence. Therefore, this study proposes that:

> **Proposition 11:** In emerging economies operating under high uncertainty, entrepreneurial ecosystem emergence and regional competence is initially influenced by entrepreneurial cognitive traits.

This proposition places the entrepreneur as the focal point, which is consistent with prior literature (Stam, 2015). However, this study further specifies the importance of cognition in entrepreneurial ecosystem emergence, which prior studies have inadequately captured.

International human capital dominated the Russian commercialisation narratives and is clearly central to entrepreneurial ecosystem emergence in Russia. In some instances in this study dataset, international human capital was reflected in returnee Russian nationals that had spent a period of time in developed economies. These returnee entrepreneurs assist in the development of knowledge capabilities, particularly international knowledge spillovers and social capital (Liu et al., 2010). Similarly, international collaborations and partnerships are critical to entrepreneurial ecosystems at the U-I boundary in emerging economies. This is especially true in high-technology sectors but does present challenges (Trifilova et al., 2013). It is suggested here that in nascent ecosystems, human embodied competence capital and entrepreneurial ecosystem emergence is moderated by international partnerships, such that:

> **Proposition 12a:** In emerging economies operating under high uncertainty, weak international partnership activity is negatively associated with human embodied competence capital and entrepreneurial ecosystem emergence.

> **Proposition 12b:** In emerging economies operating under high uncertainty, strong international partnership activity is positively associated with human embodied competence capital and entrepreneurial ecosystem emergence.

The propositions highlighted in Essay 3 clearly emphasise the importance of viewing entrepreneurial ecosystem emergence from an EOE and competency bloc framework.

While legitimisation is important during new venture growth (Zimmerman and Zeitz, 2002) and regenmed commercialisation (Jain and George, 2007), in emerging economies legitimisation of both the entrepreneur and venture represents a significant aspect of entrepreneurial ecosystem emergence. This is particularly necessary in the Russian context given the current political tensions. Therefore, in support of prior literature, this study suggests that in nascent ecosystems entrepreneurial ecosystem emergence and regional competence depends on legitimisation of the entrepreneur and their venture.

This study has emphasised the importance of context in entrepreneurial ecosystems. While this research clearly emphasises the importance of coping mechanisms in the emergence of entrepreneurial ecosystem at the U-I boundary, in emerging economies other attributes initially dominate. Within these emerging economies, entrepreneurs should look towards accessing international human capital and developing strong international partnerships. A key aspect of this will be legitimising their ventures.

5.5.4. Policy implications

Policymakers often seek short-term, "silver bullet" mechanisms to drive economic activity and job creation. Entrepreneurial ecosystems at the U-I boundary are commonly promoted as attractive structures to generate rapid, regional industry growth (Etzkowitz and Leydesdorff 2000; Guerrero et al., 2015). The economic reality of ecosystem development is, however, much less optimistic. University spinout activity, on its own, only drives significant regional economic development in exceptional, hard to emulate circumstances (Miner et al., 2001).

The challenge for research institutions and state policymakers lies in bridging localised, high-risk venturing activity with mid-term regional economic growth processes. Competence bloc theory emphasises that an ecosystem requires a minimum configuration of key resources and capabilities to improve growth prospects for risky technology ventures. Policymakers have, appropriately, focused

on available financial capital and skills-based training because the processes and outcomes are relatively easily measured.

Study results show that policymakers must consider three additional levers to effectively connect technology venturing at the U-I boundary with regional economic outcomes. These levers include experiential (rather than skill-based) entrepreneurial training, incentives for market-facing activities within research universities and more efficient knowledge sharing mechanisms that span the U-I boundary. Each is briefly discussed.

Experiential training appears to be a powerful lever for improving technology venturing outcomes at the U-I boundary. Researchers in knowledge-intensive fields, such as regenmed, can apply technical and analytical skills to business problems. The pace and high failure rate of technology venturing, however, present unfamiliar behavioural and emotional contexts for decision-making. Skills-based training provides a valuable foundation for academic entrepreneurs but does not address coping strategies.

Marketing-facing activities at research universities include consulting practices, contract research, graduate student internships and practicums, and other opportunities that directly connect university research investigations with emerging needs in industry. These boundary-spanning experiences help academic scientists and nascent entrepreneurs develop market-centric identity (George and Bock, 2008). This facilitates the identification and creation of opportunities, and the development of broad-based entrepreneurial culture within the university.

Knowledge sharing at the U-I boundary presents special challenges. Many research universities have a TTO specifically tasked with controlling knowledge transfer. Although these organisations are intended to ensure and facilitate authorised technology transfer and commercialisation, concerns over inadvertent disclosure may inhibit appropriate and valuable knowledge transfer. One example of improved knowledge sharing and market-facing activity is Scotland's Interface programme. Interface connects SMEs with Scotland's major research universities to generate research contracts overseen by the relevant TTOs. This type of programme appears to encourage more entrepreneurial activity within university structures and SME-

based economic development, despite having no direct impact on *de novo* venturing activity.

5.5.5. Limitations and future research

There are several limitations to this study that must be recognised, which suggest areas for future research. First, the study relies on qualitative data to develop theories of entrepreneurial ecosystem emergence and the importance of context. Therefore, caution should be exercised in generalising the findings prior to the testing of specific hypotheses. Further studies may test and refine these theories with quantitative data. Second, since the study data is cross-sectional, it is not possible to comment on the rate of ecosystem emergence. A longitudinal study would provide insight into how ventures progress through each of the phases that have been identified in the framework of entrepreneurial ecosystem emergence. Third, while the study proposes a typology of ventures at the U-I boundary, the data lacks performance measurements of these ventures. Further research should include performance measurements of firms so that it is possible to fully understand the link between culture, coping and firm/ecosystem performance. Fourth, the Russian dataset is relatively small. Additional research should build on the propositions identified. In particular, a large-scale survey exploring entrepreneurial traits and/or international exchanges/partnerships at the U-I boundary has the potential to further reveal the importance of context in the emergence of entrepreneurial ecosystems. Despite these aforementioned limitations, the study findings progress the understanding of the emergence of entrepreneurial ecosystems and the importance of context in entrepreneurial processes.

5.6. Conclusion

This study investigated entrepreneurial ecosystem emergence across three nations. Findings have revealed the importance of institutional entrepreneurial culture, coping and knowledge capabilities in the types of ventures formed at the U-I boundary. In turn, this has important implications for the emergence of entrepreneurial ecosystems. The study situated the investigation in a developed and an emerging economy context. This revealed the importance of context for

entrepreneurial ecosystems and the idiosyncratic characteristics of ecosystem emergence in such contexts. This research is an important step forward in developing an understanding of entrepreneurial ecosystem emergence at the U-I boundary amidst uncertainty.

Part IV

Chapter 6: Conclusion

The purpose of Chapter 6 is to provide a summary of the three essays. Each of these essays has important theoretical contributions and practical implications and, therefore, these will be discussed. More specifically, the practical implications include the presentation of three practitioner papers that were published as a direct result of this PhD research. Following this, the research limitations and opportunities for future research are considered. This chapter and this PhD thesis concludes with some brief final words.

6.1. Summary of essay findings

This PhD thesis investigated entrepreneurial behaviour and the development of entrepreneurial ecosystems under uncertainty. In doing so, the following research question was explored:

> **"How does irreducible uncertainty affect entrepreneurial behaviour and the development of entrepreneurial ecosystems at the U-I boundary?"**

To address this research question, this thesis initiated three independent (but linked) empirical studies (essays). Essay 1 investigated how ecosystem participants in the regenmed sector make sense of uncertainty during venturing at the U-I boundary. Relying on 23 long-form narrative interviews and a pilot survey with regenmed informants in Edinburgh, it addressed two research questions:

1. How do ecosystem participants make sense of highly uncertain venturing contexts?

2. What are the unique features of collaborative knowledge development in regenmed venturing?

The essay findings revealed a model of sensemaking during regenmed venturing. This highlighted that PEU and institutional entrepreneurial culture affect an individual's preferred coping strategy. The chosen coping strategy then influences both the generation of venture narratives as well as collaboration efforts. It was shown that a key purpose of the venture narrative is the legitimisation of the firm's innovation or business model.

In essay 1, coping strategies consisted of a problem-based coping response and an emotion-based coping response. Problem-based coping was shown to be associated with increased knowledge collaboration and venture narratives that emphasise addressing a specific market need as the key component of a successful business model. This was linked to a strong entrepreneurial culture at the research university. In contrast, emotion-based coping was shown to be associated with reduced knowledge collaboration and venture narratives that emphasise the venture's current innovation as the key component of a successful business model. This was linked to a weak entrepreneurial culture at the research university.

Essay 1 concluded with a proposal of sensemaking types in uncertain entrepreneurial ecosystems. These included:

- *Focused visionaries*, who are participants in the regenmed ecosystem that have settled on a key innovation or business model and plan to see it through regardless of the development of alternative innovations or collaborative opportunities.
- *Informed observers*, which have similarly determined a relatively set position with regard to technology or innovation but are not actively engaged in commercialisation.
- *Open innovators*, who are individuals engaged in commercialisation activity based on a primary technology, but are willing to take the risk of collaboration in order to best address a given market problem.

- *Curious bystanders*, who are not directly involved in commercialisation, but have specific market problems or industry needs in mind and encourage collaboration for the sake of improving the knowledge of the ecosystem as a whole.

Essay 1 extends understanding of entrepreneurial sensemaking and the impact of micro-level cognition on nascent entrepreneurial ecosystems.

Essay 2 explored venturing activity and ecosystem development under irreducible uncertainty in two university-centric regenmed ecosystems. Two research questions were addressed, via long-form narrative interviews with 30 regenmed informants in Edinburgh and Madison:

1. How does micro-level cognition and behaviour differ across ecosystems?
2. Why do apparently similar entrepreneurial ecosystems develop differently?

Research findings from essay 2 highlighted multi-level effects in the ecosystems under investigation. At the micro-level, entrepreneurial coping strategies were affected by cultural artefacts generated by the ecosystem university. At the macro-level, entrepreneurial ecosystems were shown to develop along different paths. Findings revealed a model of entrepreneurial ecosystem development, which differed as a result of differences in underlying dimensions of behavioural norms and translational approaches to technology commercialisation and venture development. The dominant translational approach of an entrepreneurial ecosystem was suggested to be associated with the entrepreneurial culture of the originating institution and the utilisation of collaborative knowledge development.

The regenmed ecosystem around The University of Wisconsin-Madison was shown to combine a relatively strong entrepreneurial culture extant within the university with collaborative knowledge development. In other words, this ecosystem values a collaborative and opportunistic approach to translational activity. Findings highlighted the ecosystem around The University of Wisconsin-Madison to have much lower levels of coping strategies and outcome emphasis. This is indicative of an improvisational approach to translation at the U-I boundary, with

less emphasis on behavioural change in the service of achieving specific goals. As a result, essay 2 suggested that improvisational entrepreneurial ecosystems are associated with higher levels of entrepreneurial culture in the originating institution and increased utilisation of collaborative knowledge development.

In contrast, essay 2 showed that The University of Edinburgh was lower on entrepreneurial university culture and collaborative knowledge development. Entrepreneurs and other ecosystem participants were shown to be relying on a more autonomous and focused approach to translating technologies across the U-I boundary. The ecosystem around The University of Edinburgh emphasises coping strategies and venturing outcomes. This suggests a reactive practice to addressing uncertainty. Essay 2 suggested that focused entrepreneurial ecosystems are associated with lower levels of entrepreneurial culture in the originating institution and decreased utilisation of collaborative knowledge development.

The proposed model of ecosystem development in regenmed in essay 2 suggests that entrepreneurial ecosystem development at the U-I boundary is a dynamic and path independent process. The development of the ecosystem is both a driver and outcome of the nature and type of entrepreneurial coping strategies prevalent within the ecosystem. This particular study advances theories of U-I technology transfer and institutional entrepreneurship. Additionally, findings extend knowledge linking entrepreneurial cognition and sensemaking to ecosystem development.

Essay 3 explored the emergence and development of entrepreneurial ecosystems, and considered how these drive technology-based economies. This essay addressed two research questions:

1. What is the role of the university and the technology transfer process in assisting with the emergence and development of entrepreneurial ecosystems at the university-industry boundary?
2. How does context influence entrepreneurial ecosystem development?

Relying on narrative interviews with 47 regenmed participants across three regenmed ecosystems, findings revealed how entrepreneurial ecosystems at the U-I boundary

emerge. This emergence involved four phases, which emphasised institutional culture, organisational knowledge creation, entrepreneurial narratives and entrepreneurial cognition. A typology of spinout ventures formed within technology-intensive ecosystems was proposed, driven by university culture and entrepreneurial coping strategies. These included:

- *Dynamic, high growth ventures*, which reflect an ecosystem that emphasises high levels of university entrepreneurial culture and a problem-based approach to uncertainty reduction.
- *Life-support ventures*, reflective of a low entrepreneurial culture and emotion-based coping within the ecosystem.
- *Life-style ventures*, which represent the problem children of entrepreneurial ecosystems and are characterised by high institutional entrepreneurial culture and emotion-based coping.
- *Resilient ventures*, who face significant challenges within the ecosystem. These reflect an ecosystem characterised by low institutional entrepreneurial culture and problem-based coping.

Additionally, essay 3 highlighted how context clearly matters in the emergence of entrepreneurial ecosystems at the U-I boundary. In particular, it illustrated that ecosystem emergence in Russia was initially driven by: human embodied competence capital; entrepreneurial cognitive traits; international partnerships; and legitimisation of the entrepreneur and their venture. Overall, essay 3 extends knowledge of entrepreneurial ecosystem emergence and the importance of context in entrepreneurial processes.

A summary of each essay is provided in Tables 6.1., 6.2., and 6.3. respectively.

Table 6.1. Summary of essay 1

Research questions	RQ1: How do ecosystem participants make sense of highly uncertain venturing contexts? RQ2: What are the unique features of collaborative knowledge development in regenmed venturing?
Motivations / research gap	- Extends prior research on patterns of sensemaking cognition when PEU is high. - Limited understanding of how entrepreneurs make sense of venturing process amidst irreducible uncertainty.
Theory	Sensemaking; Entrepreneurial behaviour; Academic entrepreneurship; Institutional entrepreneurship.
Methodology	Qualitative narrative interviews and pilot online survey.
Key findings	1) When PEU is high, individuals engage in problem-based or emotion-based coping strategies. Coping is driven by institutional entrepreneurial culture and influences collaboration efforts and the generation of venture narratives. 2) Model of sensemaking process in regenmed venturing is proposed. 3) Several propositions presented: a) Emotion-based coping strategies are associated with weak institutional entrepreneurial culture and reduced knowledge collaboration. b) Problem-based coping strategies are associated with strong institutional entrepreneurial culture and increased knowledge collaboration. c) Coping strategies, which rely on selectively revealing knowledge during collaborations, are associated with the partnering of firms with similar business models. 4) A typology of sensemaking profiles within entrepreneurial ecosystems is offered. These include: focused visionaries, informed observers, open innovators and curious bystanders.

(Source: Author)

Table 6.2. Summary of essay 2

Research questions	RQ3: How does micro-level cognition and behaviour differ across ecosystems? RQ4: Why do apparently similar entrepreneurial ecosystems develop differently?
Motivations / research gap	- Lack of understanding of entrepreneurial ecosystems. In particular, the full effects of university-based translational and commercial activity on ecosystems remains uncertain. - Limited research on entrepreneurial ecosystem emergence / development. - Limited knowledge of the influence of institutional characteristics on entrepreneurial ecosystems. - Further understanding required on the impact of university policy, practice and culture on micro-level cognition and behaviour at the U-I boundary.
Theory	Entrepreneurial ecosystems; Academic entrepreneurship; Entrepreneurial behaviour; Institutional entrepreneurship.
Methodology	Qualitative narrative interviews and pilot online survey.
Key findings	1) Institutional entrepreneurial culture drives entrepreneurial coping strategies. 2) Technology transfer at the U-I boundary is influenced by entrepreneurial culture and collaboration efforts. 3) Entrepreneurial behaviour and translational activities differ across ecosystems. 4) Entrepreneurial ecosystems develop along different paths as a consequence of entrepreneurial culture, cognition and collaboration efforts at the U-I boundary.

(Source: Author)

Table 6.3. Summary of essay 3

Research questions	RQ5: What is the role of the university and the technology transfer process in assisting with the emergence and development of entrepreneurial ecosystems at the university-industry boundary? RQ6: How does context influence entrepreneurial ecosystem development?
Motivations / research gap	- Lack of research linking entrepreneurs to the emergence of entrepreneurial ecosystems. - Few studies consider the emergence of ecosystems. - Further understanding required of contextual influences on entrepreneurial processes. - First transnational, multi-level study to explore entrepreneurial ecosystems within an EOE/competence bloc theory framework.
Theory	EOE and competence bloc theory; Entrepreneurial ecosystems; University technology transfer; Entrepreneurial context.
Methodology	Qualitative narrative interviews and pilot online survey.
Key findings	1) At the U-I boundary, entrepreneurial ecosystem emergence is driven by: the institutional commercialisation culture; coping mechanisms; knowledge capabilities; and micro-level competence and cognition. 2) Institutional entrepreneurial culture, technology transfer, collaboration efforts and coping mechanisms drive a range of university spinout venture types. 3) Context matters in the emergence and development of entrepreneurial ecosystems at the U-I boundary. 4) In nascent ecosystems, ecosystem emergence depends on: human embodied competence capital, entrepreneurial cognitive traits; international partnerships; and legitimisation of the entrepreneur and their venture.

(Source: Author)

Collectively, the three essays extend knowledge on entrepreneurial behaviour under uncertainty and entrepreneurial ecosystems at the U-I boundary. Together, the essays reveal that when uncertainty is high, entrepreneurs make sense of venturing uncertainties at the U-I boundary by the implementation of specific coping strategies. These include either a problem-based coping or an emotion-based coping response. The former actively seeks to reduce uncertainty, whereas the latter avoids uncertainty. Coping responses are linked to the entrepreneurial culture at the research university. When the university displays an enhanced entrepreneurial culture, greater levels of problem-based coping are witnessed. In contrast, a reduced entrepreneurial culture is linked to emotion-based coping. When entrepreneurial culture is high and

problem-based coping mechanisms are in place, greater levels of knowledge exchanges at the U-I boundary are evident. Lower levels of entrepreneurial culture and an emphasis on emotion-based coping reveal reduced knowledge collaboration at the U-I boundary.

As a result of these differences, the particular (entrepreneurial) ecosystem displays different individual sensemaking types and drives a variety of spinout ventures. As such, entrepreneurial ecosystems at the U-I boundary develop along different paths, even if the ecosystems appear similar. The actual emergence of the ecosystem is contingent upon institutional commercialisation culture; coping mechanisms; knowledge capabilities; and micro-level competence and cognition. However, ecosystem dynamics are also contingent upon context. In particular, this PhD research has revealed that in nascent ecosystems both the emergence and development of the ecosystem depends on: human embodied competence capital; entrepreneurial cognitive traits; international partnerships; and legitimisation of the entrepreneur and their venture.

6.2. Contributions

This PhD research offers important theoretical contributions. A summary of the contributions from each of the three essays is provided in Table 6.4. Collectively, the three essays support contributions to three specific areas, which include entrepreneurial ecosystems, academic entrepreneurship, and context in entrepreneurial studies. Each is discussed in turn, following a summary of the essay contributions.

Table 6.4. Summary of essay contributions

Essay	Study contributions
1	- Findings progress theories of micro-level cognition and behaviour under uncertainty. - Research extends knowledge on venturing behaviour and knowledge development. - Findings progress understanding of entrepreneurial coping strategies to uncertainty.
2	- Study findings advance knowledge on the development of entrepreneurial ecosystems at the U-I boundary and institutional entrepreneurship. - Findings extend understanding of the role of entrepreneurial cognition and sensemaking processes in the development of entrepreneurial ecosystems at the U-I boundary. - Research progresses understanding and highlights the importance of the entrepreneur in entrepreneurial ecosystems at the U-I boundary.
3	- Research highlights the importance of context in venturing and entrepreneurial ecosystem emergence at the U-I boundary. - Findings progress understanding of spinout ventures formed at the U-I boundary in technology-intensive sectors. - Research extends knowledge on entrepreneurial ecosystem emergence at the U-I boundary - Study provides a novel framework (EOE/competence bloc theory) to study entrepreneurial ecosystems at the U-I boundary.

(Source: Author)

6.2.1. Entrepreneurial behaviour

Entrepreneurial responses to uncertainty represent important sensemaking devices (Cornelissen and Clarke, 2010; Weick, 1995). At the U-I boundary, venturing activities are fraught with high levels of uncertainty. For example, when academics engage in commercialisation activities, it creates unique tensions (George and Bock, 2008; Jain et al., 2009). University spinout ventures face significant market challenges (Doganova and Eyquem-Renault, 2009; Lehoux et al., 2014; Vohora et al., 2004) and access to resources is challenging (Clarysse et al., 2011). In the field of regenmed, these uncertainties are often irreducible. Yet, there has been limited research that distinguishes and unpacks the interconnected cultural and cognitive drivers of entrepreneurial behaviour around entrepreneurial universities (Hayton and Cacciotti, 2013; Hayton et al., 2003). In addition, the impact of university policies and culture on micro-level behaviour and cognition has received

limited attention (Jennings et al., 2013). Entrepreneurial coping to uncertainty is also a poorly understood phenomenon (Autio et al., 2014).

This PhD thesis has extended understanding on entrepreneurial behaviour during venturing, and ecosystem development at the U-I boundary in technology-intensive fields. Findings have revealed how entrepreneurs cope with uncertainty at the U-I boundary and explore knowledge partnerships. Coping reflects individual sensemaking to uncertainty and is linked to university entrepreneurial culture and uncertainty. This drives collaboration efforts and the generation of venture narratives. These findings extend knowledge on the cultural aspects that drive individual coping responses. More specifically, this PhD research has progressed understanding of the role of the entrepreneurial university in cognitive drivers of entrepreneurial behaviour. In particular, it has helped explain how specific coping strategies drive particular individual sensemaking types within entrepreneurial ecosystems at the U-I boundary. In doing so, this thesis has generated important contributions to the scholarly literature on entrepreneurial behaviour, progressing understanding of entrepreneurial coping mechanisms amidst uncertainty. This has important implications for research that links entrepreneurial cognition and decision-making to opportunity exploitation and venture processes.

Additionally, this investigation has emphasised the importance of the decisions made by ecosystem actors within the entrepreneurial ecosystem by using the backdrop of the EOE and competency bloc theory. More specifically, consistent with theories of entrepreneurial creation (Alvarez and Barney, 2007), this PhD investigation has re-framed the emergence of entrepreneurial ecosystems as a process driven by micro-level cognition, venture formation, experimentation and competency bloc formation. In particular, as a consequence of knowledge limitations, entrepreneurs operating within the competency bloc must experiment with commercialisation activities. Successful ecosystems and competency blocs are those where ecosystem actors have the competency to select the best combination of ventures within the ecosystem.

6.2.2. Entrepreneurial ecosystems

This PhD thesis further contributes to literature on entrepreneurial ecosystems. These ecosystems are important drivers of economic activity, with the entrepreneurial university being an important aspect of these ecosystems (Audretsch, 2014; Guerrero et al., 2015). However, current understanding of entrepreneurial ecosystems remains limited, particularly the emergence of these ecosystems (Thomas and Autio, 2014) and the effects of university-based commercialisation activities on ecosystem dynamics (Audretsch et al., 2013; Audretsch et al., 2014; Wright, 2013). More specifically, the role of the entrepreneur has often been overlooked when considering entrepreneurial ecosystems (Stam, 2015), especially the role of the academic entrepreneur (Wright et al., 2012b). Furthermore, despite individual-embodied competence being an important aspect of these ecosystems (Eliasson and Eliasson, 1996; 2006), entrepreneurial ecosystems at the U-I have not been considered from an EOE/competence bloc theoretical framework.

The findings from this PhD research provide a unique understanding of entrepreneurial ecosystem emergence from an EOE/competence bloc theoretical framework. The EOE assumes that there are numerous permutations for combining production factors within a venture. Some combinations are superior to others; some combinations may remain undiscovered. The EOE, therefore, provides a useful way to analyse entrepreneurial ecosystems. It explicitly recognises that actors cannot possess perfect information. Limitations on resources and knowable information result in experimentation to seek locally-optimal configurations (Eliasson, 1996b; Johansson, 2010).

In the EOE, mid-level organisational choices and outcomes depend on human-embodied competence (Johansson, 2010). These competencies bear close relation to dynamic capabilities, reflecting entrepreneurs' ability to manage venturing uncertainties and take appropriate risks while efficiently identifying and correcting commercialisation mistakes (Bjuggren and Mueller, 2009; Eliasson, 1996b; Eliasson, 1990). Such capabilities are often primarily tacit, relying on prior experience rather than strategic planning or environmental analysis. Human-embodied competence functions within a system that responds to experimental project creation and selection by capturing winning projects/ventures and removing losers (Carlsson and

Eliasson, 2003). This is the first study of its kind to consider entrepreneurial ecosystems from this perspective. It is especially fruitful since it provides strong contributions to the entrepreneurial ecosystem literature by highlighting the importance of individual entrepreneurs, particularly their competence, in the emergence of entrepreneurial ecosystems.

Furthermore, findings from this PhD investigation contribute to theories of entrepreneurial ecosystems by highlighting the importance of micro-level factors in the emergence and development of entrepreneurial ecosystems. More specifically, entrepreneurial coping responses to uncertainty are critical to ecosystem dynamics and impact translational activities at the U-I boundary. In turn, this influences ecosystem developmental paths. These research findings have important implications for theories of entrepreneurial ecosystems, which over emphasise the role of prior history and the configuration of resources in ecosystem dynamics.

6.2.3. Academic entrepreneurship

Additionally, this PhD investigation contributes to theories of academic entrepreneurship. Universities have become increasingly entrepreneurial (Rothaermel et al., 2007), with academics playing an important role in commercialisation activities at the U-I boundary (Huyghe and Knockaert, 2015; Wu et al., 2015). However, the links between university characteristics, and entrepreneurial ecosystems (Audretsch et al., 2013; Audretsch et al., 2014) and entrepreneurial behaviour (Jennings et al., 2013) remains limited.

The PhD thesis findings have revealed that venturing at the U-I boundary depends on micro-level coping responses to uncertainty. Coping is driven by the dominant culture for entrepreneurship at the given university. Differences in coping and culture reveal a typology of university spinout ventures, which have important implications for entrepreneurial ecosystem dynamics and regional economic activity. Thus, the PhD research findings contribute to knowledge of technology transfer and commercialisation activities at the U-I boundary, with micro-level factors and (entrepreneurial) culture being critical elements of this activity.

These findings and contributions are especially pertinent to the current debates within both the scholarly and policy-based literature surrounding the role of

universities in the "third-mission" (Barrioluengo et al., 2016). Research universities across the globe have become pressurised to engage in the commercialisation of academic-led research. Academic entrepreneurship research, particularly the 'entrepreneurial university,' continues to attract the attention of scholars who have explored a variety of domains such as academic spinouts (Fryges and Wright, 2014; Pitsakis et al., 2015); university technology transfer offices (O'Kane et al., 2015; Huyghe et al., 2014); U-I engagement (D'Este and Perkmann, 2011; Perkmann et al., 2013); the contribution of universities to regional economics (Audretsch et al., 2014; Guerrero et al., 2015; Wright et al., 2012b); and academic entrepreneurial intentions and motivations (Hayter, 2013; Huyghe and Knockaert, 2015; Mosey et al., 2012).

Since micro-level factors are a critically important aspect of academic entrepreneurship and the commercialisation of university-derived science (Goethner et al., 2012), research that extends knowledge of the role of entrepreneurial universities and their contribution to entrepreneurial ecosystems is especially timely (Audretsch et al., 2014; Wright, 2013).

Findings from this PhD research have extended understanding of the link between the dominant culture for entrepreneurship at the university and the implementation of specific coping strategies to uncertainty during venturing at the U-I boundary. In turn, this drives a typology of ventures formed at the U-I boundary. Of particular importance is the competency of the actors within the ecosystem to competently recognise and select successful ventures, whist at the same time remove failed (failing) ventures.

Not only do these findings have important implications to the scholarly community, they are equally as important to managers and policymakers responsible for fostering entrepreneurial ecosystems at the U-I boundary.

6.2.4. Context in entrepreneurial studies

Finally, this PhD research has extended knowledge on the role of context in entrepreneurial processes. In doing so, it has responded to calls by Welter (2011) and Zahra et al. (2014). Additionally, it has also addressed calls to explore Russia as a study context (Bruton et al., 2013; McCarthy and Puffer, 2013; Morris et al., 2013).

Context is important in ecosystem dynamics (Autio et al., 2014). This PhD

investigation has highlighted the importance of context in the emergence of entrepreneurial ecosystems at the U-I boundary. In particular, in unique socio-cultural contexts, ecosystem emergence is dependent on: human embodied competence capital; entrepreneurial cognitive traits; international partnerships; and legitimisation of the entrepreneur and their venture. This has important implications for understanding entrepreneurial ecosystems in different contextualised settings.

6.3. Implications – impact beyond academia

In addition to the academic impact of this investigation, as evident in the theoretical contributions, this PhD research has important implications for university and governmental policymakers, entrepreneurs, society and education. Impact is described as *"the demonstrable contribution that excellent research makes to society and the economy."*[2] The several areas of impact that this thesis supports are now discussed.

Findings from this PhD investigation were published in three industry articles. These include:

1) Venturing in the dark: Technology transfer in regenerative medicine. *UK Spinouts*, 13 (Oct), 8-9

2) Building robust entrepreneurial ecosystems around universities. *UK Spinouts*, 16 (July), 13-14

3) Entrepreneurial ecosystems: Fixing the Triple Helix. *The European Business Review*, November-December, 73-76

A summary of each article is provided in Table 6.5. Following this, each article is presented in turn.

[2] ESRC website: http://www.esrc.ac.uk/research/evaluation-and-impact/what-is-impact/

Table 6.5. Summary of practitioner papers

Practitioner article	Summary
1	Article 1 addresses how university policy makers can support university start-ups and drive regional economic development. It highlights how regenmed entrepreneurs become consummate storytellers during new venture creation, in order to influence investors and partners. This article discusses how regenmed entrepreneurs engage in coping mechanisms to deal with the inherent uncertainties of venturing at the U-I boundary in this particular sector. This leads to the article addressing three questions. First, what drives regenmed managers to be problem-focused or emotion-focused? Second, how do entrepreneurs avoid coping strategy pitfalls? Third, what can be done to facilitate Scotland's entrepreneurial activity in regenmed? To answer question 1, article 1 explains how the primary driver for regenmed coping strategies is the entrepreneurial culture of the originating research university. It suggests that the best way for entrepreneurs to avoid coping strategy pitfalls is to find experienced mentors that can identify venture flaws. To facilitate Scotland's entrepreneurial activity in regenmed, article 1 suggests that TTOs should allow some high-technology ventures to fail.
2	Article 2 discusses how universities can optimise ecosystem development at the U-I boundary. It focuses on two key leverage points for universities, and a single leverage point for policymakers. It suggests that universities need to support academic entrepreneurs with experiential training that addresses coping with failure and assisting academics in collaborative knowledge development. Second, since this PhD research points towards an "imprinting" effect, where the policies and culture at the parent institution disproportionately influence entrepreneurial behaviour after spinout, article 2 suggests that universities should not aggressively protect IP or tightly manage spinout activity. For policy makers, the article proposes that the ecosystem boundary must be porous in order to allow entrepreneurs and ventures to leave and enter. This can encourage knowledge and resource sharing with other geographical ecosystems.
3	Article 3 shows how policymakers can nurture entrepreneurial ecosystems to fix broken triple helixes at the U-I boundary. It suggests that the triple helix policies, which focus on practices and resources to accelerate technology transfer and tech venture growth, often fail to support the development of entrepreneurial ecosystems just beyond the U-I boundary. Article 3 suggests that the triple helix model requires three "patches" to function properly under conditions of high uncertainty and knowledge-intensive innovation. First, it encourages universities to support independence and entrepreneurial thinking, since this drives problem-based coping responses to uncertainty. When the university attempts to protect resources, the ecosystem favours emotion-based coping. While emotion-based coping may help ventures through short-term crises, it holds little promise for adaptation in industries with accelerating rates of technological change. Second, article 3 calls for universities to promote knowledge collaboration, since early stage ventures are unlikely to possess sufficient internal knowledge. Third, it suggests that universities should embrace some failure. Healthy ecosystems and smart entrepreneurs do not ignore failure, they learn from it. Rapid failure and recycling of organisational resources provides critical, sometimes low-cost, resources to emerging and rapidly growing ventures. Artificially supporting ventures traps key people and drains the ecosystem of risk capital.

(Source: Author)

6.3.1. Practitioner article 1. Venturing in the dark: Technology transfer in regenerative medicine

University technology transfer is difficult. Research institutions develop unique procedures, culture and faculty incentives. Many promote entrepreneurial approaches; few provide the training or career support to support start-ups and drive regional economic development.

These challenges are exacerbated in regenmed. Universities have long led stem cell advances; a disproportionate number of regenmed start-ups are directly tied to university research. Translating any innovation requires scarce resources and connections to critical partners. In regenmed, however, uncertainty about regulation, distribution and IP rights makes decision-making more difficult. This is not about *risk-taking,* it is about *coping with "unknown unknowns."* For example, the unexpected exit of industry pioneer Geron in 2012 dramatically changed the landscape down to the availability of start-up funding.

For the past two years, the author has studied Scotland's entrepreneurial ecosystem in regenmed. In-depth interviews with entrepreneurs, academics, support entities and government were conducted and analysed. Some of the findings are not surprising. For example, regenmed entrepreneurs become consummate storytellers. They build narratives to sway investors and partners. They adjust those narratives as the industry evolves, partly to make sense of it themselves. Regenmed entrepreneurs also engage in both problem-focused and emotion-focused coping strategies. Problem-focused coping seeks knowledge to reduce uncertainty; emotion-focused coping accepts and adapts to uncertainty. Each strategy has strengths and pitfalls. Problem-focused coping often leads regenmed actors to partner to explore multiple possible commercial options. However, translating any regenmed technology is expensive; investigating multiple possible products can be expensive and lead to fatal delays in technology development.

Emotion-focused coping, including denial and distancing, can be effective strategies in the face of uncertainty. Rather than waste resources seeking unavailable information, these entrepreneurs and ecosystem actors simply focus on what they have. This strategy may seem counterintuitive, but regenmed is not like web commerce or retail where customer feedback is instantly available. Prior research on

world-leading Cellular Dynamics (in *Models of Opportunity: Cambridge*) showed that regenmed ventures can make effective strategic decisions based primarily on what works within the organisation.

The real challenge for all regenmed entrepreneurs arises from collaboration. Partnering creates tensions because ventures must share critical knowledge in a turbulent IP environment that differs dramatically across national borders. Problem-focused entrepreneurs face high transaction costs associated with revealing critical information due to technology sophistication and contract complexity. Emotion-focused coping strategies, however, may be especially vulnerable during collaboration processes. Managers may not be willing to risk sharing core knowledge, protected or not. In these cases, entrepreneurs with mistaken beliefs about technology or market potential are likely to partner with other firms with *the same mistaken beliefs*. Here, story-telling leads entrepreneurs and firms to believe information based on what other industry participants want to hear.

This leads to three questions. First, what drives regenmed managers to be problem-focused or emotion-focused? Second, how do entrepreneurs avoid coping strategy pitfalls? Third, what can be done to facilitate Scotland's entrepreneurial activity in this important sector?

The primary driver for regenmed coping strategies appears to be the entrepreneurial culture of the originating research university. When universities and TTOs create administrative hurdles and burdensome licensing terms for spinouts, academic and professional entrepreneurs become defensive. The apparent lack of control may drive entrepreneurs towards emotion-focused coping strategies. This "organisational imprinting" is a common phenomena, but regenmed venturing lacks a community of large mature firms, so the impact of the parent institution is disproportionately powerful. Rather than making ventures stronger, an adversarial launch environment may limit the firm's ability to create and absorb collaborative knowledge.

The best way for entrepreneurs to avoid coping strategy pitfalls is to find established, experienced mentors to identify new venture flaws. There are relatively few of these in the stem cell sector in Scotland; regenmed entrepreneurs may need to seek such resources in larger ecosystems until the Scottish ecosystem matures.

Unfortunately, there are no easy shortcuts to creating entrepreneurial culture at large institutions because it derives from decades or centuries of embedded policy. Some lessons emerge from successful ecosystems such as Stanford and MIT: transparency, consistency, even-handed processes, top-down leadership and department-level champions. However, the most challenging drivers are highlighted in Ruth Graham's MIT/Skoltech report on entrepreneurial ecosystems: trust-based relationships with the broader E&I community and creating a market for university entrepreneurial activity (tinyurl.com/MITentrepEco). These hallmarks of a vibrant and supportive entrepreneurial culture remain foreign to most large-scale research universities.

What can be done? *UK research universities that encourage high-tech venturing must allow many to fail*. Bureaucracy that slows venturing, intended to reduce failure rates of weaker ventures, handicaps weak and strong ventures alike. TTOs may need to become sensitive to the coping strategies of individual academic entrepreneurs to provide support *only when it is needed*. Like children, inventing entrepreneurs need to learn independence, rather than dependence on the parent institution. Those that do, are likely to be the most successful.

Research in this area continues—a cross-national comparison between the regenmed venturing ecosystem in Scotland and an ecosystem outside the UK was recently launched. Findings will be shared early 2015. This study may shed light on global challenges to regenmed venturing, while pointing to specific opportunities to improve entrepreneurial activity around the UK's world-class research universities.

6.3.2. Practitioner article 2. Building robust entrepreneurial ecosystems around universities

Universities can drive entrepreneurial ecosystems, especially in high-value technology sectors. Nowhere is this more evident than in regenmed, which is centred on academic stem cell research.

Over the past three years, the author has studied regenmed venturing and entrepreneurial ecosystems at the U-I boundary. Research findings from the Scottish regenmed ecosystem, centred on The University of Edinburgh, were previously reported (*UK Spinouts*, Issue 13). Similar research on the ecosystem around The

University of Wisconsin-Madison (United States) has now been completed. The University of Edinburgh and The University of Wisconsin-Madison are global leaders in stem cell research and engines of venturing activity.

In both ecosystems, entrepreneurs, academics, investors, and government and support entities were interviewed. Some of the findings are expected. Aligning academia, government and industry support encourages start-up activity. Risk capital is essential to launch and develop regenmed ventures. Prior ecosystem history makes a difference; regenmed ecosystems can leverage resources from other start-up sectors.

Despite similarities between the institutions and regions, however, regenmed ecosystems are developing differently in Wisconsin and Edinburgh. What lessons can be learnt to ensure that Scotland and other regenmed centres in the UK capitalise on stem cell research?

When uncertainty is high, entrepreneurs use specific coping strategies to make difficult decisions. It was found that the dominant coping strategies differ between Wisconsin and Edinburgh. The regenmed ecosystem around The University of Edinburgh demonstrates an autonomous approach to commercialisation. Scottish regenmed entrepreneurs prefer to "go it alone" based on their experience with low entrepreneurial culture at the University. In contrast, the regenmed ecosystem around The University of Wisconsin-Madison favours a collaborative approach at the U-I boundary. Under conditions of high uncertainty, knowledge collaboration facilitates resource and capital acquisition. Autonomous entrepreneurs are more likely to miss key market opportunities; isolationist ecosystems are fragile and less likely to adapt to changing conditions.

What should Scottish universities and policymakers do? The bad news is that some aspects of entrepreneurial ecosystems are not easily changed. There is no single policy that optimises ecosystem development around universities. Spinout ventures need capital, but too much capital will be wasted on exploring unpromising ideas or keeping dead companies alive. While regenmed ventures need facilities, this research found little evidence that purpose-built facilities specifically accelerate entrepreneurial activity. Universities should support spinoffs, but sheltering them too

much from market forces prevents the new business from obtaining early market feedback and learning to adapt when the cost of change is relatively low.

The good news is that there are two key leverage points for universities and one for policymakers. First, universities need to help academic entrepreneurs transition to a collaboration and market-focused mind-set. Many universities offer business training skills programmes to nascent entrepreneurs, but this probably is not the critical success factor. After all, academics can partner with or hire experienced business professionals. Experiential training that addresses coping with failure and collaborative knowledge development is likely more valuable.

Second, the tension between protecting IP and encouraging entrepreneurial activity merits careful consideration. This study points towards an "imprinting" effect: the policies and culture at the parent institution disproportionately influence entrepreneurial behaviour after spinout. TTOs that aggressively protect IP and tightly manage spinout activity run the risk of hamstringing start-up ventures by fostering an isolationist venturing culture. Robust ecosystems thrive on the growth of successful ventures as well as the recycling of resources from failed ventures. Universities must acknowledge the role failure plays in individual and ecosystem-level learning. Facilitating ecosystem development requires embracing failure as a common and necessary outcome. It takes a brave university to build failure into policy and metrics.

The challenge is greatest for policymakers. Robust entrepreneurial ecosystems have porous boundaries allowing the exchange of funds, assets and people with other ecosystems. "Protecting" the ecosystem will backfire by slowing entrepreneurs and excluding needed resources. Like universities, policymakers must see ecosystem development through the long-term lens. Losing some entrepreneurs and ventures is the necessary cost of building a healthy ecosystem that attracts talent, money and knowledge. All of Wisconsin's big life science spinouts have been acquired by out-of-area firms (Third Wave, Nimblegen, Lunar, Bone Care, Tomotherapy, etc.), yet the ecosystem thrives on the resulting influx of capital, expertise and entrepreneurial culture. Policymakers must encourage knowledge and resource sharing with other geographical ecosystems. Accepting that some

entrepreneurs and ventures will leave is an investment in the long-term benefits of an attractive, robust business ecosystem.

Studies in this area continue. Recently, data has been collected on the regenmed ecosystem around Skoltech in Moscow, Russia. Findings will be shared late 2015.

6.3.3. Practitioner article 3. Entrepreneurial ecosystems: Fixing the Triple Helix.

In knowledge-intensive fields, new ventures live or die within entrepreneurial ecosystems. Practitioner article 3 shows how policymakers can nurture entrepreneurial ecosystems to fix broken triple helixes at the U-I boundary. University-based venturing activity in the stem cell field was investigated in order to find missing links in healthy entrepreneurial ecosystems.

Technology transfer has become big business. Between 1996 and 2010, technology transfer in the U.S. contributed $388 billion to GDP via thousands of license agreements and more than 4,000 start-ups.[3] Research universities have embraced technology commercialisation as part of the "triple helix model" to drive innovation and regional economic development (Etzkowitz and Leydesdorff, 2000). Policy-makers at all levels have focused attention on practices and resources that accelerate technology transfer and technology venture growth (Audretsch, 2014). These policies, however, often fail to support the development of entrepreneurial ecosystems just beyond the U-I boundary where new technology ventures thrive or die. *Without a robust entrepreneurial ecosystem, the triple helix of government, industry and university, primarily benefits entrenched firms with less motivation to innovate technologies and business models.*

University spinouts are a unique and fragile breed. They often combine world-class science with new and inexperienced founders, testing asset-intensive business models in capital-poor environments. These fledgling firms face an extraordinary array of uncertainties, spanning technical, operational and market

[3] The Association of University Technology Managers. http://www.autm.net/AM/Template.cfm?Section=Tech_Transfer&Template=/CM/ContentDisplay.cfm&ContentID=14734

unknowns. Some, like Wisconsin-based Nimblegen and Tomotherapy, grow rapidly and exit via initial public offering or acquisition. These exits return wealth and knowledge to the ecosystem. However, many spinouts stall, struggling year-to-year just to raise enough capital to stay alive. From a university and public policy perspective, these are triple helix successes generating employment. These firms, however, absorb critical ecosystem resources, preventing valuable capital, knowledge and people from being recycled into better opportunities. *Neither alive nor dead, "zombie" ventures signal a weak or ailing entrepreneurial ecosystem with limited potential to generate fast-growth "gazelles" that drive innovation and high-value job creation.*

Emerging ecosystems in regenerative medicine

To go beyond the triple helix to healthy entrepreneurial ecosystems, it helps to look at an emerging sector rife with uncertainty. The regenmed sector, commercialising stem cell technology, will eventually revolutionise the health care industry (Chien, 2008). Despite research and tool sales exceeding $15 billion[4], commercialising stem cell products requires navigating complex and often conflicting IP and market regulations. To-date there are no FDA / EMA approved stem cell therapeutics. The high level of uncertainty has kept big pharma on the side-line, while universities and new ventures drive the majority of innovation and development (McKernan et al., 2010).

Regenmed entrepreneurial ecosystems (RMEEs) face unique challenges. Stem cell technologies present complex institutional, ethical and legal issues for university TTOs (Hogle, 2014). The academic scientists essential to technology translation must balance potentially conflicting scientific and commercial identities (George and Bock, 2008). Entrepreneurs in nascent ecosystems struggle to identify and emulate institutional norms that will facilitate venture growth (Santos and Eisenhardt, 2009). *In the regenmed sector, ecosystems at the U-I boundary are the leading edge, and entrepreneurs are at the sharp end facing the unknown.*

Nascent entrepreneurial ecosystems, which have formed around three stem cell research institutions, were studied. The University of Edinburgh (UK), where

[4] https://www.alliedmarketresearch.com/regenerative-medicines-market

Dolly the Sheep was cloned, is one of the leading regenmed programmes in Europe. The University of Wisconsin-Madison (United States), where James Thomson first isolated primate and human stem cells, is a global leader in regenmed research and technology transfer. Skoltech is a new research university in Moscow, formed in partnership with MIT. All three universities have active programmes to develop and commercialise stem cell innovations.

Policymakers must go beyond triple helix connections to build robust entrepreneurial ecosystems in knowledge-intensive fields like regenmed. Doing so requires rewriting the standard playbook for techology venturing at the U-I boundary. Research-driven entrepreneurs need to develop specific coping strategies and knowledge collaboration practices to address uncertain markets. *Ultimately, fostering entrepreneurial ecosystems requires policies, processes and metrics that recognise the key role of both the individual and venturing.*

The triple helix model requires three "patches" to function properly under conditions of high uncertainty and knowledge-intensive innovation. The "placebo," most commonly used in entrepreneurial ecosystems, is noted too.

Patch #1: Inspire independence

Uncertainty is ubiquitous in RMEEs. It affects everyone, but everyone responds differently. Entrepreneurs, financiers, institutional leaders and government policymakers cope with uncertainty by making decisions without complete information. RMEE participants rely on two coping strategies. A problem-based coping response attempts to resolve the underlying cause of uncertainty via information-seeking, lean experiments, or risk-sharing partnerships. An emotion-based coping response assumes the uncertainty cannot be resolved. Participants focus on leveraging available resources and mitigating the perceived downside of missing information (Johnson and Bock, 2016).

Entrepreneurial culture at the central institution appears to play a critical role in the dominant coping strategy used in the ecosystem. When the university encourages independence and entrepreneurial thinking, the ecosystem utilises problem-based coping. When the university attempts to protect resources, the ecosystem tends towards emotion-based coping.

From a psychological perspective, different coping strategies bring value to different situations. However, in RMEEs, like many high-technology sectors, knowledge is disproportionately valuable and rapidly changing. Emotion-based coping may help ventures through short-term crises, but hold little promise for adaptation in industries with accelerating rates of technological change (Derfus et al., 2008).

The policies designed to protect technology and new ventures, are, in effect, hindering the development of the entrepreneurial ecosystem. Overly restrictive IP licensing terms and programmes that shield new ventures from market forces limit opportunity-seeking behaviour and entrepreneurial learning. These policies might maximise the university's licensing revenue on any one deal, or stave off near-term failure for any one deal. However, over time, these policies slow rates of learning, innovation and growth in the ecosystem.

Tomotherapy provides an excellent example from another knowledge-intensive field. GE sponsored and then abandoned innovative radiotherapy research at The University of Wisconsin-Madison. Founder and CEO Paul Reckwerdt took the venture out of the university and tackled every unknown as a problem to be solved. Without the protection of the University or GE, Reckwerdt and his team were forced to become industry and market savvy. The uncertainties of funding, product launch, market entry and scale-up could be mitigated with prioritisation. He explains the process with an engineer's methodical analysis: *"Business is not rocket science…. There's a thousand things happening here, and you have to balance them off each other and do triage and balance their impact… you have to make the shortest path to the minimum viable product, so you can get it out there to bring money in so you can pay for future research."* As just one example, the company's revolutionary Hi-Art helical radiotherapy device received FDA clearance in less than 6 months. Tomotherapy went public in 2007 at an $800 million valuation. Since then, the founders and executives have started, run and funded more than half a dozen other technology ventures.

Patch #2: Promote knowledge collaboration

Coping strategy is only half the story. In knowledge-intensive sectors, knowledge collaboration is essential because early stage ventures are unlikely to possess sufficient interval knowledge (Zahra and George, 2002). In RMEEs, knowledge collaboration may appear high-risk, because IP is valuable, tightly controlled, but hard to enforce across geographic boundaries. Since regenmed market information is incomplete, new ventures are appropriately wary of sharing information about proprietary technologies and novel business models.

In this case, self-reliance is the problem. Entrepreneurs and ventures that apply the "independence" mantra to knowledge development are more likely to miss emerging market opportunities. They are also at risk of ignoring early market feedback about product capabilities and minimum customer value requirements.

Collaborative knowledge development is difficult. Entrepreneurs in knowledge-intensive sectors walk a fine line between protecting critical IP and partner-based knowledge creation. Cellular Dynamics, James Thompson's stem cell spinout venture, found the right balance. The company set up collaborative development projects with carefully selected biotechnology and pharmaceutical partners. At the same time, it offered research "grants" to academic scientists working on iPSCs technologies closely related to its own products. Finally, it created parallel "blue sky" funding for internal projects. Multiple paths ensured that the company stayed at the leading edge of knowledge creation and collaboration in this incredibly uncertain field. The company was first to market with more than a half-dozen iPSC types and was the Wall Street Journal’s most innovative company in the world in 2011. Cellular Dynamics was acquired by FujiFilm in 2015 for $307 million.

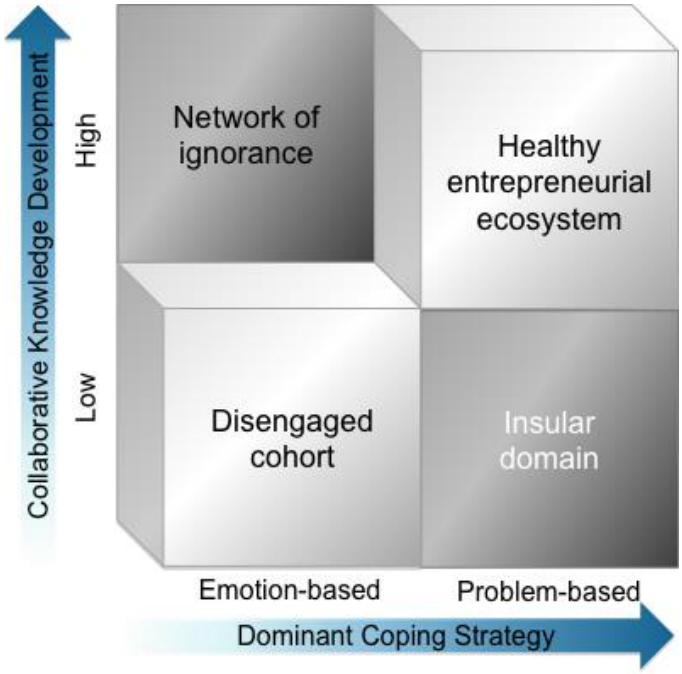
It is also useful to note the role of ecosystem recycling: the funders and executive team at Cellular Dynamics had previously led two other university spinouts: Third Wave Technologies and Nimblegen. Third Wave, the first true equity spinout from The University of Wisconsin-Madison, went public in 2001 and was ultimately acquired by Hologic for $580 million. Nimblegen was acquired by Roche in 2007 for $272 million. Healthy entrepreneurial ecosystems recycle successful entrepreneurs and exit-event wealth into new ventures.

Figure 6.1. shows the ecosystem types based on the dominant coping strategy and level of collaborative knowledge development. Healthy ecosystems arise when ventures utilise problem-based coping and collaborative knowledge development. This is encouraging because this research found that these two characteristics are correlated — the presence of one tends to encourage the other. On the other hand, emotion-based coping and low collaborative knowledge development are also correlated, generating clusters of disengaged firms focused internally on available resources (Bock and Johnson, 2016).

The mixed outcomes are less likely but important to recognise. Insular domains result when entrepreneurs and ventures are problem-solvers but poor collaborators. Of most concern, however, are networks of ignorance that result from collaboration among ventures utilising emotion-based coping. Here, homophily effects lead ventures with flawed technologies and commercialisation models to seek out firms living with the same misconceptions. Since these firms prefer to deny the effects of uncertainty, they generate networks that serve as echo chambers, failing to adapt to changing technology regimes and market conditions. A significant number of zombie ventures suggest a network of ignorance.

To avoid networks of ignorance, policymakers can create open-access forums where scientists, entrepreneurs and industry leaders can test assumptions about technologies and markets. Encouraging participation by a wide variety of knowledge leaders brings more knowledge, including marginal ideas to the discussion. When market data is scarce or non-existent, as is the case with nascent fields like regenmed, the best option is to generate collaborative knowledge bases to explore possibilities, rather than rely on internally-generated assumptions.

Figure 6.1. Entrepreneurial ecosystem types



(Source: Author)

The Placebo: "Entrepreneurial" training for scientists

As research universities attempt to meet policy expectations for entrepreneurial activity, many have begun providing "entrepreneurial" training to scientists. This is, at best, a placebo; there is no compelling evidence that entrepreneurial training improves venturing outcomes. At worst, it inflates expectations and increases the potential for cohorts of zombie ventures. General business skills training and entrepreneurial awareness are valuable to nearly any type of student, including career scientists. Supply-driven entrepreneurial activity, however, tends to generate products looking for markets and higher rates of failure.

Patch #3: Embrace (some) failure

Successful ventures are a measure of an ecosystem's *potential*. It is the failures, however, that indicate the ecosystem's overall *health and resilience*. Unfortunately, universities usually seek to shield academic entrepreneurs and new ventures from market forces, in an attempt to safeguard their survival. The intention is good: nurturing fragile ventures seems obvious. Low failure rates appear to demonstrate effective use of public funds and encourage more venturing activity.

But failure is an unavoidable element of entrepreneurial ecosystems, providing value at the individual and community level (Cardon et al., 2011). Healthy ecosystems and smart entrepreneurs do not ignore failure, they learn from it (Miner et al., 1999). Rapid failure and recycling of organisational resources provides critical, sometimes low-cost, resources to emerging and rapidly growing ventures. Artificially supporting ventures traps key people and drains the ecosystem of risk capital. Zombie companies may pad university spinout statistics and provide lifestyle income to scientist-founders, but they are entrepreneurial ecosystem parasites. High failure rates are a necessary outcome of the experimentation process required when entrepreneurs utilise problem-based coping strategies.

Universities and government policymakers must accept some failure to foster healthy entrepreneurial ecosystems. Industry expects new ventures to de-risk technologies and go-to-market strategies. If governments and universities attempt to mitigate or stigmatise failure, the triple helix cannot function properly. Universities should be less concerned with protecting new ventures from inevitable market forces. TTOs should loosen their selectivity of technologies for possible spinoff. Failed ventures are a necessary by-product of robust ecosystems and active technology commercialisation programmes. Reporting and even celebrating failure, however, may be difficult for universities and government policymakers to accept.

Coping strategies, knowledge collaboration and failure play key roles in healthy entrepreneurial ecosystems. Policymakers should go beyond the placebo effect of general business training to patch up triple helixes, especially in knowledge-intensive technology fields like regenmed.

6.3.4. Societal and educational impact

This PhD research has extended understanding on regenmed venturing and ecosystems. In particular, the research findings have important implications for entrepreneurial planning and university/governmental policy-making. Ultimately, this helps progress regenmed innovations from the lab to market. This is a particularly important step. Regenmed tools and diagnostics have important roles to play in drug development. Regenmed therapeutics can meet clinical demands.

Therefore, regenmed translational activities are critical in supporting societal healthcare and meeting the needs of the most vulnerable patients.

Additionally, findings from this PhD research offer important implications to business education. This investigation has highlighted the importance of entrepreneurial coping strategies during venturing, and in the emergence and development of entrepreneurial ecosystems. It has also suggested the necessary requirements for sustaining entrepreneurial ecosystems in technology-intensive sectors. In doing so, this PhD research can assist practitioners and university scientists/students actively engaged in venturing in high-technology sectors.

6.4. Research limitations

Each of the three essays discussed in this thesis presents certain limitations. Some limitations were mitigated as the PhD investigation progressed from essay 1 to 3. For example, essay 1 was limited primarily to regenmed venturing informants in Scotland. Essay 2 and 3 overcame this limitation via investigation of ecosystems in Madison and Moscow. Across the three essays, however, there are several common limitations. These are now discussed.

First, the dataset over represents regenmed support entities. Therefore, further data collection should focus on pre-venture academic entrepreneurs and *de novo* regenmed firms. Additionally, whilst the entrepreneur is central to entrepreneurial ecosystem emergence and regional competency (Eliasson and Eliasson, 1996; Stam, 2015), other actors are important too. In particular, Eliasson and Eliasson (1996; 2006), and Johansson (2010) emphasise the importance of VCs. As evident from the empirical findings of this investigation, and in support of Eliasson and Eliasson (1996) and Johansson (2010), competent VCs that recognise and provide the financial capital to nascent ventures are essential. Whilst this investigation included data collection from some VCs and Angel networks, future research should incorporate greater data collection from the VC community. In turn, this has strong potential to provide a more nuanced understanding of entrepreneurial ecosystem emergence and regional competency.

Second, the data is not longitudinal or time-synchronised. As such, the research cannot address potential differential rates of ecosystem development

between ecosystems. Therefore, future research that collects data at multiple points over time is well positioned to provide a deeper explanation of how perceptions of uncertainty change over time, and how this affects sensemaking, coping, technology transfer activities and ecosystem development paths.

Third, the dataset does not contain performance measures of ventures. It is, therefore, not possible to link particular sensemaking types to the success (or failure) of ventures and ecosystems. This is a particularly fruitful area for further investigation. This empirical PhD investigation has argued for greater emphasis to be placed on the micro-level factors of entrepreneurial ecosystem development and regional competency. For example, highlighting which coping strategies are linked to venture/ecosystem success (or failure) will be especially valuable to the scholarly and practitioner community.

Performance metrics of successful entrepreneurial ecosystems have been well reported (Graham, 2014; Stangler and Bell-Masterson, 2015). However, a limitation of the wider entrepreneurial ecosystem literature is that failed ventures generally do not feature as a performance measure. This is, to some extent, unfortunate. As suggested in this thesis, much remains to be learned from failed ventures, entrepreneurial cognitive processes to failure and the importance of failed ventures to ecosystem economics. Further research that studies failed ventures and the associated cognitive processes is particularly warranted.

Finally, the PhD investigation relies solely on qualitative data. Whilst this is particularly suited to theory generation, quantitative measures such as a large-scale survey, has the potential to provide greater generalizable findings of entrepreneurial behaviour and ecosystem development.

The research limitations discussed provide a strong foundation for future research directions.

6.5. Future research directions

This PhD investigation opens pathways for future research on entrepreneurial ecosystems and entrepreneurial behaviour amidst uncertainty. Each of the three essays has suggested specific future research directions. These are summarised in Table 6.6.

Table 6.6. Summary of future research directions

Essay	Future research directions
1	- Additional research to distinguish which coping strategies are linked to success or failure. This will require performance data on regenmed ventures. - Further research required on the existence and role of selective revealing in regenmed venturing, particularly the drivers and outcomes of this alternative form of collaboration mechanism. - Extend exploration on the effects of prolonged periods of PEU to environmental imprinting and the survival of young regenmed ventures. This again requires performance data on regenmed ventures and a longitudinal study. - Quantitative study to test the sensemaking model.
2	- Large-scale, quantitative research that tests for the cognitive and behavioural characteristics in entrepreneurial ecosystems, as well as ecosystem development processes, is required. - Additional research should include performance measurement of regenmed ventures. This can help distinguish whether specific translational or behavioural ecosystem profiles are correlated with the probability of success of entrepreneurs, TTOs, or ecosystems. - Longitudinal study needed to comment on the rate of ecosystem development.
3	- Theories of entrepreneurial ecosystem emergence and the importance of context should be tested via additional quantitative studies. - A longitudinal study would provide insight into how ventures progress through each of the phases identified in the emergence of entrepreneurial ecosystems. - Additional research should include performance measurements of regenmed ventures, so that it is possible to fully understand the link between culture, coping and firm/ecosystem performance. - A large-scale survey, exploring entrepreneurial traits and/or international exchanges/partnerships at the U-I boundary, is required. This has the potential to further reveal the importance of context in the emergence of entrepreneurial ecosystems at the U-I boundary.

(Source: Author)

In addition to these summarised future research directions, collectively, the three essays highlight three general potential areas for future research. These are now discussed.

6.5.1. Entrepreneurial ecosystems

This PhD research has extended knowledge on the emergence and development of entrepreneurial ecosystems at the U-I boundary. In particular, it has progressed our understanding of the role of the entrepreneur in entrepreneurial ecosystems, which was missing from current theory. While the entrepreneur is a critical aspect of entrepreneurial ecosystems, other resources and intermediaries are important too. Despite research examining the resources and intermediaries required for the efficient functioning of entrepreneurial ecosystems, these factors have often been considered in isolation (Spigel, 2015). Therefore, further research that explores how the ecosystem resources and intermediaries interact is particularly timely.

6.5.2. Academic entrepreneurship

Academic entrepreneurs engaging in commercialisation activities at the U-I boundary is an important aspect of entrepreneurial ecosystem emergence and development. Previous research has explored how academics manage their teaching and research roles in combination with commercialisation activities (Jain et al., 2009). Scholars have also investigated entrepreneurial intentions to engage in commercialisation activities (Huyghe and Knockaert, 2015). This PhD research has explored decision-making and cognition at the U-I boundary during regenmed venturing. However, further research is required to provide a more nuanced understanding of academic entrepreneurs engaging in commercialisation activities.

University academics across all disciplines are becoming increasingly engaged in commercialisation activities. This may include involvement in spinout ventures, or engagement in licensing and consultancy services. Yet, these activities do not constitute a major element of the academics' job description. As such, engagement in commercialisation activities could be viewed as a form of creative deviance behaviour (Criscuolo et al., 2014; Mainemelis, 2010). Therefore, research that explores academic creative deviance, particularly why academics engage in commercialisation activities, has the potential to reveal important insights into the idiosyncratic nature of academic entrepreneurship.

Additionally, this PhD research has revealed the importance of university-industry exchanges at the U-I boundary. In knowledge- and technology-intensive

sectors, these exchanges are critical. Therefore, research that explores these exchanges/collaborations in further detail can aid our understanding of the functioning and governance of U-I alliances. This has the potential to extend previous work by D'Este and Perkmann (2011) and Perkmann et al. (2013).

6.5.3. Business model innovation

Regenmed business models are an important consideration, since they directly influence the development of entrepreneurial ecosystems. However, unlike technology, product or process innovation, business model innovation (BMI) is relatively understudied (Bock and George, 2014; Bock et al., 2012).

The literature on business models is large in scope, with definitions of the construct being inconsistent (George and Bock, 2011; 2012). A business model is the design of an organisation to exploit a commercial opportunity (George and Bock, 2011) and has been interpreted through many lenses. Some scholars have interpreted business models as the narratives that entrepreneurs use in order to acquire resources and build legitimacy (Lounsbury and Glynn, 2001; Martens et al., 2007). Within highly uncertain environments, new ventures may rely on a "trial-and-error learning" approach to business model formation and innovation (Costa and Levie, 2012; Loch et al., 2008; Sosna et al., 2010). During uncertainty, business model formation and innovation will be challenging, as new ventures are unable to predict which resources to assemble and the outcome of such assembly is unknown.

Successful BMI requires the novel configuration of resources in order to construct new markets or serve existing markets in a different way (Zott and Amit, 2007). Central to BMI is the identification and exploitation of opportunities (George and Bock, 2011), with such innovation being viewed as a form of disruptive innovation. During the exploitation of developing markets, firms often utilise disruptive technologies (Christensen, 2008). When firms combine both disruptive technologies and BMI, industries can be reconfigured (Hwang and Christensen, 2008).

The dominant business models in the life sciences industry, such as the "blockbuster drug" model, as well as business-to-business models in which firms provide tools or services to other businesses rather than consumers, will be relevant

for some regenmed ventures. There is reason to believe, however, that the business models of regenmed ventures will differ from life science business models, especially while the industry evolves (Heirmann and Clarysse, 2004).

Therefore, further research is required to investigate regenmed business models and BMI in further detail. In particular, a greater understanding of the drivers of regenmed business models is warranted. Within dynamic and uncertain environments, it is unclear whether collaboration results in BMI or if it presents associated costs (Bock et al., 2012). An investigation into how these innovative business models influence the development of entrepreneurial ecosystems is particularly timely. Likewise, a study that explores the development of a typology of regenmed business models will be especially valuable. While any typology has limitations, in evolving industries, the key characteristics of the technology and market may provide useful direction on emerging dominant designs and sources of competitive advantage (Meyer et al., 1993).

6.6. Final words

Entrepreneurial ecosystems at the U-I boundary are an important driver of economic activity. This PhD thesis has highlighted how entrepreneurial ecosystems at the U-I boundary in the regenmed sector emerge and develop amidst uncertainty. This includes the implementation of coping mechanisms, the development of (international) knowledge collaboration, an entrepreneurial culture at the research university, and human embodied-competence and traits. Research findings from this PhD investigation have important theoretical contributions and practical implications, and provide a stimulating research agenda for future studies.

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Appendices

List of Appendices:

- Appendix A: Study informant e-mails
- Appendix B: Study informed consent form
- Appendix C: Research ethics statement

Appendix A: Study informant e-mails

Edinburgh study informant e-mail

Dear "Insert Name"

My name is David Johnson. I am a PhD Candidate at The University of Edinburgh Business School and along with my PhD supervisor, we are currently studying the life science venturing ecosystem in Edinburgh and Scotland.

I attended the BioQuarter Regenerative Medicine Conference on 25th September and I took your details from the list of attendees. **I am e-mailing to ask you to participate in our research on entrepreneurial activity in the regenerative medicine space. We would like to include information about you and your organisation.**

My supervisor, Dr Adam J. Bock, is faculty at the University of Edinburgh Business School, but also a **former medical device entrepreneur and financier**. He has published two books about science-based entrepreneurship, including a detailed profile of Cellular Dynamics. Adam's profile can be viewed here:
www.business-school.ed.ac.uk/about/people?a=15015&staff_id=736
My profile can be viewed here:
http://www.business-school.ed.ac.uk/phd/current-phd-students/current-student/121/David/Johnson

Participation in our research is generally limited to one or two in-person interviews, and all information is kept strictly confidential. We hope to develop a more thorough understanding of regenerative medicine venturing. The results of the research will be valuable to scholars, entrepreneurs and policymakers seeking to support a vibrant life science business community.

Please **REPLY** to this e-mail if you would consider participating.

Madison study informant e-mail

Dear "Insert Name"

Apologies for the e-mail out of the blue. My name is David Johnson and I'm a PhD Candidate at The University of Edinburgh Business School, Edinburgh, Scotland, United Kingdom.

Over the past few years, my supervisor (Adam Bock) and I have been investigating entrepreneurial activity in regenerative medicine. In particular, we have studied regenerative medicine venturing and entrepreneurial ecosystem development at The University of Edinburgh. **I am e-mailing to ask you to participate in our research on entrepreneurial activity in the regenerative medicine space. We would like to include information about you and your organization.** The interview only takes an hour or so and all information is strictly confidential.

I will be taking up a **Visiting Fellowship at UW-Madison School of Business** between March and June 2014. Adam is currently a **Visiting Fellow at UW-Madison** and full-time faculty at The University of Edinburgh. He is a Madison native (MBA at UW-Madison) and was an active entrepreneur and financier before moving to academia. Adam was a co-founder of Stratatech and Nerites, and he managed a couple of the early angel networks in the State. Details about Adam and myself can be found at our Business School profiles:

Adam: www.business-school.ed.ac.uk/about/people?a=15015&staff_id=736

David:http://www.business-school.ed.ac.uk/phd/current-phd-students/current-student/121/David/Johnson

Please **REPLY** to this e-mail if you would consider participating. I'd be happy to chat to tell you more about our research.

Moscow study informant e-mail

Dear "Insert Name"

My name is David Johnson and I am a Doctoral Researcher at the University of Edinburgh Business School, Scotland, United Kingdom. I work under the supervision of Dr Adam Bock , Professor of Entrepreneurship at University of Edinburgh Business School and Adjunct Professor of Entrepreneurship at Skolkovo Institute of Science and Technology.

I am e-mailing you to ask you to participate in our research on entrepreneurial activity in the regenerative medicine space.

Over the past few years, Dr Bock and I have been investigating entrepreneurial activity in regenerative medicine. In particular, we have studied regenerative medicine venturing and entrepreneurial ecosystem development at The University of Wisconsin-Madison and The University of Edinburgh. We have successfully been awarded a grant to expand our research to Moscow (Skoltech), which was supported by Professor Ilia Dubinsky at the Skoltech Center for Entrepreneurship. We hope to develop a more thorough understanding of the regenerative medicine venturing ecosystem in Moscow.

I would like to interview you about your experience in regenerative medicine. Interviews generally last 1 hour and do not require you to do any preparation beforehand. All information is kept strictly confidential. With apologies, I will only be able to conduct the interview in English.

I will be visiting Russia between May 17th and June 4th 2015 **and it would be great if we could meet for an interview**.

I would be grateful if you would reply to this e-mail to confirm if you will participate. If you have suggestions for other individuals in the Russian regenerative

medicine ecosystem space that I should include in my research, this would be very much appreciated.

Please do not hesitate to contact me for further details.

I look forward to hearing from you soon.

Appendix B: Study informed consent form

Edinburgh and Madison informed consent form

Participant's Consent for Interview

I AGREE WITH THE FOLLOWING STATEMENTS:

- I am willing to participate in the study on entrepreneurial activity and life science venturing within regenerative medicine.
- The study has been explained to me and I have had the opportunity to discuss this study and ask any further questions.
- The information obtained will be used by Dr Adam Bock (University of Edinburgh Business School) and Mr David Johnson (University of Edinburgh Business School) for the purposes of the study explained to me.
- The information collected will be kept strictly confidential unless otherwise explained to me.
- I understand that this interview will be recorded.
- I understand that I have the right to withdraw from the study at any point.
- I am not being financially rewarded for taking part in this study.

I, _____ agree with the above statements and consent voluntarily to be interviewed.

Signature _____ Date _____

I have explained the study to the potential participant and confirm that the participant was given an opportunity to ask questions and all questions asked have been answered correctly and to the best of my ability. I confirm that consent has been given freely and voluntarily.

Researcher Name _____

Signature _____ Date _____

Moscow informed consent form (in English and Russian)

CROSS-NATIONAL INVESTIGATION OF ENTREPRENEURSHIP IN REGENERATIVE MEDICINE

Investigators:

Dr Adam J. Bock (Senior Lecturer of Entrepreneurship)
Tel: +44 (0)131 6508246
E-mail: adam.j.bock@ed.ac.uk

David Johnson (Doctoral Researcher)
Tel: +44 (0)131 6513224
E-mail: d.johnson-4@sms.ed.ac.uk

Thank you for participating in this research. This interview should be conducted in English. The interview will be recorded. You may withdraw from the study at any time. You will not be financially rewarded for participating in this research. All information will be kept strictly confidential. Research results will be published in peer-reviewed academic journals and policy white papers. You will not be identified by name in any publications without your prior permission. By participating in this research, you will help ensure that university and government policymakers understand the challenges associated with translating regenerative medicine into viable products.

Participant:

I consent voluntarily to be interviewed.

Participant name (Print) _____

Participant signature _____

Date _____

МЕЖНАЦИОНАЛЬНОЕ ИССЛЕДОВАНИЕ ПРЕДПРИНИМАТЕЛЬСТВА В ОБЛАСТИ РЕГЕНЕРАТИВНОЙ МЕДИЦИНЫ

Исследователи:

Доктор Адам Джей Бок (старший преподаватель по предпринимательству)
Тел: +44 (0)131 6508246
Адрес электронной почты: adam.j.bock@ed.ac.uk
Дэвид Джонсон (аспирант)
Тел: +44 (0)131 6513224
Адрес электронной почты: d.johnson-4@sms.ed.ac.uk

Спасибо за участие в этом исследовании. Интервью будет проведено на английском языке. Интервью будет записано. Вы можете отказаться от участия в исследовании в любой момент. Финансовое вознаграждение за участие в данном научном исследовании не предусмотрено. Вся информация будет хранится в строгой конфиденциальности. Результаты исследования будут опубликованы в рецензируемых научных журналах и официальных изданиях. Ваше имя не будет фигурировать в публикациях без вашего предварительного согласия. Ваше участие в исследовании поможет повысить осведомленность людей, определяющих политику на уровне государства и на уровне университетов, о трудностях, связанных с преобразованием регенеративной медицины в жизнеспособный продукт.

Участник:

Я даю свое добровольное согласие на проведение интервью со мной

Имя участника (печатными буквами) _____

Подпись участника _____

Дата _____

Appendix C: Research ethics form

University of Edinburgh Business School
Level 1 and 2 Research Ethics Applications

Name of Student: **David Johnson**

Title of Proposal: **Entrepreneurial behaviour and the development of entrepreneurial ecosystems under uncertainty: Essays on regenerative medicine venturing at the university-industry boundary**

Please provide a brief outline of the research aims and the proposed methodology, highlighting any anticipated ethical issues (on separate sheet if necessary):

This thesis seeks to understand the relationships between uncertainty and entrepreneurial cognition, decision-making and venturing. In particular, it investigates entrepreneurial responses to venturing uncertainties at the university-industry boundary and how this influences the development of entrepreneurial ecosystems.

The proposed PhD research consists of three independent studies, which leads to a three-essay PhD structure. Collectively, the three studies will support a richer understanding of the effects of uncertainty on entrepreneurial behaviour and ecosystem development. A brief description of each study is provided below.

Overview of the independent studies

Essay	Study Objectives	Study Questions	Methods
1	Provide deeper insights into entrepreneurial cognition and decision-making under irreducible uncertainty.	- How do ecosystem participants make sense of highly uncertain venturing contexts? - What are the unique features of collaborative knowledge development in regenmed venturing?	Mixed-methods. Long form interviews and pilot online survey.
2	Provide a rich understanding of the dynamics of entrepreneurial ecosystem development at the U-I boundary.	- How does micro-level cognition and behaviour differ across ecosystems? - Why do apparently similar entrepreneurial ecosystems develop differently?	Qualitative. Long form interviews (and pilot online survey).
3	Provide a deeper understanding of the emergence and development of entrepreneurial ecosystems at the U-I boundary, with a focus on nascent entrepreneurial ecosystems operating within unique sociocultural contexts	- What is the role of the university and the technology transfer process in assisting with the emergence and development of entrepreneurial ecosystems at the university-industry boundary? - How does context influence entrepreneurial ecosystem development?	Qualitative. Long form interviews (and pilot online survey).

I have read the *Business School Research Ethics Policy* and agree to abide by it.
Yes

In the case of human subjects in research: (delete as necessary)

Participants will be told about the objectives of the study. **Yes**

Any hazards will be explained to them. **Yes**

Participants will be informed they are participating of their own free will and consent. **Yes**

They will be informed that they are free to withdraw at any point should they wish to. **Yes**

Information will be held in confidence and any information used will be used anonymously unless consent has been given otherwise. **Yes**

I confirm that this study does NOT involve children (under 18), institutionalised people; or other individuals who are vulnerable or unable to give consent. **Yes**

I have considered the risks of physical or psychological harm to research participants (including the researchers) and how to address these **Yes**