An exploratory study of micro level challenges and antecedents of university – industry engagement in open innovation networks.

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Abstract

The academic entrepreneur (AE) has been challenged with extending their skillset and knowledge as they engage in activities to commercialise their research. Coupled with this, universities are facing more pressures and expectations to contribute to economic and societal development known as their third mission along with teaching and research. This research sets out to explore how the AE develops their market knowledge and related skills and capabilities in order to contribute to the third mission mandate of the university. In particular, the aim of this research is to explore the micro level antecedents and challenges influencing university-industry open innovation collaboration. This thesis utilises absorptive capacity (ACAP) and desorptive capacity (DCAP) as lenses to examine this phenomenon. It undertakes a micro level perspective with the AE as the unit of analysis. The study is set in the Republic of Ireland and adopts an exploratory research position.

The methodology uses an inductive theory building approach given that the research sets out to discover and infer new insights and understanding in an underexplored research area. Pre-existing theory has also been used as *a priori* themes to develop an initial conceptual model in order to further contribute to the building of new theory. Data was collected using documentary review and forty semi structured interviews using a heterogeneous sampling selection of participants including AEs, Technology Transfer Managers (TTMs), funding agency specialists and industry partners.

The findings highlight the multidisciplinary approach needed to be adopted by AEs in order for them to successfully engage in academic entrepreneurship. Furthermore, the findings have identified the key capabilities and skillsets needed by the AE to exploit their research. Overall the findings illustrate the iterative, bidirectional and recursive nature of the processes, knowledge flows and behaviours used by AEs in order to succeed in their entrepreneurial role. This thesis makes a number of contributions to the literature. It advances theory on academic entrepreneurship at the micro level by exploring how AEs identify market opportunities and then refine their knowledge and processes in order to exploit their research. Furthermore, the research extends the ACAP construct by differentiating scientific and market knowledge and highlights the importance of market ACAP for AEs. This is important as literature to date has over relied on technological knowledge as a measurement in how ACAP is examined. In addition, the research contributes to the knowledge management capacities literature by

demonstrating the reciprocal nature between ACAP and DCAP for AEs engaged in academic entrepreneurship. Furthermore, this research provides practical recommendations which may form basis for policy reform and change on a number of areas within the university industry collaboration (UIC) ecosystem.

Abbreviations

ACAP – Absorptive Capacity.

AE – Academic Entrepreneur.

BDM – Business Development Manager.

CAQDAS – Computer Assisted Qualitative Data Analysis Software.

CEO- Chief Executive Officer.

CTO – Chief Technology Officer.

DCAP – Desorptive Capacity.

DTIF – Disruptive Technology Investment Fund.

EA – Entrepreneurial Alertness.

EC- European Commission.

H2020 – Horizon 2020.

IDF – Invention Disclosure Form.

IP – Intellectual Property.

IUA – Irish Universities Association.

KPI – Key Performance Indicator.

MNC – Multinational Corporation.

NDA- Non-Disclosure Agreement.

NIH – Not Invented Here.

NSH – Not Sold Here.

OCPKE – Office of Corporate Partnership and Knowledge Exchange.

OI - Open Innovation.

OVPR- Office of the Vice President for Research.

PACAP – Potential Absorptive Capacity.

PI- Principle Investigator.

POC – Proof Of Concept.

R&D – Research and Development.

RACAP – Realised Absorptive Capacity.

RQ – Research Question.

SLR – Systematic Literature Review.

SME – Small to Medium Enterprise.

STEM – Science Technology Engineering Math.

TA – Thematic Analysis.

TRL - Technology Readiness Level.

TT – Technology Transfer.

TTM – Technology Transfer manager.

TTO – Technology Transfer Office.

TTSI – Technology Transfer Strengthening Initiatives.

U-I – University – Industry.

UIC – University Industry Collaboration.

USO- University Spin out.

VC – Venture Capitalist.

Note on Access to Contents

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Chapter One.
Introduction.

1.0 Introduction

The outline of this chapter is to first provide background and rationale for the research study. Second, the aims and objectives and research questions of the study are presented, consistent with the rationale. Third, an overview of the research method selected to address the aims and objectives is given in this research. Fourth, a summary of research gaps are shown to which the study will seek to make a contribution. Finally, the structure of this thesis is presented. All of the above points will then be further developed throughout the thesis chapters.

The collaboration of universities, industry and government partners is increasingly perceived as a vehicle to drive innovation and economic development in the 21st century knowledge economy (Ankrah and Tabbaa, 2015). The increase in collaborations is due to rapid technological change, shorter product life cycles and intense global competition for industry (Fischer et al. 2018). For universities, rising costs and reduced government funding as well as the expectation that universities now make an impact with their research from an economic as well as societal viewpoint, have put pressures on universities to collaborate with industry (Etzkowitz, 2017). To date, the literature on University – Industry Collaboration (UIC) has taken a mainly macro view perspective (Rajalo and Vadi, 2017). Limited research has taken a micro level perspective and analysed how individuals develop the skills and knowledge to engage successfully in UICs at micro levels of analysis (Jones and Coates, 2020; Woolley, 2017; Rahim et al. 2015).

In responding to these challenges, the purpose of this research is to explore the micro level antecedents and challenges influencing university-industry open innovation collaboration. In particular, this research aims to explore the role of the academic entrepreneur (AE) and how they develop the skills and knowledge to translate their highly scientific, idiosyncratic and tacit knowledge into a more end user and market orientated focus. AEs have educational achievements at the highest level and through their training and development they have accumulated an abundance of scientific knowledge and expertise in their respective fields (Rahim et al. 2015). However, prior research has identified that these individuals often lack the skills to sufficiently acquire and assimilate market knowledge in developing relevant customer or end user orientated innovative products (Jones and Coates, 2020; Woolley, 2017; Rahim et al. 2015). Therefore, this research sets out to explore how AEs develop the knowledge and the underlying skills and competencies needed to commercialise their research at a micro level of analysis.

This research will adopt a dual lens focus of absorptive capacity (ACAP) and desorptive capacity (DCAP). ACAP will be used as the lens to understand how the AE learns and accumulates knowledge during the commercialisation process. This lens will analyse how the AEs internalise external knowledge through working with a range of stakeholders. The AEs reduce the technical uncertainties of the innovation project initially, enhancing their scientific knowledge through end user feedback and testing, and then assess the market feasibility, market potential and ability to meet end user needs, thus developing their market knowledge as a series of processes they engage with as they commercialise their innovation (Baglieri and Lorenzoni, 2014). Once the AE has accumulated sufficient market ACAP it is at this point, the AE can exploit their innovation using the DCAP construct. DCAP will be the lens used to analyse how the AE exploits this accumulated market knowledge by identifying potential market opportunities and then how the AE refines their processes to transfer that knowledge and realise value beyond the boundaries of the university (Behnam et al. 2018; Lichenthaler and Lichenthaler, 2009). In the literature DCAP has received little academic attention (Bravo et al. 2018; Meinlschmidt et al. 2016) despite its importance as a mechanism for identifying what knowledge resources have economic value and the ability to transfer the knowledge to realise value (Lichenthaler and Lichenthaler, 2009).

The context of the study is within university – industry collaboration (UIC) set within the Republic of Ireland (ROI). Within the state, total expenditure on R&D in the higher education sector reached €876.1 million for 2019. Over €48 million has been invested by private organisations for UIC projects thereby already reaching the innovation 2020 target (Department of Further and Higher Education, Research, Innovation and Science, 2021). In 2018, the government launched the Disruptive Investment Technology Fund (DTIF) this fund valued at €500 million is aimed at developing ground breaking technologies and solutions for industry. Under the agreement for funding, a minimum of three partners are required, two of which must be from industry and a research institution. This fund has funded over 72 projects to date and highlights the importance the ROI government is placing on UICs. (Department of Further and Higher Education, Research, Innovation and Science, 2021).

1.1 Background to the research

The importance of knowledge exchange among universities and industry has long been widely recognised as a significant phenomenon (Mascarenhas et al. 2018), where cooperation between universities and industries can facilitate knowledge transfer and stimulate the production of new knowledge and technology (Leydesdorff and Meyer, 2006). Over recent years there has been a considerable change in the approach of universities towards commercialisation activity (Jamil et al. 2015). UIC outputs are considered to be a relevant economic driver as universities harness specialised knowledge that is expected to contribute to the economic development of countries or regions (Rajalo and Vadi, 2017). Within this development decisions made at national or international government level and funding agencies have emphasised translational research as a core strategy in promoting economic development (OECD, 2019). Translational research refers to the ability to turn basic scientific research into practical applications (Bazan, 2019). The drivers which have caused the university to become more entrepreneurial include legislation protecting the university in its commercialisation endeavours, lack of funding opportunities, changing business models, support structures to incentivise commercialisation and the growing requirement to meet industrial needs. These factors are discussed in more detail below.

Firstly, many researchers attribute the growth in university technology transfer to the Bayh–Dole Act of 1980 in the United States and its legislative equivalents in other countries (Bradley et al. 2013). These legislative efforts formalised the primary legal and policy framework for universities to transfer their technology to industry that have the capabilities needed for commercialisation (Grimaldi et al. 2011). These efforts also sought to create incentives for universities to become engaged in the commercialisation of academic research by providing them with the ability to claim intellectual property (IP) ownership (Hayter, 2013). Within Europe, whilst many countries have followed along the lines of the U.S in protecting university innovations, the European Commission has noted there is a need to address the transnational dimensions of knowledge transfer and in particular to alleviate problems caused by discrepancies between national systems. (Vision 2020 – EU Commission Recommendation Report). Second, the business model of the university has evolved to align itself more with its position within the knowledge economy (Rubens et al. 2017). This has led to a requirement to be an integrated institution within society and evolve from an *"ivory tower to entrepreneurial paradigm"* (Etzkowitz et al. 2000, p325). Key drivers towards this new business model has been dwindling public funding and the push towards less ‘blue sky’ research increasingly leading universities to proactively seek partnerships with industry (Striukova and Rayna, 2015; Rubens et al. 2017).

Third, as a result of reduced government funding, universities needed to generate more revenues during recessions or contractionary fiscal policy periods, which has been a driving factor in universities pursuing industry collaborations (Rubens et al. 2017). Consequently, university research has taken on the remit to be more based on ideas suggested by the outside and taken on board actual problems faced by industry (Striukova and Rayna, 2015). Fourth, universities have put in place supports to incentivise and support commercialisation activities. The emergence of intermediaries has been central in bringing university research to market (Matt and Schaeffer, 2018). Within the Republic of Ireland, the government have developed TTSI’s (Technology Transfer Strengthening Initiatives) to promote UIC within the state. Under the TTSI’s, Irish universities are provided with funding for both staff and an operational budget used to support patent applications. TTS1 4 is due to commence in January 2022. (OECD, 2020). With the emergence of the UIC phenomenon and the evolution of university's role in national innovation systems and economic development, research into the nature, antecedents and effects of UIC has grown (Klofsten et al. 2019). However, in the main, this research has been at the macro level of analysis (Rajalo and Vadi, 2017). There is a lack of micro level studies within the UIC phenomenon (Cunningham and Menter, 2020). This research adds to this gap as one of its contributions to knowledge.

In relation to the theoretical lenses literature and theory will be explored. Within the ACAP literature to date, research on ACAP has over relied on using R&D or scientific and technological knowledge as the primary way in which ACAP has been examined. This over reliance or bias towards scientific knowledge has overlooked other important knowledge capacities in how individuals exploit technological innovations (Scaringella et al. 2017; Lichenthaler, 2016). This research sets out to provide new insights on how market knowledge is acquired and assimilated and internalised by AEs and thereby extends the literature on the ACAP construct at micro levels of analysis. Prior research has identified that knowledge flows within UICs are bi-directional in nature (D’este et al. 2012). ACAP as a construct only focuses on the inflows of knowledge and therefore has some shortcomings to explore UICs (Raisal et al. 2018). The outflow of knowledge or exploitation of research activities beyond the boundaries of the university is an important element within UIC which is often overlooked within the literature (Ahn et al. 2016; Dell'Anno and Guidace, 2015). Lichnethaler and Lichenthaler (2009) by adopting an integrated approach, respond to the limitations of ACAP and extend the knowledge management literature. They introduced the term 'desorptive capacity' to describe the knowledge needed to find suitable applications of technological innovations. DCAP theory is within its research infancy (Meinlschmidt et al. 2016) and this research provides a contribution to new insights into its importance and development within a university context. In summary, the purpose of this thesis is to explore the micro level antecedents and challenges influencing university-industry open innovation collaboration, through the theoretical lenses of ACAP and DCAP.

1.2 Aims and objectives

The overall aim of this research was to explore the micro level antecedents and challenges influencing university-industry open innovation collaboration.

The objectives of the study are:

Obj1 - To explore the micro level antecedents and challenges that influence academic engagement in university – industry open innovation collaboration.

Obj2 - To explore how the academic entrepreneur's highly tacit scientific knowledge is translated to market related knowledge and innovation outputs during UICs.

Obj3 - To develop an understanding of the capabilities of the academic entrepreneur and their influence within the UIC process.

Obj4- To make recommendations on how to enhance value creation and value capture during university – industry open innovation engagement.

The research questions underpinning the objectives are:

RQ 1- What are the micro level motivators and barriers which influences an academic entrepreneurs' decision to engage in commercialisation activities?

RQ2 - How do academic entrepreneurs develop the capabilities to convert PACAP to RACAP?

RQ3 - What approaches are taken for the AE to develop market ACAP?

RQ4 -What are the capabilities needed for the AE to develop DCAP?

RQ5 – What factors moderate the effectiveness of knowledge transfer between the AE and external stakeholders?

1.3 Research Methodology

The study adopts a qualitative, multiple case study methodology and takes a socially constructed ontological stance and an interpretivist epistemological position. The subjective view of ontology assumes that '*social phenomena are created from the perceptions and consequent actions of social actors'* (Saunders et al. 2007 p108) and that our reality can change and be socially constructed (Bryman, 2012). As the researcher wants to understand the motivations, beliefs and assumptions from the participants, this could not be achieved from an objectivist view which views one true social reality experienced by all social actors (Scotland, 2012). As this is a multiple stakeholder study including participants from AEs, Technology Transfer Managers (TTMs), funding agency specialists and industry partners, all the participants view the phenomena from different angles, with different work, academic and life experiences. This enables the researcher to view the phenomena in a holistic way and incorporate diverging opinions. Ultimately, this adds context and richness to the findings and discussion chapters. Moreover, the interpretivist epistemological position taken in this research enables the researcher to understand phenomena through meanings attributed to them by individuals rather than seeking an objective reality (Saunders et al. 2016).

The approach to this research is to inductively build theory towards developing new insights (Yin, 2018; Locke, 2007; Eisenhardt, 1989). The research strategy for this thesis is using a multiple case study method. Multiple case studies allow for commonalties and differences to be highlighted between the cases where results generated are more robust and generalisable than single case studies (Saunders et al. 2016; Eisenhardt, 1989). In addition, this research is following an exploratory design, the reason for this is that the RQs and aims of this study involve how, why, what type questions where the researcher is trying to understand and explore the phenomenon rather than test a hypothesis (Saunders et al. 2016; Yin, 2018). As the intention of this research is to discover new ideas and explore the topic, an exploratory design is deemed to be aligned with the purpose of this research. Data collection is through semi structured interviews, initially face to face and then online due to COVID -19. In addition, the researcher uses relevant documentary evidence to gain an insight into the tools and templates used in academic entrepreneurship. The three case studies were selected due to their capabilities and leadership in commercialising STEM research. Each had similar outputs in terms of licensing, spin out formations and invention disclosure forms (IDFs) completed. This was important in building pattern based replication leading to theory building as suggested by

Pratt et al. (2020) and Aguinis et al. (2018). In total 43 interviews were conducted, 8 pilot, 32 main interviews and 3 follow on interviews.

1.4 Table of gaps

Table (1.1) highlights the gaps in the literature and the calls for further research relevant to this study.

Table 1.1 Gaps in the literature relevant to this research.

Author(s)	Gap in the research
Micro perspectives.	
Joan and Coates (2020, p736).	*'Micro level academic entrepreneurship provides a good theme to further research case studies looking at the micro level of UIC's. It is important to compare commonalities in both barriers faced and methods to overcome them'*
Cunningham and O'Reilly (2018, p552).	identified that '*further micro level studies are needed that examine more of the antecedent factors that shape individual perspectives and behaviours prior to engaging with a technology transfer process'*
Sjodin et al. (2019).	Further research within the ACAP literature to be focused at the individual level.
Skills and competencies within academic entrepreneurship.	
Hayter et al. (2016).	How skills and competencies are developed for AEs and how knowledge asymmetries can be reduced within UICs.
Cunningham and Menter (2020 p7).	*'There has been little focus on developing their managerial skills and competences that are required to be an effective star scientist'*.
Desorptive capacity Literature.	
Behnam et al. (2018 p6). Referring to open innovation capabilities.	*'Few studies have focused mainly on desorptive capacities thus, a comprehensive integrated framework of capabilities is lacking'*.
Ahn et al. (2016, p2).	*Lichtenthaler and Lichtenthaler (2009) and Robertson et al. (2012) indicated that other capacities, such as 'integrative' and 'desorptive', complement 'absorptive' capacities in the implementation of OI, but the validity of these theoretical suggestions have rarely been examined in empirical studies.*
Dell'Anno and Giudice, (2015); Meinlschmidt et al. (2016).	Desorptive capacity is in its research infancy and further research is needed to explore this topic. It has been neglected and is wide open for research opportunities.

ACAP literature	
Scaringella et al. (2017) Lichenthaler, (2016).	Few papers have identified a different source of knowledge (other than technological knowledge) that is needed to develop ACAP in individuals.
Processual view of academic entrepreneurship.	
Skute, (2019).	Although, prior research has identified, the 'critical junctures' within academic entrepreneurship, little research has explored these junctures in depth.
Garcia- Teran and Skoglund (2019) Wood (2013).	Further research is needed on the processual view of academic entrepreneurship and the processes and interactions between quadruple helix members.
Contextual factors Within academic Entrepreneurship.	
Robertson et al. (2019).	Further research is needed on the influence of contextual factors in academic entrepreneurship
Hayter et al. (2018).	Proposed future research should take a holistic ecosystem perspective looking at how the different actors and systems involved interact with each other.
Learning behaviours	
O'Kane et al. (2015) ; Rasmussen et al., 2011).	There is limited literature on the learning behaviours of AEs.
Role of supports in promoting academic entrepreneurship.	
Gubbins et al. (2020).	Called on further work on how social supports within academic entrepreneurship help the AE more specifically, the delivery mode and the support sought.
Mathisen and Rasmussen, (2019 p29).	Identified a key gap in the research stating '*because USOs typically rely on many different actors in their development, research that shed light on the relationship between USO teams and their support networks or ecosystem, would be of high practical relevance'.*

These gaps and responses to them are developed in the ensuing literature and theory chapters.

1.5 Outline of the thesis

The thesis is composed of eight chapters, and an appendices section. Chapter two, introduces and critiques the UIC literature. The chapter highlights the opportunities and challenges that UIC presents for both academic and industry partners. The role of intermediaries are also analysed. Open innovation theory is explored and how the philosophy has impacted on the role of universities and the AE. The final section discusses the AE, and the key findings from extant literature are critically evaluated. Chapter three, is the theoretical lens chapter of the thesis. ACAP is first discussed, with a focus on individual ACAP. Next, potential (PACAP) and realised (RACAP) absorptive capacity are evaluated and critiqued where they are broken into different sections to denote their different yet complementary nature (Zahra and George, 2002; Sjodin et al. 2019). Then, DCAP is introduced and the researcher highlights the two stages involved in relation to the knowledge capacity and its relevance within this topic area. Finally, learning theories are analysed as ACAP and DCAP are not static concepts and evolve through learning (Todorova and Duirsin, 2007; Lichenthaler and Lichenthaler, 2009).

Chapter four, is the theory development chapter. Here the gaps from the different literature streams are highlighted and synthesised. This leads to the new theoretical developments from converging the different literature streams in order to develop initial theory prior to the empirical study. This theory development led to the development of an initial conceptual model, which formed the basis of the RQs outlined in this study. Chapter five, is the research methodology chapter, where the researcher sets out the methodological frameworks, strategies and philosophies adopted for this work. Chapter six is the findings from the pilot study, this included interviews with eight AEs from two case organisations. The rationale for a pilot study was to test out interview questions and clarify/eliminate/add interview questions so a rich and detailed examination of the RQs could be progressed as the researcher moved forward.

Chapter seven presents the findings from the main study, including 32 main interview and analysis of documentary evidence. The findings are presented from each case under eight themes. After all the cases are discussed, a cross case analysis is conducted, and key overall findings are outlined. Chapter 8 is the discussion chapter. This chapter discusses each of the five RQs in light of the findings and are compared and contrasted against extant literature and existing theory. This is followed by the revised conceptual model which is based on the findings from this research as the final part of the inductive theory building process.

The thesis ends with a conclusions and contributions section (as part of Chapter 8) which identified the main conclusions and the contributions for theory, policy and practice. Furthermore, limitations and avenues for future research are noted.

Chapter two, is next it begins with a discussion on UIC and the opportunities and challenges it presents for the AE, universities and industry.

Chapter Two.

University -Industry Collaboration.

2.0 Introduction

The chapter explores and critiques the literature relating to university- industry collaboration (UIC). Section 2.1 discusses UIC and the opportunities and challenges it presents for both universities and industry. Section 2.2 examines the role of intermediaries within UICs. Section 2.3 discusses the concept of open innovation and looks at the effects of open innovation philosophies on universities and the AE. Section 2.4 critically evaluates the literature on the AE themselves to gain a deep understanding on what prior research has explored relating to these individuals. As AEs are the unit of analysis in this research, this was deemed necessary. The chapter ends with a conclusion section.

2.1 University industry collaboration (UIC)

University- industry collaboration (UIC) consists of the interaction of university, industry and government institutions to promote regional economic growth and development also referred to as the triple helix model of innovation (Etzkowitz 1997). This model of innovation has been extended by Carayannis and Campbell (2009) to include a fourth helix which acknowledges the important role of the public or innovation users as a key stakeholder in innovation processes. The quadruple helix model places a stronger focus on cooperation within innovation with the end user playing a central role in contributing to societal needs (Carayannis and Rakhmatullin, 2014). It is argued the interaction of these key stakeholders is the driving force of innovation in the knowledge economy. The knowledge economy refers to the increased role of knowledge intensive activities in the production of goods and services which has contributed to a rapid pace of advancement in technical and scientific innovation as well as rapid obsolescence (Powell, 2004). Traditionally, the roles of a university has comprised of teaching and research duties (Etzkowitz, 2017) however, increasingly universities are expected to be more entrepreneurial, which is referred to as their third mission. The third mission of universities refers to '*all activities concerned with the generation, use, application and exploitation of knowledge and other university capabilities outside academic environments'* (Gallart and Martinez, 2007 p321). These activities add to the 'first' and 'second' missions of the university, which are teaching and research. Perkmann et al. (2013) separated the collaboration activities by academics with industry into academic entrepreneurship (the focus of this study) and academic engagement. Academic engagement refers to the softer channels of collaborating with industry and includes consulting, contract research, collaborative research as well as providing ad hoc advice and guidance. Academic entrepreneurship on the other hand, consists of patenting, licensing and spin out formations (D'este et al. 2012). Academic entrepreneurship is part of the third mission activities of entrepreneurial universities (Perkmann et al. 2011). It can be defined as ' *a practice performed with the intention to transfer knowledge between the university and the external environment in order to produce economic and social value both for external actors and for members of the academia, and in which at least a member of academia maintains a primary role'* (Cantaragiu, 2012 p 687). The central actors within academic entrepreneurship are the academic scientist or engineer who is the originator of the IP (Intellectual Property) also known as the academic entrepreneur (AE), Technology Transfer Managers (TTMs) and support staff act as an intermediary between the AE and industry partner and also manage the IP of the university, drafting contracts and legal agreements (Seigel et al. 2003). As a result of universities taking on their third mission they have had to open up their processes and work with external stakeholders in order to make an impact with their research (Barrioluengo and Benneworth, 2019). Simeone et al. (2018) argues academic entrepreneurship is a multifaceted role adopted by universities, it involves the management of multiple stakeholder relationships and requires strategic thinking and action on how to develop regions and local economies not just economically but also socially, consistent with the quadruple helix multi stakeholder approach.

There are a number of reasons why universities and industry collaborate together. For example the collaboration of university and industry partners allows both parties to avail of synergies and exchanges of knowledge and resources which are complementary in nature, in order to drive economic development (Camison, 2013). Furthermore, within the bioscience sector universities possess strong discovery and early stage drug development capabilities, often missing within large industrial organisations (Wang et al. 2016); whereas the industry partner often has a large R&D budget and resources for more downstream activities. These include access to key proprietary technologies to drive the development of the basic research conducted at the university (Dooly and Kirk, 2007). Proprietary technologies refers to any process, system or tool that is developed in house, is legally protected and that provides competitive advantage for an organisation (Kelley and Rice, 2002). Many of the downstream technologies such as bulk production in drug manufacturing are seen as proprietary technologies within large R&D pharma companies (Kelley and Rice, 2002).

Tables 2.1 and 2.2 outlines the motivations and challenges for both industry and universities when engaging in UICs.

Table 2.1 motivations to participate in UICs

Motivation	**University Perspective**	**Industry perspective**
Access to resources	Access to proprietary technology and processes such as chemical and compound libraries developed by industry.	Industrialists can work with experts in the area of discovery and exploration. Opportunity to work with the originator of the IP.
Complementary skillsets	Scientific discovery and prototyping Upstream activities.	Testing, validation and integration of technologies Downstream activities.
Access to knowledge	Access to knowledge on the needs and requirements of the company and its market. Identifying end user needs.	Access to tacit knowledge that is highly specialised and by its nature naturally excludable to parties outside of the UIC.
Funding	AEs and universities can avail of the funding stream from UICs to further develop their early stage innovations.	Industry can co fund UIC projects with governments thereby reducing their cash contribution.
Strategic focus	Given the impact agenda taken on by universities, they have set up resources and support services to help drive UICs.	Industry are now more quicker to be able to verify /validate findings from universities.

Source (Lind et al. 2013; Dooley; Adler et al. 2009; Dooley and Kirk, 2007).

Table 2.2 Challenges in participating in UICs.

Challenges	University perspective	Industry perspective
Time horizon	Long term	Short term
Goals	Knowledge creation	Organisational growth.
Mindset	Intellectual curiosity and challenge.	Delivery of the project, end goals and quantifiable metrics.
Output	Publish findings and disseminate results.	To protect ideas and innovations in order to maximise the potential of the IP.
Culture	Culture of open science, where scientific knowledge of all kinds should be openly shared in the discovery process.	Culture of proprietary science where the organisational culture is to maximise revenues and not openly disclose results.

Source (Lind et al. 2013; Dooley; Adler et al. 2009; Dooley and Kirk, 2007).

The above two tables highlight the opportunities and challenges that UIC presents for both academic institutions and industry partners. Steinmo (2015) found the development of personal relationships and developing common goals regarding the collaboration mitigated against collaborative challenges. Furthermore, Thune and Gulbrandsen (2014) identified that UICs evolve over time and are contingent on clear roles for each participant in the research collaboration. Here, clear goals, outputs, and resource commitments for the partnership need to be communicated clearly to both parties to allow for a more harmonious working environment. Schofield (2013) identified that high levels of bureaucracy and inflexibility at the institutional level of universities added to the challenges for UICs. This suggests a greater need for support structures, governance regimes and knowledge management policies at the university level. Gretsch et al. (2020) found when collaborative partners use shared governance strategies during a UIC project, this builds trust and allows partners develop shared meaning and allows for change during the project to happen more harmoniously as both parties are involved in the planning and coordination of any change. Bstieler et al. (2015) found that individuals within the UIC process that adopt the role of championing enhance the positive effects of shared governance and allow for less emphasis on the formal rules and regulations around IP ownership towards one of shared planning, coordination and implementation between industry and academia. This is all built around the level of trust developed within the partnership (Bruneel et al. 2010). In summary, to reduce the different cultures, logics, norms and expectations governing both industry and universities, it is argued the shared planning, development and implementation of UICs projects helps alleviate the existing challenges within UICs as outlined in table 2.2.

As universities adopt to their emerging role as a central stakeholder in the knowledge economy, they have implemented support structures and resources to help AEs and the institution to achieve their third mission mandate (Davey et al. 2016). As a result, a number of intermediaries have been set up to help the university achieve their entrepreneurial goals. The role of these intermediaries is discussed next.

2.2 Role of intermediaries

Universities have set up a number of intermediaries to help translate academic research into market driven products and processes. The TTOs, research centres, incubators and science parks are all intermediaries that assist the third mission mandate of universities (Seigel et al. 2007). Technology Transfer Offices (TTOs) serve as an intermediary between suppliers of innovations (university scientists) and customers who can commercialise these innovations, i.e., firms, entrepreneurs and venture capitalists (Musico, 2010). TTOs facilitate commercial knowledge transfers of intellectual property resulting from university research primarily through licensing to existing firms or start-up companies (Seigel and Wright, 2015). More specifically, they help academics to understand the needs of industry and to access critical resources, expertise and support in the commercialisation process (Clarysse and Moray, 2004; Colombo and Delmastro, 2002; Markman et al. 2005; Siegel et al. 2003).

TTOs have a varied network of angel investors, venture capitalists, external contractors and consultants, patent agents, consultancy firms, and industry contacts to help the academic on their commercialisation journey (Schaeffer and Matt, 2016). They have been found to conduct important boundary spanning work translating highly scientific language and know how into a language understandable to industry (Schaeffer and Matt, 2016).

Most academics are not trained in IP law, business development, and other business-related aspects of science (O'Kane et al. 2018). The TTO plays a critical role in bridging the divide between the science and business domains of knowledge (O'Kane et al. 2018). Markmann et al's (2005) research highlighted that when inventors collaborate actively with TTOs, technologies tend to be commercialised faster and earn higher revenues. However, these offices have come under some scrutiny in their approaches to supporting commercialisation. For instance, Lowe (2006) found that TTOs will not intervene if the technology in question has only a small commercial value, despite the mission of the TTO to support commercialisation and the AE within the process. Siegel et al. (2007) found evidence that the involvement of TTOs may slow down the commercialisation process due to an excessive focus on safeguarding researchers' interests and maximising university returns. Clarysse et al. (2011) found the TTO played a small role in shaping academic venture creation, and that the efficiency of the TTO is only of marginal value. The researchers placed the importance on the AE in fostering and building industry collaborations. This finding is similar to Boehm and Hogan's (2014) suggestion that it is now AEs not TTOs, who have the dominant responsibility and influence in initiating, bridging and coordinating university-business collaborations. O'Kane et al. (2018 p70) found the boundary work (how TTMs interact with AEs to communicate the importance of their role) conducted by the TTO to build trust with AEs was '*partially effective'* in their study. The AEs where initially reluctant to trust TTMs but found the TTO increasingly supportive as the process continued. This finding highlights the importance of relationship building between the TTO and the AEs. Hayter (2016) found that there are a number of reasons why academics would bypass working with a TTO. These included their predominant focus on life science technologies, preference for large company licensing over start-up support, greed, slow response times, and lack of entrepreneurship support capability.

Furthermore, Fini et al. (2018) found the pathway of informal interactions by the AE with industry is one channel in which AEs can bring their innovations to the marketplace. As a result, Hayter et al. (2018) argued commercialisation of academic research should take on a broader context and use an ecosystem perspective, looking at all the channels and routes of commercialisation available to the AE. This broader conceptualisation allows for the AE to maximise the potential impact of their research to society (Fini et al. 2018). In summary, the literature on the performance of TTOs is mixed i.e. from providing key networking and boundary spanning activities to slowing down the process and with the AE having to do most of the work.

Research centres are another type of intermediary within the UIC ecosystem (Perkmann and Walsh, 2007). Research centres are typically co-funded by government and participating companies where the centre provides the opportunity for researchers to conduct more blue sky research or fundamental research. However, it also includes finding a way for that research to be translated to have both societal and economic impact by collaborating with industry (Dooley and Kirk, 2007). The output of research centres can be quite wide from coauthoring paper publications, academic consulting and applied R&D to the more traditional outputs of patents, licenses and spin outs (Perkmann and Walsh, 2007). Lind et al. (2013) found there are competing institutional logics within research centres from stakeholders namely funding agencies, industry and university participants. The motivation for funding agencies to be affiliated with research centres is as a mechanism for them to develop society and bring about change, based on the direction decided by government. The research centres have key performance indicators (KPIs); which they must report to funding agencies and their performance is evaluated periodically (Albats et al. 2018). Industry are motivated to participate in UICs at research centres to gain access to state of the art knowledge and processes held by AEs to ultimately establish a pipeline of scientific discoveries into their R&D processes (Lind et al. 2013). Finally, the motivation behind why AEs and universities participate with research centres are that they are a vehicle to access funding and move their discoveries along the stages of development. AEs who are affiliated with research centres have an additional route to access funding compared to their peers who are non-affiliated. In addition, AEs can develop their skills and knowledge in more market driven processes and needs of industry by engaging in a UIC project within a research centre (Bozeman et al. 2013; Dooley and Kirk, 2007).

Incubators are another type of intermediary where university incubators offers a physical work space for AEs or recent graduates to access specialist supports in order to grow a spin out company (Redondo and Camarero, 2019). Kolympiris and Klein (2017) identified the supports offered by an incubator as access to infrastructure such as labs and equipment, and networking support allowing AEs the access to networks of investors, industry partners and other external stakeholders. They can also access seed funding provided by the incubator, finally the incubator trains the AE on the commercialisation process through mentoring, coaching and peer learning. Furthermore, Patton (2014) found incubator facilities and the supports offered (mentoring, support agents and directors at incubators) allowed the nascent AEs develop the skills and knowledge needed to engage successfully with academic entrepreneurship. Link and Scott (2017) found universities have also increased their affiliation with science and technology parks; which are often the location for incubators and spin out companies. As universities strive to meet their third mission mandate, the growth of these intermediaries has played a critical and influential role, helping translate scientific innovation into market opportunities (Redondo and Camarero, 2019; Seigel et al. 2003). These opportunities for the university have required it to become more open with a bidirectional flow of knowledge and expertise flowing into, and disseminating out of, the university (Etzkowitz, 2017; D'este et al. 2010); which ultimately has required universities to work closer with external partners and open up their processes (Etzkowitz, 2017).

In summary, these intermediaries have been set up by universities to provide linkages and support mechanisms for the university and the AE to engage in UIC. Universities have recognised there is a need to make an economic and societal impact with their research outputs, this has resulted in a more open flow of knowledge, communication and interaction with external stakeholders. As a result of these more open processes, the theory of open innovation argues organisations such as universities, should combine internal and external flows of knowledge and ideas to develop pathways to market. This concept is further discussed in the next section.

2.3 Open innovation

Open innovation (OI) has been proposed as an emerging paradigm for the management of innovation (Chesbrough, 2003; Gassmann, 2006). It is defined as '*the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively'* (Chesbrough et al. 2006 p1). Chesbrough and Crowther (2006) comment that at the heart of the OI model is the recognition that today, competitive advantage often comes from inbound open innovation where knowledge flows into an organisation from the outside, the authors argue that organisations need not and indeed should not rely exclusively on their own R&D. As well as inbound open innovation, the theory also includes outbound knowledge flows and coupled processes which have been given less academic attention to date (Ahn et al. 2016). Outbound open innovation refers to the exploitation of internal knowledge, it recognises that in some instances other organisations may be better positioned to exploit the innovation, the out licencing of IP is an example of an outbound open innovation practice (Bianchi et al. 2011). Finally, the coupled process combines both the inbound and outbound processes where knowledge can flow inwards and outwards and occur simultaneously creating an effective knowledge management process (Ahn et al. 2016).

Chesbrough (2003) argues that we are witnessing a paradigm shift in how organisations commercialise knowledge, from ‘Closed Innovation’ to ‘Open Innovation.’ Closed Innovation is a view that says successful innovation requires firm control. Companies must generate their own ideas and then develop and support them on their own. This paradigm argues firms to be strongly self-reliant, because one cannot be sure of the quality, availability and capability of others’ ideas (Enkel, 2009). Chesbrough (2003) however argues that the closed model is no longer sustainable as an approach to innovation. The OI model assumes that organisations can and should use external as well as internal ideas, and internal and external paths to market, as they look to advance their innovations (Chesbrough and Bogers, 2014). The principles of the closed vs open innovation model are summarised in table 2.3.

Table 2.3 Key principles of the open and closed innovation models.

Closed innovation	Open innovation
Based on the concept of control where the organisation comes up with its own ideas and development plans.	The OI model assumes that firms can and should use external as well as internal ideas, and internal and external paths to market, as they look to advance their technology
Argues there is no need to search externally to seek talent as it is already sufficiently sourced in house.	Argues there is a need to externally search for ideas and knowledge outside of the organisation.
First mover advantage i.e. if we discover it first, we will get to the market first.	Priority on developing a sustainable business model rather than first mover advantage.
If the organisation creates superior ideas and has a competitive advantage over rivals, the company wins.	If we make the best use of internal and external ideas, we will win. We have to be involved in basic research to benefit from it but the discovery does not have to be ours.
We will own all our results from contract research with universities.	We will partner with external organisations such as universities and research centres to create knowledge and encourage use outside our field.
We should control our IP, so that our competitors cannot profit from it.	We should profit from other's use of our IP (license out) and we should license in other's IP whenever it advances our business model.

Source: Chesbrough (2003).

In summary, under the OI philosophy the university has the potential to be a great source of knowledge with specialised skillsets which can be harnessed by industry within a UIC. However, it is important to analyse how the philosophy has impacted the university and the AE. This is further discussed in the below section.

2.3.1 OI within the UIC context

Villasalero (2014) and Fabrizio (2006) identified the OI literature has focussed primarily on the ideas and knowledge flowing from industry i.e. the exchanges from one firm to another However, there is a second important source of knowledge and ideas useful to the OI processes of firms, universities. Gassman et al. (2010) highlighted this as they argued the role of universities under the open innovation era has moved from ivory towers to knowledge brokers, with a trend towards a more systematic approach on how firms collaborate with universities.

The transfer of knowledge from university to industry can be a complex and problematic process, please see the table 2.2 on the challenges of UIC. However, factors such as lack of public funding and the push towards less ‘blue sky’ research mandated by governments have increasingly led universities to proactively seek partnerships with industry, (Striukova and Rayna, 2015). Consequently, there has been an increased pressure put on universities that their research activities should be more based on ideas suggested by the external environment and take on board actual problems faced by industry (Striukova and Rayna, 2015).

Researchers have found the potential role utilised by universities adopting the OI philosophy can put them in a powerful position within OI networks. Hayter (2016 p5) argues universities can act as an ‘*anchor organisation’* within an OI ecosystem as long as it is guided by a strong ethos to support entrepreneurship and has developed knowledge intermediaries such as TTOs and incubators to support the AE. Striukova and Rayna (2015) found entrepreneurial universities are becoming central actors within OI ecosystems and should position themselves as hubs through which collaboration can happen. Janiero et al. (2013) found universities are drivers of knowledge diffusion as they are often source providers of new knowledge used in disruptive technologies where they can exert strong influence over regional innovation systems. However, Jonsson et al. (2015) stresses the point that OI entails only a possibility and potential for universities to adopt in order to leverage their innovative ideas and embryonic technologies. They argue that OI remains a largely general and abstract theory built on general principles and abstract themes rather than a detailed functioning as a result there is no easy recipe on how it works. Barrioluengo and Benneworth (2019 p 206) found entrepreneurial universities have become ‘strategically overloaded’ as they try to incorporate their third mission activities into their traditional research and teaching roles. This finding is important as it implies universities are struggling to integrate these multiple missions into a coherent strategy and overall focus. Audretsch and Belitski (2021) emphasise the role of knowledge and entrepreneurial capital to be strategically aligned across three levels within the entrepreneurial university – individual, organisational and systems level. These levels working in unison to meet the third mission mandate of universities, allows for them to be more responsive and adaptable to market opportunities as they arise. Philpott et al. (2011) identified that as well as the top down influence OI has had within a university, there is also a bottom up effect which focuses on entrepreneurship originating at an individual level. It is therefore important to analyse the effects of OI on the AE.

2.3.2 The AE and OI philosophy

As identified in section 2.3.1, the university has adopted more open innovation processes and engages in collaborations with other regional stakeholders to meet its third mission mandate. As a result, the role of the AE has taken on a wider remit where a new skillset and mindset is needed beyond traditional research and teaching skills (Alexander et al. 2016). AEs often take on several research projects at one time and their entrepreneurial intentions can vary between projects under an open innovation context (Holly and Watson, 2017). Indeed O'Kane et al. (2015) acknowledge whilst an AE can have an exploratory research agenda, they can still engage in exploitative projects concurrently. Some AEs can exhibit different entrepreneurial behaviours depending on the nature of the projects they are working on and the level of supports they receive particularly around funding (Holly and Watson, 2017). Holly and Watson (2017) found AEs are likely to engage in entrepreneurship when three conditions are met 1) they are aware of the opportunity to commercialise their discoveries exists, 2) they are not opposed to research commercialisation i.e. do not follow an orientation following traditional norms and performance metrics and 3) the appropriate supports are in place to help leverage the discoveries of the AE into fledging innovations.

AEs wishing to commercialise their research under the OI philosophy broadly speaking, can license their IP through a licensing deal directly to an established firm or from a USO (University Spin Out) (Minshall et al. 2007). Licensing refers to rights to use technologies discovered at a university and controlled by patent protection. Traditionally, licensing has been the main mechanism used to exploit university inventions. However, Fini et al. (2016) and Wright et al. (2004) have found USO's (University Spin Out) have become an increasingly popular mode in commercialising university IP. A USO refers to the creation of a new company from a parent organisation in this case the university (O'Shea et al. 2008). Rather than licensing university IP to a third party, the AE(s) may decide to commercialise the technology themselves. USOs have the potential for high returns, job creation and value creation (Minshall et al. 2007). When the underlying technology within an innovation is of a disruptive or highly innovative nature, industrial partners may not recognise the potential value of the IP or if this technology is not readily available to license out to third parties, the AE(s) may decide to create a business venture to exploit their research (Fontes et al. 2008).

In summary, the result of AEs working under an open innovation remit has provided more routes to market and different opportunities for AEs of working with industry than if the university was following the closed model of innovation. It also has presented more challenges (discussed in section 2.1) therefore, it can be argued the role of the AE has taken on more importance and centrality within entrepreneurial ecosystems. This argument is further discussed in the next section.

2.4 The academic entrepreneur in the OI ecosystem

The AE has been found to be a central actor within the OI ecosystem (Kidwell, 2013). Prior research has highlighted this centrality where the AE has been described as being '*at the nexus of engaging and interacting'* with other partners within the open innovation paradigm (Cunningham et al. 2016 p3). They hold a unique position at the forefront of open science and manage a diverse set of stakeholder relationships within the open innovation process (Casati and Genet, 2014). They have also been described as linchpins within the UIC ecosystem acting as influential boundary spanners facilitating the interface between academia and industry (Mangematin et al. 2014; Kidwell, 2013). The academic entrepreneur can be defined as '*faculty, technicians, postdoctoral fellows, or students who act as the primary entrepreneurial agent for the dissemination and commercialization of new knowledge generated in universities'* (Hayter, 2015 p3). Academic entrepreneurs are individuals who hold technical qualifications at the highest academic level, developing scientific expertise and technical skills sufficiently for them to be regarded as experts in a particular technology field (D'este et al. 2012). Their focus on exploration and discovery of new science allows them to shape new research avenues and they have been found to play a vital knowledge brokering role between academia and industry (Kidwell, 2013). Boehm and Hogan (2014) found that the academic entrepreneur has to be a 'jack of all trades' with an array of responsibilities. For example, they take on the roles of project manager, negotiator, resource acquirer as well as the traditional academic role of Ph.D. academic supervision and mentoring. Regarding their role identity, Jain et al. (2009) argue that typically academic entrepreneurs adopt a hybrid role identity where most of them see themselves as scientists first and entrepreneurs second. Furthermore, O'Kane et al. (2020) found an AE's role identity is made up of four roles – science networker, research contractor, project manager and entrepreneur. These roles are mutually reinforcing and combine together to form a hybrid science-business role identity. Baglieri and Lorenzoni (2014) suggest that

AEs can adopt the roles of '*scientist*' and '*end user'* were more capable of accomplishing technology transfer tasks.

Carl (2020, p740) identified that AEs are now taking on 'grand challenges' facing society and as a result now include social innovation as part of their thinking and design strategy to new innovations. The European Commission (2015) defines social innovation as '*new ideas that meet social needs, create social relationships and form new collaborations. These innovations can be products, services or models addressing unmet needs more effectively'.* This has resulted in AEs having a more inclusive approach to entrepreneurship than only that of economic benefit or pure technological innovation (Carl, 2020). Working within an OI ecosystem, requires the AE to develop their connectivity with external stakeholders and for the configuration of their social networks to not comprise of too much homogeneity. Hayter et al. (2018) argues the social contacts the AE can build outside the university are of critical importance to gain the knowledge and assistance of key end users. Another critical component in academic entrepreneurship activities, is the motivation of the AE. As D'este et al. (2012) highlighted the act of academic entrepreneurship for the AE is a discretionary one. Therefore, the question of what motivates the AE to want to commercialise their research is an important question. This is further discussed in the next section.

2.4.1 Motivation and the AE in the OI ecosystem

As identified in the previous section, AEs hold an important and central role within the OI ecosystem, it is therefore important to analyse the underlying motivational factors that allow for an AE to want to engage with commercialisation activities. Prior research has identified that AEs are motivated by both intrinsic and extrinsic rewards (Lam, 2011). There is evidence of AEs engaging in commercialisation activities to increase their personal wealth and for personal gain (D'este and Perkmann, 2011; Perkmann and Walsh, 2008). Also, during times of reduced government spending, AEs who secured collaboration deals with industry afforded them an additional revenue stream in order to fund their research (Rubens et al. 2017). Lam (2011) challenged the assumption that AEs are primarily motivated by personal gain stating that in the main, AEs were motivated by reputation and career rewards than financial gain. More crucially, the intrinsic satisfaction derived from commercial engagement itself, emerged as a central motivation shared by many of the scientists. Galati et al. (2020) identified that AE's motivations evolve over time, with financial motivators becoming less important with making an impact and delivering solutions to societal problems becoming more important over time. This is an important finding as it suggests the AE transitions their thinking from a pure economic benefit to a more social focus and want to problem solve (Carl, 2020). Furthermore, Antonioli et al. (2016) found intrinsic motivations alone are sufficient as antecedents of scientists' entrepreneurial intention. However, this effect was mediated by both the academic position of the scientists and the working context in which the scientists were embedded. This is an important finding, as Davey et al. (2016) found that AEs respond to the environment around them. Gumusay and Bohne (2018) highlighted the importance of sufficient supports at the university and departmental levels to encourage AEs to engage with entrepreneurship and a culture within universities that is open and transparent towards academic entrepreneurship, which is consistent with the principles of OI. Their research found mistrust and scepticism among academic colleagues at universities as a key inhibitor towards Open Innovation and commercialisation for nascent entrepreneurs. Furthermore, Tartari et al. (2014) found academics' engagement with industry is informed by the behaviour of their departmental peers. There is now a stronger emphasis and expectation on AEs to make an impact with their research (Etzkowitz, 2017). Orazbayeva et al. (2019) found this social responsibility motivates the AE to engage in self-directed behaviours in collaborating with industry and other stakeholders in an OI manner. In summary, the AE is motivated by a complex mix of financial and non - financial rewards where their motivations are not static and evolve over time. The culture at the university, behaviour of peers as well as the social responsibilities felt by AEs have an impact on their motivations to operate in an open innovation orientated UIC system. As well as motivational factors, Skute (2019); Ramussen et al. (2011) and Rasmussen and Wright (2015) have all highlighted the importance on the human capital development of the AE and in particular their skills and competencies needed to engage in commercialisation activities. This is further discussed in the next section.

2.4.2 Skills and competencies of the AE in an OI ecosystem

As identified in section 2.4, the role of the AE comprises of a multitude of tasks that require a varied skillset. Within the literature it is argued that AEs often lack the skills and competencies needed to transform scientific findings into viable products and services within an open innovation orientated UIC (Rahim et al. 2015; Vohora et al. 2004). The AE must develop competencies not only regarding exploring scientific innovations but also how to commercialise these early stage embryonic innovations through effective OI linkages

(Rasmussen et al. 2011). Arguably, commercialisation competencies are in short supply within universities and among typical nascent academic entrepreneurs (Mosey and Wright, 2007). While AEs possess knowledge important for scientific and technological progress, these individuals typically lack the experience or business acumen important for knowledge exploitation (Hayter, 2015; Murray, 2004; Franklin et al. 2001). There is a lack of research on the skills/competencies needed by the AE when pursuing academic entrepreneurship within OI ecosystems (Hayter, 2016). In the academic entrepreneurship context, Thomas et al. (2020) identified four key capabilities developed by a star scientist in their research on spin out formations. Their research showed that AEs need to develop dynamic capabilities to operate effectively within the OI environment involving shaping, sensing and seizing opportunities when commercialising their research. The four capabilities identified were technology market matching capabilities, claiming and protecting the innovation, attracting and mentoring the founding team and awareness around strategic timing. Foncubierta -Rodrıguez et al. (2020) also conducted research on the capabilities of AEs, their research identified six capabilities of human capital on a scale as determinants of success in academic entrepreneurship. The six capabilities identified were 1) research knowledge, 2) open-minded research ability, 3) research perform ability, 4) stoic research skill, 5) innovation skills and 6) critical skills. Foncubierta -Rodrıguez et al. (2020) use skills, knowledge and abilities (SKA) as the dimensions to measure the capabilities of the AE, a limitation of their research is that there is no mention of market knowledge and how it is acquired and exploited by AEs in an open innovation orientated UIC. Furthermore, Rasmussen et al. (2011) identified three competencies which they identified to be critical to make the transition from academic research to the development of a potential commercial opportunity – opportunity refinement, leveraging and championing competencies. In addition, Vohora et al. (2004) identified opportunity recognition competencies needed by AEs as they commercialise their research under open innovation – opportunity screening and opportunity framing capabilities. Finally, Cunningham et al. (2015) found AEs were challenged with developing their project management, project adaptability and network management competencies as they engaged with academic entrepreneurship activities.

For an AE to successfully transfer knowledge in an OI process they must possess a strong orientation towards learning where they seek new skills, knowledge and learning by experience to develop themselves (Bird, 2019). By developing the entrepreneurial competencies needed to commercialise academic research the AE can improve their related knowledge, traits, and skills (Sánchez, 2011). Skute (2019) highlighted an important gap in the literature, the researcher found although prior research has identified the critical junctures within academic entrepreneurship, little research has explored these junctures in depth and the skills needed to accomplish them. This research taking a micro perspective adds to this gap. Table 2.4 summarises the competencies and underlying capabilities identified from prior research on the skills that support AEs as they engage with the commercialisation process in an OI environment.

Table 2.4 – Linking entrepreneurial competencies and capabilities for academic entrepreneurship:

Author(s).	**Higher order competencies**	**Underlying capabilities**
Foncubierta-Rodrıguez et al. (2020).	Human capital competencies by the AE are developed through the six underlying capabilities.	Research knowledge, open minded research ability, research performance ability, stoic research skills, innovation skills and critical skills.
Thomas et al. (2020).	Sensing and shaping opportunities.	Technology market matching skill.
Thomas et al. (2020).	Seizing opportunities.	Claiming and protecting the innovation. Ability to attract and mentor the founding team.
Cunningham et al. (2015)	Project adaptability competencies.	Environment scanning and maintaining project agility.
Cunningham et al. (2015)	Project management Competencies.	Day to day supervision of the project so it meets intended targets and milestones. Building up relationships with different stakeholders to meet targets and manage networks effectively. Ability to engage in multidisciplinary projects – integrating knowledge from different disciplines/domains.
Rasmussen et al. (2011)	Opportunity refinement Competencies.	Developing creativity and adapting the innovative idea. Seeking improvements in the innovation process and making changes to it according to new insights. Acquiring and developing market related capabilities.
Rasmussen et al. (2011)	Championing competencies.	Ability to foster commitment in others. Provide emotional meaning and energy to the idea. Takes responsibility of moving the opportunity forward.
Vohora et al. (2004)	Opportunity recognition competencies.	Assessing whether the innovative idea has sufficient underlying value to pursue commercialisation outside of the university lab. Ability to identify alternative markets and applications of the technology.

2.4.3 Gaps within the literature on the AE

Given their important role in academic entrepreneurship and its open innovation orientated UIC environment, researchers have called upon further research to provide a deeper analysis of the AE's behaviours, learning processes and abilities with respect to the commercialisation of academic research (Cunningham et al. 2018; Hayter, 2018; D'este et al. 2012). Cunningham and O'Reilly (2018, p552) identified that '*further micro level studies are needed that examine more of the antecedent factors that shape individual perspectives and behaviours prior to engaging with a technology transfer process'.* Cunningham et al. (2016, p794) called on further research to examine '*how do AEs actually contribute to value creation and capability development within and beyond the academic environments*. Hayter (2016) called on further research on how AEs possess the skills in order to improve their understanding on what is needed for technology commercialisation. Carl, (2020) identified two gaps in the literature pertinent to this study. First, on the need for further studies on how AEs can be supported in their role as transformational agents within entrepreneurial ecosystems. Second, how AEs contribute to social innovation should be determined empirically. Finally, Joan and Coates (2020 p736) identified a research gap stating '*micro level academic entrepreneurship provides a good theme to further research case studies looking at the micro level of UIC's. It is important to compare commonalities in both barriers faced and methods to overcome them'.* This research adds to these gaps which are further explored within the RQs discussion in section 8.2.

From an open innovation ecosystem perspective, Hayter (2016) called on further research on how AEs can develop the networks to engage in more open innovation processes with external stakeholders (Hayter, 2016). Furthermore, Skute (2019) has called on further research under OI ecosystems to provide more insights on the developmental processes of the entrepreneurial competencies and potential inhibitors on the AE.

2.5 Conclusion

This chapter explored the UIC concept and explained the actors involved and their role within the process. The opportunities and challenges of UIC were presented. Next, the open innovation philosophy was discussed and the impact it has had on universities and the AE.

The final section analysed the literature on the AE as operating in an OI oriented UIC environment and highlighted gaps in the literature relating to the AE where this research adds a contribution both from a theoretical and practical perspective. This is discussed further in chapter 8. The next chapter is the lens chapter where the researcher begins with a discussion on ACAP.

Chapter Three. Theoretical lenses for the development of the study.

3.0 Introduction

The overall aim of this study is to explore the micro level antecedents and challenges influencing university-industry open innovation collaboration. To build the theoretical foundation to analyse this aim, in building on the AE and OI discussed in Chapter 2, this chapter evaluates the absorptive and desorptive capacity literature. The research takes a dual lens approach to extend our understanding of knowledge flows and the underlying mechanisms within an open innovation environment in a UIC system. Section 3.1 and 3.2 provides an overview of ACAP and its dimensions. Section 3.3 differentiates potential and realised ACAP, whereas section 3.4 looks at the role of individuals in the ACAP process. The antecedents are discussed next, which are sub divided into PACAP (Section 3.5) and RACAP antecedents (section 3.6) to provide a more fine grained analysis. Section 3.7 differentiates scientific vs market ACAP and how these capacities can be translated. Section 3.9 introduces the desorptive capacity literature and the challenges the AE faces as they exploit their research. Next, Section 3.10 provides a detailed analysis on the related learning literature and how its complements the ACAP and DCAP perspectives. The role of ambidexterity is then analysed before the chapter is concluded where the gaps in the literature are summarised.

3.1 Overview of ACAP

Theoretically, the concept of absorptive capacity (ACAP) is located between the fields of organisational learning, (Lichenthaler and Lichenthaler 2009; Lane et al. 2006), knowledge management (Chiva et al. 2005, Oshri et al. 2006) and dynamic capabilities (Teece et al. 1997). Cohen and Levinthal (1990, p.131) define absorptive capacity (ACAP) as the '*organisational ability to value, acquire, assimilate and exploit external knowledge to achieve organisational outcomes*'. The principle premise of absorptive capacity is that an organisation needs prior related knowledge to assimilate and use new knowledge (Cohen and Levinthal, 1990). Although Cohen and Levinthal (1990) analyse ACAP at the organisational level, they make reference to the important role played by individuals in leveraging ACAP where it depends on the '*links across a mosaic of individual capabilities*' (p.133). Since their seminal work, researchers have promoted the importance of ACAP at the individual level. For example, Tian and Soo (2018) examine how individual ACAP is developed. Sjodin et al. (2019) offers a processual model on how individuals engage in ACAP and new external knowledge and Ojo et al. (2017) investigated the micro level antecedents of ACAP in project engineering teams.

Despite these recent studies the individual level (such as the AE) is relatively an understudied and analysed unit of analysis (Volberda et al. 2010). Individual level ACAP is defined as an individual's ability to identify, assimilate, and utilise new external knowledge (Lewin, 2011). It is found in individual cognition, motivation, action and interaction (Volberda et al. 2010). Therefore, besides a firm's level of prior related knowledge, an organisation's absorptive capacity depends on the cognitive abilities of individuals. (Cohen and Levinthal, 1990). Moreover, research to date has mainly neglected to study the micro-foundations of organisations' ACAP involving the role of individuals rather than at firm level (Ebers and Maurer, 2014). Therefore, much remains unknown on how the actions and interactions of lower level actors such as individuals, teams and subsidiary units contribute to organisational ACAP (Sjodin et al. 2019).

3.2 Dimensions of ACAP

The seminal pieces of work within the ACAP literature are at the organisational level (Volberda et al. 2010) therefore a short summary of these are presented below. Individual ACAP is discussed in section (3.4) as the objectives of this research are focused at the micro level of analysis. Cohen and Levinthal (1990) proposed three components of ACAP. Firstly, they identified 'recognizing the value' as the first component of ACAP. They contend that organisations without prior knowledge are not able to evaluate the new information and thus fail to absorb it. It refers to an organisation's ability to locate, identify, value, and acquire new knowledge relevant to an organisation (Lane et al. 2006). This requires not only proficiency in external knowledge search but, more importantly, the ability to value knowledge for subsequent use (Todorova and Durisin, 2007). Despite its importance, the ability to recognise the value of new knowledge is not sufficient to enhance a firm's innovative potential, (Zahra and George, 2002). An organisation must develop capabilities for the integration and utilisation of the newly acquired knowledge. These antecedents are known as combinative capabilities that consist of various organisational or social mechanisms (Kogut and Zander 1992, Van Den Bosch et al. 1999; Zahra and George 2002; Jansen et al. 2005; Van Den Bosch et al. 2006). 'Assimilation' is the second component of the Cohen and Levinthal (1990) ACAP model, consisting of activities through which acquired knowledge is combined with prior knowledge and then distributed to different parts of the organisation (Lane et al. 2006). Assimilation implies activities or processes that allow knowledge to be analysed, processed, interpreted, understood, and internalised (Jansen et al. 2005; Lane et al. 2006). Assimilation can be highly challenging since knowledge tends to be sticky and hard to transfer (Szulanski, 1996; Tsai, 2001). Finally, 'exploitation' permits organisations to apply new knowledge within their operations (Cohen and Levinthal, 1990). It allows organisations to build new capabilities and change old ones (Zahra and George, 2002) in order to strengthen competitive advantage (Todorova and Durisin, 2007). Cohen and Levinthal (1990) specifically use R&D activity as the tool to measure ACAP. Fosfuri and Tribo (2008) indicate that firms in their study who were involved in R&D collaborations and market based transactions in R&D developed stronger capabilities to understand and assimilate knowledge flows relating to the external environment. This finding is important as it shows that there is not only one type of ACAP and that heterogeneous sources of ACAP may improve innovative performance.

Within the UIC context, a key challenge that many AEs have is developing their market based knowledge where they develop the skills and abilities in order to exploit their innovative ideas (O'Gorman et al. 2008; Rahim et al. 2015). This is further discussed in section 3.7 which differentiates scientific and market ACAP. Zahra and George (2002) identify that ACAP comprises of two subsets, potential and realised ACAP, which both have different value creating potentials, this is further discussed in section 3.3.

3.3 Potential and Realised ACAP

Zahra and George (2002) build upon the theoretical framework developed by Cohen and Levinthal (1990) discussed in the previous section 3.2. They refine the ACAP construct viewing it as a process, where they introduce two subsets of ACAP with differing value potentials - potential and realised ACAP. This research follows the Zahra and George (2002) model, as it is a widely used and still currently recognised model within ACAP research and because this research views the learning behaviours of the AE as a series of processes, arguing different types of knowledge are needed at differing stages of the ACAP process. Potential ACAP (PACAP) incorporates the two components acquisition and assimilation whereas realised ACAP (RACAP) incorporates the transformation and exploitation components (Zahra and George, 2002). Along with Cohen and Levinthal (1990) they take an organisational level perspective.

Zahra and George (2002) propose ‘transformation’ as the new component of ACAP. According to their model, transformation allows organisations to combine existing knowledge with the newly acquired and assimilated knowledge through a cognitive style known as bisociation (Koestler, 1966). This allows organisations and individuals the ability to combine two apparently incompatible sets of information to arrive at a new conjecture, where new knowledge emerges as connections are made that are not readily apparent (Lowik et al. 2017). Zahra and George (2002) argue PACAP & RACAP are complementary rather than mutually exclusive. They must exist simultaneously in order to achieve optimal performance results (Zahra and George, 2002). The distinction is important because new knowledge has to be identified and assimilated first (i.e., potential AC) before it can be transformed and exploited (i.e., realised AC). Zahra and George’s model therefore argues knowledge flows are linear moving in a sequence from PACAP into RACAP.

The linear assumption proposed by Zahra and George, (2002) is criticised by Todorova and Durisin (2007) who suggested that the transformation process is not followed by the assimilation process, but, rather, that they can be substituted for each other. Todorova and Durisin (2007) regard transformation not as a consequence but as an alternative process to assimilation. The researchers argue when new knowledge is distant from prior stocks of knowledge an organisation or individual cannot assimilate this new knowledge easily, here individuals must learn how to adapt to a new idea which they cannot assimilate. A feedback loop is therefore used in the Todorova and Duirsin (2007) model until a problem solving outcome has been reached partly based on the newly assimilated knowledge (Horvat et al. 2019). Zahra and George (2002) theoretical framework (see Figure 3.1) also suggests that the absorptive capacity process is moderated by activation triggers, social integration mechanisms and regimes of appropriability. Activation triggers are defined as events that force the firm to react to given stimuli (a “shock”). Activation triggers might be internal such as the failure of a drug compound for an academic scientist or external such as macro conditions like the downturn in an economy or a public health crisis such as a pandemic. Kim (1998) argues that discontinuous or nonlinear learning normally takes place in the presence of activation triggers. Disruptive events within the organisation break existing frames, hence, activation triggers might require a different type of knowledge that is not available within the firm. This activates search activities and stimulates learning (Fosfuri and Tribo, 2006).

ACAP is moderated by social integration mechanisms which aims are to promote the sharing of relevant knowledge between group members (Zahra and George, 2002). These mechanisms can include cross-functional teams, self-managing teams, participation in decision making, job rotation, and quality circles, among others (Jansen et al. 2005). Finally, the appropriability regime of a firm, which protects innovations and intangible assets, can comprise a range of mechanisms of varying formality (Zahra and George, 2002).

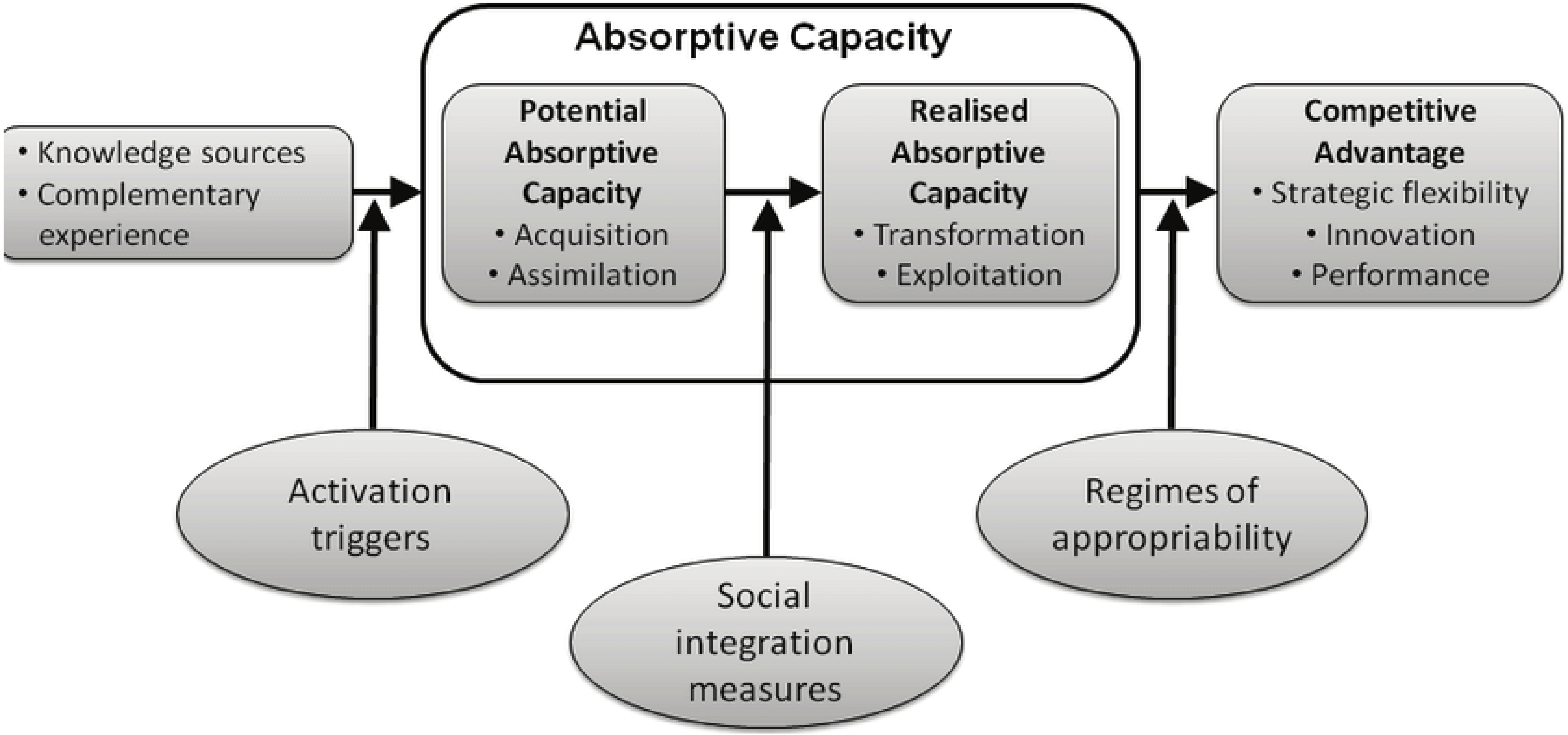

Figure 3.1 Zahra and George (2002) ACAP Model.

Lichenthaler (2016) argues from an organisational perspective, knowledge accumulations may not always enable a firm to gain advantage from external knowledge, unless an effort is made to upgrade its own internal knowledge (Lichenthalther, 2016). The presence of valuable external sources of knowledge does not imply that the flow of external new ideas and knowledge into organisations is an automatic or easy process (Vanhaverbeke and Cloodt, 2014). Implicitly, external knowledge is considered to be ‘out there’ within open innovation processes ready to be harnessed by organisations (Chesbrough, 2003), an organisation must however develop its own learning and competencies in order to leverage this external knowledge. Therefore, intensity of effort is critical for successful ACAP practices (Yao and Chang, 2017). Furthermore, Lichenthaler (2016) argues that most prior studies on absorptive capacity do not incorporate sufficient time lags with financial performance, which implies financial gains materialise immediately. Cohen and Levinthal, (1990 p136) note this in stating that accumulating absorptive capacity in one period will permit its more efficient accumulation in the next. It can therefore be stifled by time lags in its realisation. Table 3.1 provides an overview of the four sub processes within Zahra and George’s model (2002) and related behaviours/activities. The table takes a micro level perspective in alignment with the nature of the research with a discussion on individual ACAP following.

Table 3.1 ACAP Processes and accompanying behaviours/activities.

ACAP Components:	Behaviours /activities
Acquisition. An individual's ability to identify and acquire externally generated knowledge (Zahra and George, 2002).	Activities relating to the searching for new knowledge, identifying it, and evaluating it for potential use – activities related to entrepreneurial alertness such as scanning and search activities (Gaglio and Katz, 2001). Here an AE may engage in search process based on curiosity following an exploratory research trajectory or scanning and search may start from an encountered problem that needs a solution (Baglieri and Lorenzoni, 2014).
Assimilation. The individual's routines and processes that allow them to interpret, analyse, and process the external knowledge. (Zahra and George, 2002).	Here the AE engages in processes to understand the external knowledge (Zahra and George, 2002). Baglieri and Lorenzoni, (2014) identified that scientific discovery often begins with experimentation which needs to be refined into logical steps where causal relations are explained. The AE makes the knowledge understandable to other team members (post docs and Ph.D students) at this stage also Zollo and Winter, 2002). Here, the AE generates multiple ideas and prototypes which have the potential to be used as application products in market domains (Baglieri and Lorenzoni, 2014). The AE's learning at this stage reduces technical uncertainties (Baglieri and Lorenzoni, 2014).

Table 3.1 ACAP Processes and accompanying behaviours/activities (continued).

Transformation: The capability of the individual to develop and refine the routines needed that facilitate the combining of existing knowledge with the newly acquired and assimilated knowledge (Zahra and George, 2002).	Here, the AE uses different sources of knowledge from a range of stakeholders to develop new pathways and novel knowledge creation (Kogut and Zander, 1992). This stage implies that the AEs are socially skilled to be creative in groups, where the generation of new ideas occurs with the collaboration of others (Lowik et al. 2017). It also encourages perspective taking where AEs can learn and gain insights from different stakeholders with varying skillsets. (Distel, 2019). The AE combines their scientific expertise with other domain experts to develop their knowledge on market information and market needs (Hayter, 2016).
Exploitation: According to Zahra and George (2002) exploitation refers to the individual's ability to refine, extend and leverage the externally absorbed knowledge to increase commercialisation.	For this research, exploitation refers to the activities to apply new knowledge in the AE's own work routines i.e. to internalise the external knowledge (Lowik et al. 2017; Nonaka, 1994). The AE may develop improved work routines and practices by experiential learning (Kolb, 1984), learning from past experiences (Cegarra et al. 2016) or vicariously through others (Myers, 2018).

The next section discusses individual ACAP, as this is a micro level study, it is important to understand the foundations of individual ACAP and how individuals develop their ACAP.

3.4 Individual ACAP

As identified in section 3.1, Cohen and Levinthal's model (1990) highlights the important role individuals play in the development of the ACAP for an organisation. According to Cohen and Levinthal (1990 p 132) a '*firm's ACAP depends on the individuals who stand at the interface of either the firm and the external environment or at the interface between subunits within the firm'*. Their model explicitly asserts that a firm's ACAP is largely determined by the cognitive abilities and the search efforts on the part of its individual members (Sjodin et al. 2019). Since Cohen and Levinthal's work, studies on ACAP have paid little attention to the multi-dimensionality nature of the construct (Volderba et al. 2010). As a result of insufficient attention paid to different units of analysis (such as groups, projects, individuals), the ACAP concept got reified over time, i.e. became a taken-for-granted, general-purpose concept. Lane et al. (2006) identified fundamental weaknesses in the understanding of ACAP calling for a '*rejuvenation of the construct'* (Lane et al. 2006 p855). The weaknesses identified were, firstly there was a bias towards R&D activity as the metric used to examine ACAP in past literature. This bias constricts any potential use of ACAP theory in other settings. Schmidt (2005) proposes that R&D activities *"are not the only building blocks of absorptive capacity"* (p7), where Schmidt (2005) argues the stimulation of knowledge transfer and emphasis on the human capital capabilities of its members are critical components in determining organisational ACAP. Furthermore, Jansen et al. (2005) and Vega et al. (2007) also argue for a move away from R&D measures and position the role of social integration mechanisms and organisational antecedents as critical tools in developing ACAP. Another related weakness according to Lane et al. (2006) is the over-reliance and focus on R&D activity, has led to an over emphasis on the understanding of scientific or technological knowledge at the expense of how knowledge is processed or applied. Lichenthaler (2016) found that whilst technological and scientific knowledge was of critical importance in the ACAP processes, it alone however was not sufficient in developing ACAP, with market orientated knowledge also needed. Finally, according to Lane et al. (2006) there hasn't been enough attention given at the individual level within the ACAP literature.

As a result of the individual being overlooked in past studies, the existing research lacks an understanding into the role played by individuals within the ACAP literature. Volderba et al. (2010) also points to a lack of studies at the individual level stating the ACAP literature lacks a richness on how individuals in practice engage in knowledge absorption through the ACAP process (Volderba et al. 2010). Hence, there is a need to address the insufficient understanding of the micro level origins of the ACAP concept and the role of key individuals (the AE in the current study) (Lane et al. 2006; Ojo et al. 2017; Sjodin et al. 2019). This micro perspective also needs to add to the literature outside of R&D contexts (Jansen et al. 2005; Scaringella et al. 2017) and to add to the processual view of ACAP (Zahran and George, 2002; Horvat et al. 2019) where different knowledge processes are used by the AE in a UIC context. This research intends to extend our understanding in these areas.

The next section discusses the role of antecedents in the ACAP process. It analyses the key antecedents applicable to the AE therefore it takes a micro level perspective. This is deemed necessary as the aim of this research is to explore the micro level antecedents and challenges within open innovation collaborations. The antecedents are divided into PACAP and RACAP subsets, to align with the theory of Zahra and George, (2002) and their finding of the different value creating potentials of these complementary subsets.

3.5 Antecedents and ACAP in relation to the AE

In order to determine the antecedents of ACAP for the AE, the researcher conducted a Systematic Literature Review (SLR). Using the ABI/INOFRM and EBSCO (Business Source Complete) databases, the researcher searched for specified keywords relating to the antecedents of absorptive capacity and on the academic entrepreneur. The keywords used were "micro level antecedents of absorptive capacity" and "antecedents of micro academic entrepreneurship". After each query, the researcher manually searched through the abstracts to pre-screen the relevant articles. Subsequently, the researcher reviewed the references of each relevant article in order to identify published material not archived in the databases. After filtering and evaluating the initial pool of papers, the researcher extracted the papers relating to individual academic entrepreneurship. These papers were then applied to the micro level ACAP literature to deem which antecedents were most appropriate for the study. Table 3.2 provides the results of searches found from each database on the keywords. Table 3.3 and table 3.4 provide a summary of the papers analysed during the SLR.

Table 3.2 – SLR Keywords and searches found

Keywords:	ABI INFORM	Business Source Complete	Time Period
Micro level antecedents of absorptive capacity	7	6	2010- 2020
Antecedents of micro academic entrepreneurship	40	462	2010-2020

Table 3.3 PACAP antecedents from past studies

PACAP Antecedent	Influence/Description	Author(s)
Motivation and organisational commitment	Conceptualised subsidiary ACAP as consisting of aggregate levels of employees' motivation and abilities. Both of these components are necessary for knowledge transfer success.	Minbaeva et al. (2013).
Intrinsic Motivation / individual autonomy	Individual autonomy is positively related to intrinsic motivation for engaging in knowledge transfer, which increases the level of knowledge absorption.	Foss et al. (2009).
Entrepreneurial intuition	Entrepreneurial intuition refers to the affectively charged recognition and evaluation of an opportunity. This cognitive process results in gut feelings or hunches as outcomes in the evaluation of an opportunity.	Bradley (2006).
Mental models/information processing.	Mental models determine how individuals use information to make decisions. Due to the limited information processing capacity of individuals they may develop mental shortcuts (heuristics) to facilitate the recognition of opportunities.	Spicer (1998).
Entrepreneurial Alertness	Alertness, as an entrepreneurial schema bridges internal knowledge-building activity with external opportunity-related knowledge, which is positively associated with opportunity related absorptive capacity.	Patel (2019). Kizner (1973). Gaglio and Katz, 2001).
Self- Efficacy.	Self -efficacy is one's perception of their own ability to successfully undertake entrepreneurship.	Hayter et al. (2015).
Prior related knowledge (scientifically orientated)	A prior related knowledge base means an individual is more likely to associate new knowledge with existing knowledge enhancing their learning abilities.	Cohen and Levinthal, (1990). Zahra and George, (2002).
Exploratory learning processes	Exploratory learning refers to acquiring external knowledge. Exploration consists of search, variability, experimentation and discovery.	Lane et al. (2006). March (1991).

Table 3.4 RACAP antecedents from past studies

RACAP Antecedent	Influence/Description	Author(s).
Bisociation	Argues bisociative cognitive style only leads to open innovation performance when it is deployed via individual ACAP.	Lowik et al. (2017)
Network Ties	Network diversity indicates the likelihood that individuals will come into contact with persons from other knowledge domains, which increases new knowledge-sharing activities.	Hayter (2015).
Relational Capital	Refers to the level of mutual trust, respect, and friendship that arises out of close interaction at the individual level between alliance partners.	Kale et al. (2000)
Prior industrial experience	Non -academic experience and engagement is generally predictive of entrepreneurial activity among university scientists.	Rasmussen et al. (2011). Hayter, (2015).
Perspective taking	Individuals' cognitive process of perspective taking and creative behavior are important individual antecedents of organisational level ACAP.	Distel (2019).
Communicative and social skills	Personal interaction with different stakeholders supports individuals in accessing external sources of knowledge.	Enkel et al. (2017).
Knowledge sharing	Internal connectedness of an individual increases internal acceptance of external knowledge – it is crucial to inspire and engage peers regarding the underlying potential of external knowledge.	Ebers and Maurer (2014).
Prior related knowledge (market orientated)	Allows individuals to identify valuable external knowledge and apply it into market orientated contexts.	Lichenthaler (2016).
Exploitative learning processes	Exploitation consists of refinement, efficiency, selection and implementation. Exploitative learning allows an individual to gain a greater ability to acquire external knowledge on market developments, technological change and end user requirements.	Lane et al. (2006). March (1991). Cegarra et al. (2016).

Both PACAP and RACAP antecedents are discussed next, in sections 3.5.1 -3.5.1.6 and 3.6 - 3.6.4. The PACAP antecedents contribute to the understanding on how the AE develops their technical knowledge, the RACAP antecedents contributing to how the AE develops their market knowledge.

3.5.1 PACAP Antecedents of the AE.

From the SLR conducted and the antecedents identified in table 3.3, It is argued entrepreneurial intuition, mental models/ information processing, entrepreneurial alertness, self- efficacy and intrinsic motivation, exploratory learning (discussed in section 3.10.2) and prior related knowledge (scientific) are deemed most relevant for the PACAP of the AE. These will now be discussed.

3.5.1.1 Entrepreneurial Intuition

From table 3.3, entrepreneurial intuition has been identified as a key antecedent to the development of the AE's PACAP. Entrepreneurial intuition can be defined as '*the dynamic process by which entrepreneurial alertness cognitions interact with domain competence (e.g., culture, industry, specific circumstances, technology, etc.) to bring to consciousness an opportunity to create new values'* (Mitchell et al. 2005, p.667). The concept of intuition originates beyond conscious thought, includes holistic associations and results in affectively charged judgements (Blume and Covin, 2011). Intuition is the start of an individual's learning and facilitates the exploratory learning processes (Crossan, 1999). As it originates in the subconscious, it has been a difficult concept to conceptualise with many interpretations as to what constitutes intuition (Mitchell et al. 2005). Crossan (1999) differentiated two types of intuition which an individual can form, expert intuition which involves past pattern recognition developed through experience and entrepreneurial intuition which involves the ability to make novel connections by breaking out of the constraining effects of an individual's cognitive framework (Crossan, 1999). The AE makes entrepreneurial decisions under uncertainty where information is imperfect there is an element of risk associated with academic entrepreneurship (Baglieri and Lorenzoni, 2014). Strong intuitive skills assist with the discovery process of new scientific innovations where an individual can observe unfamiliar (often unorganised) cues and sets of information and synthesize this information to help them make a decision (Kickul and Gundry, 2011). Intuition therefore assists with the identification of a potentially viable opportunity (Blume and Covin, 2011). In summary, when the AE develops their entrepreneurial intuition, they are more attuned and alert to discovering innovations with the potential to meet a market need or have an impact on society, this develops their research processes for information and assists in their search processes. When the AE has developed their entrepreneurial intuition, their mental models also are enhanced (Daniel and Daniel, 2018). This is discussed next.

3.5.1.2 Mental Models / Information Processing for the AE

From the SLR conducted and as noted in table 3.3, the mental models of the AE are identified as a key antecedent to the development of their PACAP. Often AEs are experimenting and risk taking in their role, especially under exploratory research, here the AE is prone to using trial and error information processing to make sense of the information, they may also develop mental shortcuts (heuristics) based on past experience to help identify entrepreneurial opportunities (Vagely and Julien, 2010). In essence, individuals perceive, interpret and evaluate the world according to mental categories (or forms of thought, frames or mental models) which they have developed in interaction with their physical and their social/institutional environment (Nooteboom, 2007). Lane et al. (2006) proposed that individual cognition is a critical internal driver of ACAP. They argued that fundamentally the Cohen and Levinthal (1990) model was akin to an algorithmic matching process i.e. develop X amount of ACAP in Y, and then your organisation can learn Z. However this simplistic notion does not take into account the uniqueness and valuable ways in which individuals combine and apply knowledge. A key antecedent to this is the mental model processes of the individual (Lane et al. 2006). Individuals' experiences lead to the development of mental models which reflect the way individuals' value and understand new knowledge (Kim, 1993).

It is suggested that mental models not only influence the way individuals see the world, but also affect their understanding of new knowledge (Senge, 1990). Shane (2000) found that each individual has a unique set of mental models which contributes to the idiosyncratic ways in which individuals identify and exploit opportunities. The mental models of the AE can typically start off based on experimentation and trial and error learning as the AE learns new ways of working and developing the skill of matching their technical ability with a market need (Baglieri and Lorenzoni, 2014). Shane (2000) identified that each person's distinct prior knowledge generates a knowledge corridor that allows the individual *'to recognise certain opportunities but not others'* (p452). This can inhibit the ACAP development of the AE, if the AE is unable to recognise market opportunities based on previous experience, where the AE has developed inward looking ACAP based on technical knowledge alone (Lichenthaler, 2016). The next section analyses the role of alertness as an antecedent of ACAP.

3.5.1.3 Entrepreneurial Alertness and the AE.

As identified in section 3.5.1.2, past experience can allow an AE to recognise certain opportunities and not others, the mental models of the AE can be enhanced by the AE developing their entrepreneurial alertness skills. Kizner (1979) argues alert individuals have more accurate mental models. Entrepreneurial alertness refers to a '*distinctive set of perceptual and cognitive processing skills that directs the opportunity identification process'* (Gaglio and Katz, 2001 p96). Kirzner (1979) asserts that the mental representations and interpretations of entrepreneurs differ because they are driven by *entrepreneurial alertness*, (EA) which is a distinctive set of perceptual and cognitive processing skills that direct the opportunity identification process. Since Kizner's seminal work on EA, researchers have argued alertness is based on a number of cognitive capacities and processes such as prior knowledge and experiences, pattern recognition, information processing skills, and social interactions (Ardichvili et al. 2003; Baron, 2006; Csikszentmihalyi, 1996; Gaglio and Katz, 2001; Shane, 2003). Cunningham et al. (2015) found the PIs in their study, engaged in environmental scanning where they were searching for cues or ties that their innovation was both based on a market demand as well as scientific development. This finding implies, alert AEs are better attuned to the environment and changes that are occurring, they are therefore better able to reduce both technical as well as market uncertainties as they engage in the commercialisation process. The next section address the role of self-efficacy for the AE.

3.5.1.4 Self -Efficacy and the AE

From the SLR and identified in table 3.3, the self -efficacy of the AE is a key antecedent to the development of their PACAP. When the AE is dealing with uncertainties, which is often the case within the innovation process (Shane, 2000), an AE who can build resilience and a belief in their abilities is likely to develop their ACAP based on this belief. Self -efficacy theory is built on '*people's beliefs in their capabilities to produce desired effects by their own actions'* (Bandura, 1997, p. vii). It is important to note, self – efficacy is not a personality trait, it is a set of beliefs (based on their ability) that an induvial can accomplish a task(s) with a desired set of outcomes (Maddux, 2012). An individual's self -efficacy is determined largely by past experience, where the outcomes of these experiences impacts on their belief on whether they are able to achieve a desired outcome or not (Mauer et al. 2009; Bandura, 1997). It is argued, that self -efficacy and motivations for the AE are linked to their identity (Hayter, 2016). As identified, an AE that is able to maintain a hybrid role identity, has a stronger propensity to engage with academic entrepreneurship and to succeed at these activities (Jain et al. 2009). An AE with a high degree of self- efficacy is likely to be more resilient in the face of adversity and with problems they occur in commercialising their research (Da Silva and Davis, 2011). They also are more prone to taking risks, gaining mastery in their tasks and in extending their locus of search for external knowledge (Da Silva and Davis, 2011; Gaglio and Winter, 2009). It is argued self- efficacy contributes to the AE seeking external knowledge from novel sources and creativity in the innovation process which enhances their PACAP capabilities (Hayter, 2016). In summary, a self-efficacious AE is likely to experiment and test out new ideas and ways of working which develops their PACAP capabilities. The next section looks at the role of intrinsic motivation within the PACAP development of the AE.

3.5.1.5 Intrinsic Motivation and the AE

As mentioned in table 3.3 intrinsic motivation has been identified as key antecedent to contribute to the PACAP of the AE. Intrinsic motivation represents a self-determined behaviour instigated by an individual's personal willingness and genuine desire, which results in intangible outcomes such as self-pride and task accomplishment (Antonioli et al. 2016). Individuals who are intrinsically motivated are also likely to have a learning goal orientation which refers to an individuals' disposition to seek an increase in their competency levels and to understand and master something new (Dweck, 1986). These individuals are motivated by mastering the underlying task and are driven by a curiosity with a strong disposition to learn (Dweck, 1986). These individuals are also more likely to acquire the skills and underlying knowledge within problem solving tasks (Ojo and Raman, 2016) and therefore possess strong ACAP capabilities. For the AE, Orazbayeva et al. (2019) identified that due to the social responsibility and pressure on the AE to make an impact with their research, this has stimulated AEs using self -directed behaviour in collaborating with industry. Moreover, Lam (2011) found the intrinsic satisfaction derived from commercial engagement itself, emerged as a central motivation shared by many of the AEs in their study.

In addition, Antonioli et al. (2016) found intrinsic motivations alone are sufficient as antecedents of scientists' entrepreneurial intention. However, this effect was mediated by both the academic position of the scientists and the working context in which the scientists were embedded. Guerrero et al. (2008) and Hayter (2011) identified the desire for independence, achievement, skill enhancement, intrinsic satisfaction and self- realisation were the key drivers of intrinsic motivation for the AE (Guerrero et al. 2008; Hayter, 2011). These findings imply that AEs who are intrinsically motivated are more likely inclined to develop the skills and knowledge needed to engage in the commercialisation process. This also facilitates completing tasks for the AE where there are uncertainties and complexities involved as they assimilate external knowledge. In summary, it is argued the intrinsically motivated AE has a tendency towards possessing higher ACAP capabilities.

3.5.1.6 Prior related knowledge and the AE

The final antecedent contributing the PACAP of the AE is prior related knowledge (scientific). Absorptive capacity is identified to be path dependent in nature therefore significant emphasis is placed on prior related knowledge (Cohen and Levinthal, 1990; Zahra and George, 2002). Cohen and Levinthal (1990, p136) state '*prior knowledge permits the assimilation and exploitation of new knowledge'*. Prior experiences facilitate knowledge absorption by defining the locus of knowledge search (Lane et al. 2006), thus an individual is able to recognise and internalise external information that is related to those stored in their memory (Ojo and Raman, 2016). Lichenthaler (2016) argues that there is an overemphasis on prior related knowledge within the ACAP literature. Even though an individual needs prior related knowledge to develop absorptive capacity, Lichenthaler (2016) argues focusing on prior related knowledge may lead to a self-reinforcing tendency to ignore completely new knowledge. Over reliance on prior related knowledge, a core notion behind the absorptive capacity concept (Cohen and Levinthal 1990), can thus have negative consequences that may arise from the emphasis on related rather than distant or completely new knowledge (Lichenthaler, 2016).

At the individual level, it is argued that prior knowledge increases the risk of becoming cognitively bound by the widely acknowledged overlooking more distant information, thus limiting one's creative potential (Prandelli et al. 2016). Furthermore Winklebach and Walter (2015) found reliance on prior knowledge may breed competence traps and an inability to foresee opportunities beyond the familiar. Recently, the concept of perspective taking (Distel, 2019) has been debated as a more generic and sustainable antecedent to ACAP than prior related knowledge, often suggested as the ultimate antecedent of absorptive capacity (Cohen and Levinthal, 1990; Zahra and George, 2002). For an AE, the social networks and accessing a diverse network structure has been found to be a challenge especially for nascent AEs (Hayter, 2015). Nikiforou et al. (2018) found that typically, the networks of AEs begin as being quite homogeneous in nature with AEs having a tendency to team up with other academics sharing similar experiences and mindsets, this homogeneous composition however restricts the access to market knowledge and access to networks. The result of this, is for the AE to overemphasise the technical or scientific attributes of their innovation whilst neglecting the market or social impact of their research. As identified in this section, this can inhibit the AE and competency traps can develop. Whilst prior scientific related knowledge is important to develop the technical aspects of the innovation, it is not the only type of knowledge that is required. (This is discussed further in the next section).

In summary, the antecedents that contribute to the development of the PACAP of the AE are entrepreneurial intuition, entrepreneurial alertness, mental models, self-efficacy, intrinsic motivation, exploratory learning (discussed in section 3.10.2) and prior related scientific knowledge.

3.6 RACAP Antecedents

From the SLR conducted and as identified in table 3.4, the following RACAP antecedents of the AE deemed most relevant to this research are learning processes, (discussed in section 3.10.2) network ties (diversity & density), prior industrial experience (see section 3.7) relational capital, bisociative decision making and knowledge sharing, finally a section of scientific vs market ACAP is discussed which discusses some of the mechanisms to translate PACAP into RACAP.

3.6.1 Network ties (diversity & density) and the AE

The first antecedent contributing to the development of the AE's RACAP are network ties. firstly, a short synopsis on network theory is outlined and then the implications for the AE are discussed. The strength of ties theory (Granovetter, 1973) argues strong ties are associated with the exchange of fine grained information which is usually complex and tacit in nature (Elfring and Hulsink, 2003). Strong ties develop commonalities in the way network member's think and interact and this shared cognition is built upon strong levels of mutual trust and respect for each other (Lewin and Cross, 2004). Furthermore, trust is important for a network as it allows for the willingness to listen and absorb the knowledge of others, more freely, provide useful information and reduces conflict and the risk of opportunism within a collaborative process (Levin and Cross, 2004). However, it has been argued that after a certain point strong ties can become over embedded within the network, which restricts knowledge searches to local connections (Tortoreillo et al. 2014) and as a result stifles the generation of new ideas with the risk of members becoming cognitively locked in and bounded by groupthink (Hayter, 2013; Dooley et al. 2013). The absence of a connection to individuals important to enterprise success within an entrepreneur's social network demonstrates what Burt (1992) terms a 'structural hole'. By bridging structural holes, actors can benefit from establishing ties that bridge these otherwise unconnected actors (Burt, 1992). Occupying a bridging position provides an opportunity to wield power, or influence on those who are otherwise unconnected to the broader network (Krackhardt, 1995). Tortoreillo et al. (2014) found individuals' position in the internal knowledge-sharing network was an important characteristic in the relationship between external knowledge and an individuals' ability to generate innovations based on that knowledge. In particular, occupying positions rich in structural holes (Burt, 1992) is significantly associated with a higher likelihood of generating innovations based on external knowledge. The AE's network consisting of structural holes and network homophily are challenges in the development of the AE's RACAP, this is discussed in the next section.

3.6.1.1 Social networks and the AE

Prior research has identified that AEs are central actors within the entrepreneurial ecosystem (Carl, 2020). Kidwell (2013) found AEs are moving beyond their functional roles to practice boundary spanning activities as they create value by bridging structural holes and building trust through specific brokering activities. Social capital is an important contributor to the commercialisation pursuits of academic research (Hayter, 2013), yet typically the social networks of academics are constrained to narrow scientific research networks (Hayter, 2016; Mosey and Wright, 2007). The network homophily often present in an academic's social networks consist of structural holes (Burt, 1992) and gaps in knowledge and resources for successful academic entrepreneurship (Robertson et al. 2019). As a result, of the diminishing knowledge benefits from strong ties over time an individual is motivated to search for more novel and diverse knowledge (weak ties). For the AE, they may seek to develop their weak ties with actors outside the boundaries of the department/ university in order to develop the knowledge and skills necessary for venture creation (Mosey and Wright, 2007). By developing their ties with actors from different institutional spheres, the academic can develop their learning and knowledge. As they leverage this new knowledge, this helps the AE improve their absorptive capacities (Dell'Anno and Giudice, 2015). Prior research concluded that both weak and strong ties are important for innovativeness (Hansen, 1999) and these ties provide different yet complementary roles (Lowik et al. 2012). The challenge here is for the AE to have access to networks with the optimal mix of local connectiveness and interactive learning yet diverse enough to allow for novel and specialist knowledge from a range of stakeholders to allow for the development of their ACAP (Dooley et al. 2013).

In summary, as mentioned in section (3.5.1.6) AEs have a tendency to team up with individuals with similar mindsets and values (Nikiforou et al. 2018) this however can present as a challenge as the AE seeks out diverse knowledge needed to provide solutions to market needs (Carl, 2020). Thus, AEs who can hold central positions within diverse network compositions allow for the development of their RACAP.

3.6.2 Relational capital and the AE

From table 3.4, the next antecedent to the development of RACAP is relational capital.
Relational capital refers to the '*level of mutual trust, respect, and friendship that arises out of close interaction at the individual level between collaboration partners'* (Kale et al. 2000 p218). It is based on social capital theory and facilitates cooperation between members of a collaboration (Chang and Gotcher, 2007). Relational capital based on interpersonal ties such as trust, information sharing and joint problem solving allows for learning to happen with actors who possess different domains of knowledge (Collins and Hitt, 2002; Kale et al. 2000) (see section 3.10.7 on relational learning for further discussion). Relational capital allows people to seek feedback and help without fear of criticism (Carmeli and Azeroual, 2009). For an AE, the building of their relational capital allows for relationship building to occur with other stakeholders within the innovation ecosystem, this rapport built up with contacts such as TTO, industry, clinical input and business expertise, facilitates the development of their RACAP, as they are interacting with individuals who hold different domains of expertise, where the AE can learn and take perspectives from (Hayter, 2016). In summary, relational capital facilitates help seeking behaviours for the AE by seeking out expertise and domain knowledge from others which complements the AE's own cognitive repertoire and knowledge (Carmeli and

Azeroual, 2009). The next RACAP antecedent is decision making which is discussed in section 3.6.3.

3.6.3 Decision making – bisociation and the AE

As identified in table 3.4, decision making has been identified as an antecedent to the AE's RACAP. Bisociative decision making is usually applied at the transformation stage of the ACAP process (Todorova and Duirsin, 2007). The transformation stage requires individuals such as the AE to not only possess domain specific knowledge but also the ability to break existing cognitive frameworks using information from a wide variety of sources enabling the individual or AE to generate new ideas (Zahra and George, 2002). Bisociative decision making style facilitates this, by allowing individuals to use imagination and creativity to seek solutions outside their knowledge domains, where they discover connections which are not readily apparent (Lowik et al. 2017). Here, the individual or AE is needed to 'think outside the box' as they generate original ideas (Ko and Butler, 2006). Bisociation also requires unlearning (Koestler, 1964) (see section 3.10.3 for further analysis on the role of unlearning) as older less relevant knowledge may need to be unlearned before any new decision making strategies are adopted. Lowik et al. (2017) identified that a bisociative cognitive style allows the AE search for unknown solutions and new working methods. This creative process helps the AE to join the dots regarding diverse sets of information and seek out novel solutions to problems (Ko and Butler, 2006). In summary, due to AEs having a high level of technical knowledge, they may lack generalist knowledge or knowledge on the market need, by developing a decision making style based on bisociation, this facilitates the development of their RACAP. The next RACAP antecedent is knowledge sharing.

3.6.4 Knowledge Sharing and the AE

From the SLR and as identified in table 3.4, knowledge sharing is a key antecedent in the development of the AE's RACAP. When an AE and industry partner share knowledge the they can benefit from the synergies of knowledge sharing as U-I knowledge transfer has been found to be complementary in nature (Bozeman, 2005; Collins and Hitt, 2006). The sharing of knowledge enables the AE to gain insights from individuals from a different domain of knowledge and allows them to take the perspectives of others (Distel, 2019). As the AE gains valuable downstream know how and experience and different perspectives and insights, they can refine their technological outputs towards a more market related orientation. The sharing of knowledge can be problematic however, with issues around opportunism, secrecy, and IP protection facing both parties. (Bruneel et al. 2010). Gumusay and Bohne (2018) identified that AEs may be reluctant to share knowledge when they mistrust and/or when they are sceptical of the intentions of others within the entrepreneurial ecosystem. Knowledge sharing usually requires close interaction due to the tacit and complex nature of UIC projects. When a common language can be found in how knowledge is transferred between U –I partners, this can overcome potential barriers in the knowledge transfer process (Lowik et al. 2017). In summary, the AE can engage in joint sensemaking (further discussed in section 3.10.8.2) when they share tacit knowledge with industry, this allows for the potential of conflicts to be reduced and for the AE to actively engage and seek out knowledge from other stakeholders, therefore facilitating the development of their RACAP.

In summary, the RACAP antecedents for the AE identified are diverse social networks, bisociative decision making, knowledge sharing, building of relational capital and prior industry experience (discussed in section 3.7) and exploitative learning processes (discussed in section 3.10.2). Without the AE being able to develop these antecedents it is unlikely they will accumulate their RACAP knowledge. This implies they may struggle with identifying market needs and end user requirements which are key outcomes from the RACAP process. This is discussed further in the next section.

3.7 Scientific vs Market related ACAP in relation to the AE

Scientific ACAP refers to state of the art, academic expertise and specialised knowledge in a specific domain (Belderos et al. 2016). Specialised technological knowledge that the AE possesses is highly tacit in nature, the complexities and idiosyncratic nature of this knowledge makes it naturally excludable to other stakeholders within the UIC innovation process (Zucker et al. 2001). The transfer of knowledge in this context therefore requires repeated close interaction between partners (Karnani, 2013) as typically these inventions do not self- disclose (i.e. do not intrinsically reveal how they are made and used). Murovec and Prodan (2009) argue ACAP is a two factor structure comprising of '*demand – pull'* and '*science push'* components. Science push ACAP is based on scientific information and driven by entrepreneurial universities based on scientific capabilities whereas demand pull ACAP is based on market information and driven by end users, suppliers, competitors and market requirements. Furthermore, Lichenthaler (2016) identified two distinct types of knowledge namely technological and market related knowledge and argued that an individual's prior knowledge should possess both of these components to increase their ACAP. Due to the specialised nature of technological knowledge, it is likely to be insufficient for recognising the market value of technologies and for exploiting them (Lichenthaler, 2016). Market related ACAP can be gained from prior industrial work experience (De Cleyn et al. 2015). It allows the AE to gain the knowledge and experience needed surrounding the market orientated applications of their technology which facilitates the exploitation of their innovations (O'Gorman et al. 2008). Tartari et al. (2012) found that AEs who coupled previous academic and industry work experience had a stronger propensity to engage in commercialisation activities. Furthermore, Gulbrandsen and Thune (2017) found the academic scientists with non- academic work experience (industry experience) described their work as more applied in nature with a stronger orientation with interacting with groups outside of the university and a stronger appreciation of the market potential of their technologies. Munshaw et al. (2019) found that human capital gained from prior industry experience had a strong influence on the behaviours of academic scientists. Specifically, the AEs in their study with prior industry experience were 'more *knowledgeable about the mechanics of commercialisation and significantly more likely to report patent applications'* (p1231).

In order for the AE to gain market orientated knowledge, along with prior work experience, learning has been found to be a critical underlying mechanism to facilitate the exploitation of academic entrepreneurship (Baglieri and Lorenzoni, 2014). To date, research on ACAP has over relied on using R&D or scientific and technological knowledge as the primary way in which ACAP has been examined (Scaringella et al. 2017; Lichenthaler, 2016). This over reliance or bias towards scientific knowledge has overlooked other important knowledge capacities in how individuals such as AEs exploit technological innovations. Other important sources of knowledge are market knowledge (Lichenthaler, 2016) and the role of social innovation and solving unmet needs (Carl, 2020).

In summary, the knowledge development for the AE is a multi-dimensional construct, this requires a diverse set of capabilities to be developed in order to for the AE to commercialise their research. The next section discusses the knowledge capacities needed for the AE to engage in academic entrepreneurship.

3.8 Extending the knowledge capacities perspective in an academic entrepreneurship context

As identified in section 2.1, knowledge flows within UICs are bidirectional in nature consistent with the OI perspective (D'este et al. 2012) i.e. flows of knowledge can be inward and outward flowing into and from an organisation. Absorptive capacity as a theory only focuses on the inflows of knowledge (Zahra and George, 2002; Cohen and Levinthal, 1990), however, other pathways of knowledge flows are possible. i.e. the outflow of knowledge from an organisation and simultaneous inflows and outflows of knowledge referred to as the coupled process (Chesbrough, 2003). Lichnethaler and Lichenthaler (2009) adopting an integrated approach respond to this limitation of ACAP and extends the knowledge management literature. Their framework provides an integrated view on capacities needed to manage knowledge flows across boundaries such as those with a UIC context (Sshaarschmidt, 2012). Lichenthaler and Lichenthaler, (2009) introduce the term 'desorptive capacity' to describe the knowledge needed to find suitable applications of technological innovations. ACAP according to Lichenthaler and Lichenthaler, (2009) does not include the realisation part of the Zahra and George (2002) model, where leveraging of the knowledge that has been absorbed is a function of the innovative and desorptive capacities in the Lichenthaler and Lichenthaler, (2009) model. DCAP has been developed to analyse the OOI (Outbound Open Innovation) practices and outflows of knowledge from an organisation, it is therefore a complementary theory to ACAP which extends the OI paradigm (Lichenthaler and Lichenthaler, 2009; Sshaarschmidt, 2012; Hu et al. 2015). Ahn et al. (2016) identified there is a lack of research examining the outward knowledge transfer process. Cunningham et al. (2016 p794) identified a gap in the literature related to the DCAP of the AE. Their research identified further research on '*how do PIs actually contribute to value creation and capability development within and beyond the academic environments'*.

As identified in section 2.3.2, the open innovation philosophy has had an influential effect on the AE where they have pressures to extend their remit with the need to develop their skills and knowledge (Hayter, 2016). Based on this, the AE is challenged with not only accumulating their knowledge and learning from both a technical and market viewpoint but also on how they exploit their knowledge where they make an impact with their research and contribute to solving market needs. In summary, the theory of ACAP is not sufficient alone to understand the knowledge processes and skills gained to examine how AEs successfully engage in academic entrepreneurship, the DCAP of the AE is a critical knowledge capacity needed to implement OOI practises. DCAP is further discussed in the next section.

3.9 Desorptive capacity and the AE

As identified in the previous section, DCAP is a key capability underlying the OOI philosophy (Lichenthaler and Lichenthaler, (2009). DCAP is used as the mechanism for identifying what knowledge resources have economic value for an organisation and the ability to transfer the knowledge to realise value is termed desorptive capacity (Lichenthaler and Lichenthaler, 2010). Lichenthaler and Lichenthaler, (2009) propose two main stages of desorptive capacity within the external technology exploitation process; (1) the identification of technology transfer opportunities, and (2) the transfer of the technological knowledge. DCAP is in its research infancy (Behman et al. 2018; Dell'Anno and Giudice, 2015; Meinlschmidt et al. 2016).

Hu et al. (2015) argues primarily DCAP can be achieved from two sources (1) collaboration with various external partners, which allow for pathways for the exchange of knowledge and resources and (2) an individual's learning from their own technological trajectory. Individuals, such as AEs, who learn from a cumulative process of incremental problem defining and solving activities, build up a knowledge base that is unique and distinctive. The path dependency of this specific learning to the individual in part determines their potential to transfer knowledge outwards (Hu et al. 2015). The path dependency aspects of ACAP is widely known and acknowledged (Horvat et al. 2019, Cohen and Levinthal, 1990), however less attention has been emphasized on the path dependant nature of DCAP (Sikimic et al. 2016). In summary, the development of the DCAP of the AE requires them to interact with a range of stakeholders to identify market opportunities and to refine their knowledge and processes in order for them to make an impact with their research. This can present a number of challenges for the AE which is discussed in the next section.

3.9.1 Challenges with developing DCAP in relation to the AE.

There are a number of challenges with developing desorptive capacity capabilities for the AE. Firstly, prior research has identified, that AEs often lack market knowledge and due to this limited knowledge do not fully understand end user needs and requirements (Jones and Coates, 2020; Woolley, 2017; Rahim et al. 2015). Secondly, AEs may be reluctant to transfer knowledge and ideas to collaborative partners in case they are selling core tacit knowledge

(Lichenthaler and Ernst, 2012). Within the UIC context, a not sold here bias can inhibit the actions of the AE to engage in outbound technology transfer activities, this bias stems from a perceived threat of loss of privilege and superiority that can develop with knowledge sharing activities from university to industry (Dell'Anno and Giudice, 2015). Also knowledge asymmetries and market imperfections are challenges when developing DCAP for the AE (Hayter, 2016). The AE often lacks the knowledge on the market potential and relevancy for a market application of their technology whilst the industry partner often lacks the knowledge about the specifics of the technology, these knowledge asymmetries contribute to the challenges of the AE developing their DCAP (Hu et al. 215). The next section discusses the forms of DCAP for the AE.

3.9.2 DCAP of the AE

In the UIC context, forms of DCAP for the AE can include, publishing in business/academic journals including co-authoring with industry scientists to disseminated knowledge, exposure of internal knowledge into the public domain via participation in academic and business conferences, listing patents domestic/international[1] (Ahn et al. 2016), out licensing agreements and spin out formations (Sikimic et al. 2016). D'este and Patel (2007) found that AEs who interacted with industry through a wider set of mechanisms are more likely to build the capabilities necessary to bridge the gap between scientific research and application. Some of the 'soft' mechanisms such as publishing and conference presentations can influence the 'hard' mechanisms such as out licensing and spin offs as they signal prestige, competence and a specialised skill and knowledge base to external potential partners. The mix of these interactions with established partners helps build the DCAP of the AE by gaining valuable technological and market knowledge (Ahn et al. 2016).

An AE can benefit from their market knowledge that they have accumulated in their prior internal innovation activities to help develop their DCAP. For example, Sikimic et al. (2016) found that repeated execution of in licensing transactions contributes to the development of higher out licensing capabilities due to the commonalities that exist between both activities in terms of skills and tasks required. Similar activities include, technology and market intelligence, partner selection, technology transfer and contract monitoring, IP valuation and

[1] A large number of patent citations represents high status, this signals competence and prestige to the patents underlining the out licensing agreements (Hu et al. 2015).

negotiation skills. It can be therefore argued that the new knowledge base of the AE that was either acquired internally from their own learning processes or acquired externally using the ACAP construct, provides the basis for any subsequent outward technology exploitation (i.e. development of DCAP) (Lichenthaler and Ernst, 2012). Learning is a critical mechanism in how the AE translates their scientific knowledge into market related knowledge (O'Gorman et al. 2008). The next section discusses the role of learning as an underlying mechanism within the ACAP and DCAP constructs.

3.10 Overview of the learning literature

This section evaluates the learning literature that corresponds to the development of the ACAP and DCAP of the AE. The first section introduces the concept of learning and differentiates single vs double loop learning, then the learning literature is analysed as an underlying mechanism within the development of ACAP and DCAP, the role of unlearning is then examined and finally the different types of learning are analysed. Explorative learning is discussed in section (3.10.2) as a key antecedent to the development of PACAP and exploitative learning as an antecedent to the development of RACAP and DCAP for the AE.

3.10.1 Learning and the AE

Learning is a fundamental mechanism in the entrepreneurial process (Shane, 2000). The literature on how individuals learn spans the cognitive, social and behavioural sciences (Rae and Carswell, 2011). Learning involves some form of change which enables an individual to do things differently (Agbim et al. 2013). It has been regarded as a discursive process where an individual engages in sensemaking to gain a better understanding of their external environment (Rae, 2000). It can encompass both relatively passive ways of learning such as learning by doing and more deliberate cognitive processes such as articulating and codifying knowledge (Zollo and Winter, 2002; Schotten, 2019). It is important to note, learning differs from knowledge in that knowledge is a static concept that is activated when we put it to use, whereas learning is a continuous social process which encompasses a more holistic perspective (Corbett, 2005).

There are different theoretical viewpoints on the nature of learning including the cognitive perspective (Bandura, 1977) which focuses on the cognitive processes of acquiring and structuring knowledge, the experiential view (Kolb, 1984) which argues individuals learn through direct experience. Also, learning can be implicit (Marsick and Watkins, 1990) where an individual learns incidentally and unintentionally and occurs as a by- product of something else, also referred to as serendipitous learning (Buchem, 2011). Learning can be viewed as a deliberate process through which active and intentional processes are used by individuals to learn (Lichenthaler and Meuthal, 2012). Finally, learning can occur through observing the actions and processes of others referred to as vicarious learning (Meyers, 2018).

Within the literature a distinction has been made on single vs double loop learning. Single loop refers to when errors are corrected without altering the underlying governing values whereas double-loop learning occurs when errors are corrected by changing the governing values and then the actions (Argyris, 2002). It has been argued that single loop learning requires only a modest adjustment in actions (Rae and Creswell, 2001) whereas double loop learning involves critical self -reflection where the AE challenges previously held assumptions and creates new more appropriate routines (Brady and Davies, 2004). Double loop learning often focuses on the root cause of problems (Henderson et al. 2013). A number of research gaps exist pertinent to the AE with regards to learning firstly, Rasmussen et al. (2011) taking a capabilities perspective on academic entrepreneurship stated with only a few exceptions (Clarysse and Moray, 2004; Vanaelst et al. 2006), there is almost no research on the learning process of academic entrepreneurs. Furthermore, O'Kane et al. (2015) called on further research to focus on the strategic behaviours of AEs. This research enriches these gaps by examining the learning behaviours of the AE.

3.10.2 Learning and A/DCAP and the AE

ACAP and DCAP are not static concepts, they evolve through learning processes (Todorova and Duirsin, 2007; Lichenthaler and Lichenthaler, 2009). As an individual acquires, assimilates, transforms and finally exploits external knowledge, there is an underlying learning process happening simultaneously (Sun and Anderson, 2010; Lane et al. 2006). Individuals can store and recall memory more effectively when they have prior related knowledge on the topic (Da Silva and Davis, 2011), this happens primarily through associative learning which is where prior stored knowledge allows for new knowledge to be assimilated and linked to existing concepts, patterns and memories (King and Lakhani, 2011).

According to Cohen and Levinthal (1990) the accumulation of knowledge, allows for individuals to store and retrieve knowledge from one task to subsequent tasks enabling them to improve their learning, problem solving and decision making abilities. As a result, learning is a cumulative and path dependant process. Cohen and Levinthal (1990) argue that the more distant the acquired knowledge is to an individual's accumulated stock of prior knowledge the more difficult the learning process will be. Since Cohen and Levinthal's (1990) work, there have been a number of re-conceptualisations of ACAP with reference specific to learning. For example, Lane et al. (2006) was one of the first re-conceptualisations to incorporate underlying learning mechanisms into the construct. They argued three learning processes were used to leverage the ACAP construct – exploratory, exploitative and transformative learning.

Exploratory learning refers to acquiring external knowledge, its focus is on recognising and understanding new external knowledge (Lane et al. 2006). For the AE it enables them to become more flexible and responsive in their learning abilities and avoiding competency traps (Sun and Anderson, 2010). As identified in table 3.1, scientific discovery by AEs often begins with experimentation which needs to be refined into logical steps (Baglieri and Lorenzoni, 2014). The AE uses exploratory learning to search, discover and experiment with new potentially innovative ideas and develops these to a working prototype (Baglieri and Lorenzoni, 2014). Exploratory learning is the underlying mechanism corresponding to PACAP (Lichenthaler and Lichenthaler, 2009; Zahra and George, 2002). Exploitative learning refers to the application to the acquired knowledge. It goes beyond the assimilation of external knowledge and is associated with matching knowledge with its application to meet market requirements (Sun and Anderson, 2010). Exploitative learning is the underlying mechanism corresponding to RACAP and DCAP (Lichenthaler and Lichenthaler, 2009; Zahra and George, 2002). Some AEs are relatively inefficient at exploitative learning based on limited market knowledge complementing their prior technological knowledge (Rahim et al. 2015), hence this mode of learning is of critical importance to realise innovative potential. Transformative learning links the explorative and exploitative learning processes together and refers to maintaining knowledge over time (Lane et al. 2006). For the AE, transformative learning is critical for them to avoid losing skills and routines. Transformative knowledge needs to be reactivated by internalising it through experience (Nonaka, 1994). For the AE, this implies that the degree of novelty regarding the learning and the length of time between when transformative learning converts to the subsequent exploitative learning are critical factors that impact on their ability to transition from transformative to exploitative learning (Cohen and Levinthal, 1990, Lane et al. 2006).

As the three learning processes differ, distinct components of prior related knowledge are needed by the AE in order for them to make a societal impact with their research (Sun and Anderson, 2010, Lane et al. 2006). This concept is overlooked in the Cohen and Levinthal's (1990) model, where prior related knowledge is related to R&D activity only (Cohen and Levinthal, 1990). An excessive dependence on one type of prior related knowledge can lead to single loop learning and change that is more reactionary and adaptive in manner. In this case, new knowledge is likely to have a high degree of overlap with what is already known with the AE at risk of developing inward looking ACAP and falling into competency traps (Cohen and Levinthal, 1990). A research gap exists on how individual's utilise these three learning mechanisms within the entrepreneurial process which to date has not been given sufficient scholarly attention (Sjodin et al. 2019; Sun and Anderson , 2010; Lane et al. 2006). Also, the complementarity of multiple learning processes has been relatively neglected by prior research (Lichenthaler and Lichenthaler, 2009). The next section looks at the role of unlearning in the ACAP process for the AE.

3.10.3 Role of unlearning in the ACAP process for the AE

For the purposes of this research, RACAP is manifested in the internalising of external knowledge in the form of improved rules, procedures and problem solving routines for the AE (Nonaka, 1994). Often the process of converting PACAP into RACAP is by a trial and error process, where it is first unpacked so that it can be exploited by individuals (Carrion et al. 2012). This consideration therefore can argue that unlearning is a necessary sub process which determines RACAP performance (Carrion et al. 2012). For the AE, they may need to unlearn some habits or routines from past experience in order to improve their ACAP, also they may require a more entrepreneurial mindset (Ireland et al. 2003). An entrepreneurial mindset promotes flexibility, creativity, continuous innovation and renewal and a heightened alertness to new opportunities among others within individuals (Ireland et al. 2003). This type of mindset is required as AEs transition from their traditional role into a more entrepreneurial one. As the AE engages in entrepreneurship, unlearning may be a necessary task in the acquisition of new knowledge where the new knowledge is incompatible with their current stocks of knowledge, here as the AE learns more market orientated knowledge, this knowledge is replaced with the older less relevant knowledge and new routines are adopted (Carrion et al. 2012). Cegarra – Navarro et al. (2014) developed three unlearning mechanism to help individuals improve their ACAP – *awareness, relinquishing and relearning*. The researchers argue that firstly, an individual must develop an awareness that there is a new way of looking at a certain problem. This awareness can be created by individuals possessing a high degree of learning goal orientation (LGO) (Dweck, 1986). Next, the individual must have the desire to relinquish old habits and routines and taken for granted assumptions (Cegarra – Navarro et al. (2014). Here, the AE must transition from a mindset and set of behaviours based on traditional norms and behaviours to a new set of logics based on cooperation and collaboration (Fini and Lacetera, 2010). The traditional norms governing basic science follow the four Mertonian principles of communality, universalism, disinterestedness, and organised scepticism (Merton, 1973). These norms argue an AE should not be motivated by financial gain, they should remain detached and objective during the research process, they should disseminate all research findings to the whole scientific community as quickly as they can and finally, that AEs continually challenge conventional wisdom and remain sceptical about research results until conclusive evidence is found (Anderson et al. 2010). However, it is argued a new set of logics are imposing on the work of the AE (Bjerregaard, 2010) which encourages the AE to cooperate and cocreate more with external stakeholders (Smart et al. 2019). This can result in the AE co-authoring papers with industry partners as well as patenting, licensing and spin out formations (Hayter, 2016). Here, the AE may need to unlearn the norms and behaviours of a traditional academic scientist or engineer which focuses on basic science and fundamental research (Anderson et al. 2010) in order to learn new routines, practices and sets of behaviours conducive to engaging with academic entrepreneurship (Rasmussen et al. 2011).

Once the AE has unlearned, they can now relearn where they can look at new ways of doing things. Here exploratory learning is a core function as the AE explores new working practices and relearns by experimentation (Kim et al. 2012). This provides the opportunity for the AE to fine-tune their leaning to match the current external environment (Akgun et al. 2007). In relation to unlearning and ACAP, Leal – Rodriguez et al. (2014) argues further research is needed to assess the role of unlearning mechanisms in the tie from PACAP to RACAP. In summary, due to the opposing conflicts between traditional norms and a new set of entrepreneurial norms, the AE may need to unlearn certain behaviours, routines and practices to engage fully in academic entrepreneurship. The next section analyses the types of learning that facilitate the development of the AE’s knowledge and skills.

3.10.4 Types of learning and the AE

For the purposes of this research, the main ways in which an academic entrepreneur (AE) can learn are from learning by doing or on the job training referred to as experiential learning (Kolb 1984, Honey and Mumford, 1982). Their accumulation of skills and knowledge previously acquired referred to as congenital learning (Cegarra et al. 2016) and learning from others also referred to as vicarious learning (Yamakawa and Cardon, 2015). Each of these are discussed below. Exploratory and exploitative learning have been identified as key antecedents to the AE's PACAP and RACAP respectively from tables (3.3 and 3.4). The follow section explores the different types of learning (which can use explorative and/or exploitative learning processes) as an underlying mechanism in order to develop the ACAP and DCAP of the AE.

3.10.5 Experiential learning and the AE

As identified in section 3.10.4, experiential learning has been identified as a key type of learning used by the AE. Learning based on experience is often referred to as experiential learning (Kolb, 1984). It is an integral part of how individuals learn, grow and develop their decision making and problem solving abilities (Kolb and Kolb, 2006). During the experiential learning process, individuals are actively engaged leaners where learning typically happens through hands on direct experience (Morris, 2019). Experiential learning involves the role of risk taking as this type of learning involves novelty and challenging experiences, where critical reflection is an imperative and critical task in the learning process (Morris, 2019). AEs who learn through experience also learn in a relational way i.e. they learn through the relationship of working with an external stakeholder (this is discussed further in section (3.10.8).

One of the most influential theories on learning is Kolb's (1984) work titled Experiential Learning Theory (ELT). According to Kolb (1984 p41) learning is defined as '*the process whereby knowledge is created through the transformation of experience*'. ELT argues individuals learn in a cycle of four stages, Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualisation (AC) and finally Active Experimentation (AE). Each will be explained.

Firstly, an individual learns from concrete experience (CE), which leads to reflective observation (RO) of that experience. Next, the individual forms new ideas or modifies existing abstract ideas (AC) based on the reflection, finally the individual applies the new ideas to their context (academic entrepreneurship). ELT argues that learning is best conceived as a process not as a set of outcomes. In addition, ELT argues learning involves thinking, feeling, perceiving and behaving – it therefore takes a holistic perspective on how an individual learns. Kolb's theory also argues that all learning is relearning, where the individual develops new more refined ideas as they engage in the learning process (Kolb and Kolb, 2006). Kolb (1984) developed a learning style inventory where four specific learning styles emerged. According to the theory, individuals will have a preferred learning style that they use and not all four styles may be used. Tursky and Gallaher (2011) criticised this where they argued learning styles that are over utilised at the expense of others can lead to an incomplete learning experience and result in poor performance outputs. Loo, (2004) used the term 'effective learner' to describe an individual who can use different learning styles effectively in different learning situations rather than relying on their preferred style. Finally, Garner (2000) argued there is a misunderstanding around whether learning styles are traits and therefore stable or states in time and therefore more flexible and transient. Despite the limitations of the ELT, it is a widely used learning theory and has emerged as a useful tool in entrepreneurship research (Gemmell et al. 2012) as it focuses on learning as a process, where an entrepreneur can transform experience into new knowledge allowing them to discover new outcomes from their learning (Kolb and Kolb, 2006). This processual view of learning compliments the ACAP research, which views learning as a process with underlying mechanisms (Zahra and George, 2002; Lane et al. 2006).

Prior research has identified that AEs learn on the fly or on the job as the primary way in which they learn (Cunningham et al. 2016 and O' Kane et al. 2017). More specifically, Cunningham et al. (2014 p8) found many AEs used '*self- learning or learning through experience'* as the way they learned important managerial and leadership skills. Their research highlights a lack of support at the institutional level towards training which led the AEs to learn through experience. This finding is similar to Walter et al. (2011) who found that AEs learn how to patent through experience. Their research argues that due to constraints at TTOs, AEs learn the patent process themselves through experience, by filing their first patent and receiving the feedback on the patent application, it is through this repeated experience that the AE accumulates the knowledge on how to patent effectively. Furthermore, Cope and Watts (2000) found the AEs in their study, faced a steep learning curve when they formed a USO, where the AEs learned through experience how to successfully grow a small company. In summary, there is limited research on the learning behaviours of AEs (Rasmusen et al. 2011) to date, the research has identified AEs principally learn by doing.

3.10.6 Congenital learning

As identified in section 3.10.4, congenital learning has been identified as a key type of learning used by the AE. Congenital learning refers to the stocks of knowledge accumulated within an individual from past experiences (Bruneel et al. 2010). It is analogous to the human capital concept. Prior experience that an individual builds up regardless of where this experience has come from can be a source of learning from direct experience (Clarysee et al. 2003).Within the literature, congenital learning has been explored from the perspective of the founder of the spin off company, such as an AE (Ding, 2011). Cegarra et al. (2016) found congenital learning as a mechanism which facilitated the translation of PACAP into RACAP. They found that learning from previous direct experience allows an individual to gain a greater ability to acquire external knowledge on market developments, technological change and end user requirements (Cegarra et al. 2016).

It has also been suggested that AE's who have founded previous start ups have the advantage over novice (budding) entrepreneurs to benefit from task specific social networks ties where they learn more market driven processes and know how (Shepard et al. 2013). They also have had the opportunity to build up contacts with other university scientists turned entrepreneurs, which enables them to access information on how to navigate through the commercialisation process. By learning from experience, the AE accumulates the stocks of knowledge on how to improve their RACAP and DCAP abilities (O'Gorman et al. 2008). Also, an AE with previous start up experience, can learn from past failure with their business ventures, where they have developed an ability to recognise patterns and appropriate responses (Cegarra – Navarro and Wensley, 2009). Previous projects that AEs have undertaken can be seen as competence building experiments where they enhance their knowledge through trial and error learning (Shepard et al. 2013). For example, an academic scientist may fail to develop a new drug and on refection may find that the scientific mechanism underlying the assumptions about the target disease was incorrect, this can allow the academic scientist the opportunity to follow a more promising drug candidate pathway (Wang et al. 2016). Huber (1991) argues congenital learning strongly influences future learning, as the past experiences of spin off founders guides and directs their attention of what knowledge the founders search for and ultimately exploit. it can be argued congenital learning, ACAP and DCAP are complementary in nature with them being path dependant and accumulative over time.

3.10.7 Vicarious Learning

As identified in section 3.10.4, vicarious learning has been identified as a key type of learning used by the AE. Vicarious learning occurs when individuals learn from the behaviours and outcomes achieved by other people (Huber, 1991). It has been related to the simplistic notions of ‘copying’ or ‘matching’ others (Gioia and Manz 1985) however it is a more detailed and processual form of learning than simply copying the actions of others (Kim and Miner, 2007). It involves the actions of active listening and reflective thinking which can be reciprocal in nature, i.e. both parties can learn from each other (Roberts, 2010). At the individual level, Myers (2018) introduced the Coactive Vicarious Learning (CVL) model, which incorporates a more relational view on how individuals learn from each other.

The model argues the passive one directional way in which individuals observe and imitate others overlooks the interpersonal view of learning (Bandura 1977). CVL posits individuals are cocreators in the learning process, where they mutually share ideas, reflect on experiences, develop shared abstract understanding and new interpretations of ideas, where they can develop a more nuanced view of the experience. It therefore adopts a more experiential view of learning (Kolb, 1984). As CVL exposes individual to the experiences of others, in the UIC context, AEs are likely to be sought out as a source of specialist knowledge from which others can learn from (Belderos et al. 2016). This can happen through personal interactions such as shadowing or mentoring and also where others can seek out tacit knowledge from their past experiences (Zucker et al. 2001; Rahim et al. 2015). The AE can also learn from others with complementary areas of expert knowledge and develop their ACAP and DCAP capabilities as well as developing skills such as perspective taking and their transactive memory i.e. the awareness of who knows what information (Akgun at al. 2005). CVL is contingent on the orientation of the learning goal and motivation to learn for individuals, individuals with a strong LGO have a tendency to pursue goals related to learning and mastery of tasks (Yao and Chang, 2017) and therefore are more likely to seek out information from others and learn vicariously (Meyers, 2018).

3.10.8 Relational Learning and the AE

As identified in section 3.10.5, AEs who learn through experience also do so within the context of a specific relationship with an external stakeholder. When individuals learn in the context of a relationship, ACAP is not an absolute construct but rather relative to the relationship (Lane and Lubatkin, 1998). What can be learned through relationships is somewhat idiosyncratic, the learning processes within the relationship are experiential (learning through direct experience) rather than learning vicariously (imitating other relationships) (Knoppen et al. 2011). For example, Zucker et al. (2001) found the work of star academic scientists to be naturally excludable to others outside the collaborative group given the highly tacit, complex and specialised knowledge held by the academic scientist. Senker and Senker, (1994) found working closely with experts and learning through example and experience is how an individual or group acquires tacit knowledge. Relational learning can be referred to as a joint activity between an individual and another partner where the purpose is to share information, contribute to the enhancement of the knowledge base of the participants and their underlying capabilities. (Leal – Rodrigues et al. 2013). Leal – Rodrigues et al. (2014) found that relational learning plays a key moderating role between PACAP and RACAP. They found that relational learning activities such as information sharing on experiences of success and failure, establishing joint project teams and promoting face to face interaction facilitated the closing of the knowledge gap between PACAP and RACAP. Leal – Rodrigues et al. (2013) argue relational learning is made up of three components - *information sharing, joint sensemaking and knowledge integration.* Which will now be discussed as follows.

3.10.8.1 Information sharing and the AE

The sharing of knowledge is the process of exchanging tacit knowledge through social and collaborative processes (Nonaka, 1994). Knowledge sharing practices develop ACAP by creating an enabling environment for knowledge transfer to happen (Ali et al. 2018). For example, the sharing of best practices, idiosyncratic routines and prior mistakes are ways in which an individual can learn from the sharing of knowledge (Mura et al. 2013). Bruneel et al. (2010) found the underlying mechanism or ‘glue’ that facilitates knowledge sharing is trust. For example, trust allows for U-I partners to share commercially sensitive information and tacit knowledge and also reduces the fear that one partner will act opportunistically (Bruneel et al. 2010). For the AE information sharing allows the AE accumulate market knowledge from other domain experts and thus contributes to the development of their market ACAP. The AE can also identify market opportunities and refine their innovations based on knowledge gained from industry partners thus developing their DCAP (Rahim et al. 2015). In summary, the role of trust is of critical importance in allowing the tacit sharing of information, as identified in section 2.1, the AE and industry partner come from two different institutional spheres with diverging work practices, norms and routines embedded into their cultures.

3.10.8.2 Joint sensemaking

One way of alleviating the diverging cultures and norms between industry and academia is through joint sensemaking. Joint sensemaking incorporates the role of social learning between members of a project group and argues social relationships enable the learning process of sensemaking (Leal – Rodrigues et al. 2014). Sensemaking is a process of social construction and meaning (Weick 1993; Berger and Luckmann, 1967) in which individuals attempt to interpret and explain sets of cues from their environment (Wrzesniewski et al. 2003). As individuals differ in the way they make sense of information (Weick, 1993, Dutton, 1992) differences in mental models can result in cognitive dissonance (Nooteboom, 2007) where conflicts can arise among partners. Joint sensemaking acts as a mechanism for explaining and communicating the link between information and its meanings (Fang et al. 2018) and reduces the tensions surrounding meaning construction differences among individual group members. Joint sensemaking is of particular importance in this research, as U-I partners typically come from diverging institutional cultures, with different dominant logics, ways of working, norms and expectations (Steinmo, 2015; Davenport et al. 1998).

For the AE, it is important that they communicate the technical aspects of the innovation in a way that the industry partner will understand, as the AE is the originator of the IP, they hold the expert scientific knowledge on how the innovation works (Belderos et al. 2016). In comparison, the industry partner will have a greater understanding on the market relevancy and need for the innovation from an end user perspective (Bazan, 2019) when both parties jointly engage in sense making learning processes, this enhances both the AE and industry partner’s learning outcomes.

3.10.8.3 Knowledge integration

The final component of relational learning as identified in section (3.10.8) is knowledge integration (Rodrigues et al. 2013). Knowledge integration refers to the knowledge specific attributes gained from the relationship. Here idiosyncratic routines are developed which are context specific such as within UICs and difficult to imitate from an outside perspective (Leal – Rodrigues et al. 2014). Here, the AE can store relationship specific knowledge to their memory where collective insights, routines and procedures are learned. The AE increases their knowledge through the interaction with other experts where they gain new perspectives and insights and thus avoid falling into competency traps (Fang et al. 2018). This learning which is context specific is built upon relational capital (Kale et al. 2000). Finally, the learning intent (i.e. the propensity to learn from each other) is a critical moderator in how effective relational learning can be (Fang et al. 2018).

In summary, the types of learning (which can use explorative and/or exploitative learning processes) used as an underlying mechanism in order to develop the ACAP and DCAP of the AE are experiential learning, vicarious learning and congenital learning. As a subset of experiential learning the AE learns in a relational context based on the propensity of the AE and industry partner to share knowledge, jointly engage in sense making activities and integrate knowledge into their routines so it is not lost and can be developed. As an AE learns how to explore using (ACAP) and exploit (using DCAP) knowledge, they must also be able to balance the paradoxical tensions that these diverging knowledge domains possess, the next section discusses the challenges of achieving this.

3.11 Ambidexterity

Ambidexterity allows the AE to switch between exploratory and exploitative behaviours and learning processes as they engage with the commercialisation process. It therefore acts as an underlying mechanism in the development of the AE's ACAP and DCAP. Ambidexterity refers to maintaining both exploration and exploitation learning behaviours (Yeganegi et al. 2019). Mom et al. (2009 p 812) defines individual ambidexterity as an individual's '*behavioural orientation toward combining exploration and exploitation related activities within a certain period of time'.* They argue that an individual must possess three key characteristics in order to achieve ambidexterity. Firstly, they possess the ability and motivation to attend to conflicting opportunities, needs and goals. Second, they have the ability to multitask (i.e. being '*comfortable wearing more than one hat*' (Gibson and Birkinshaw 2004, p49) and finally they actively refine and renew their skills and expertise as well as their related knowledge. This requires the individual to be able to deal with conflict and engage in paradoxical thinking (Volery et al. 2013). Managing a paradox requires creativity, in order to capture both extremes of exploring and exploiting innovations, rather than a simple trade -off between the two opposing innovation strategies (Eisnhardt, 2000). Table 3.5 analyses the different mindsets and sets of behaviours that an individual exhibits as they follow an explorative, exploitative and ambidextrous strategy. O'Kane et al. (2015) identified that an AE can have an exploratory research agenda and still engage in exploitative projects concurrently. Table 3.5 outlines the different skills and attributes regarding ambidexterity, exploration and exploitation.

Table 3.5 - Comparison of mindsets and behaviours related to individual level exploration, exploitation and ambidextrous behaviours.

Ambidextrous	Exploration	Exploitation
Creativity. Ability to switch between different mindsets. Ability to manage role conflict as behavioural expectations may differ. Demonstrates self-efficacious behaviours. Use of paradoxical thinking. Able to embrace contradictions.	Search for novelty. Experimentation with new alternatives. Explore risky but potentially more profitable alternatives. Ability to disengage with the current task. Divergent thinking. Opportunity recognition and original ideas requires dealing with setbacks and adversity.	Using present knowledge. Focus on short term goals Use of heuristics (mental shortcuts). Using relevant stimuli. ignoring potential disruptive information. Attention to detail. Convergent thinking. Implementation of ideas requires repeated action and persistence.

Table 3.5 is adapted from (Mon et al. 2009; Rosing and Zacher, 2017; Kauppila and Templeaar, 2011; March, 1991).

3.12 Conclusion

This chapter presented a critical review of the ACAP and DCAP capacities literature which are the main theoretical lenses of this study within the broader context of OI theory. It also provided an evaluation on the literature of underlying themes such as learning, ambidexterity and social capital. Antecedents for the AE's ACAP were divided into two subsets which allows the research to follow a processual view of ACAP. The DCAP literature was explored and an argument was made why both capacities complement and enhance the OI literature. The challenges around developing the AE's DCAP was also discussed. Furthermore, the learning theories were critically evaluated from the perspective of the AE with types of learning analysed. A number of gaps have been highlighted throughout this chapter, to summarise there is a lack of research at the micro individual level of both the ACAP and DCAP literature (Sjodin et al. 2019; Lichenthaler, 2010). The over reliance of using R&D activity as the metric in how ACAP is examined has overlooked different types of knowledge needed for academic entrepreneurship such as market knowledge (Lichenthaler, 2016) and the role of social innovation and solving unmet needs (Carl, 2020). Next, DCAP was analysed which is in its research infancy with calls to further extend our understanding on the construct (Behman et al. 2018; Dell'Anno and Giudice, 2015). Therefore, this research sets out to contribute new insights into DCAP and its importance and development within a university context. The next chapter is theory development in relation to the aims and objectives of this research which will present the initial conceptual model.

Chapter Four.
Theory Development.

4.0 Introduction

This chapter synthesises and links the UIC, OI, ACAP and DCAP literature streams (chapters 2-3) and identifies the research gaps in each set of literature. Through converging these complementary research streams in order to build theory (Corley and Gioia, 2011), a conceptual model and research questions will be presented and discussed; which will form the basis of structuring the empirical analysis. In section 4.1 the UIC literature is summarised and gaps in the literature are identified. Section 4.2 summarises the OI literature and the gaps in the literature. Section 4.3 summarises the ACAP literature and gaps whilst section 4.4 summarises the DCAP literature and gaps. Next, section 4.5 presents the conceptual model which is broken down into three stages as this model views academic entrepreneurship as a series of processes. The three stages are discussed in detail, with RQs stated after each stage of the model. In section 4.8 moderators relating to the conceptual model are discussed with the chapter concluding thereafter.

4.1. Synopsis and gaps identified from UIC literature

Within the UIC literature, there is a general consensus that entrepreneurial universities have taken on a broader scope and range of activities (Etzkowitz, 2017). A number of external macro level conditions have been key drivers for change within entrepreneurial universities. For example, legislation protecting the university in its commercialisation endeavours (Grimaldi et al. 2014), a reduction in government funding for research (Rubens et al. 2017) and research funding being increasingly linked to the impact a university has on society (Etzkowitz, 2017). As a consequence of these drivers, Davey et al. (2016) identified that the entrepreneurial university is facing an extended remit and set of activities and pressures as they seek to meet their traditional roles of research and teaching along with entrepreneurship simultaneously. Consequently, Barrioluengo and Benneworth (2019, p206) found that entrepreneurial universities have become '*strategically overloaded'* as they struggle to integrate these multiple missions into a coherent strategy and overall focus.

These external conditions, have had top down and bottom up influential effects within the entrepreneurial university (Philpott et al. 2013). From the university level perspective, it has resulted in entrepreneurial universities needing to identify additional revenue streams and to explore ways of demonstrating the impact of their research (Rubens et al. 2017).

As a result, these institutions have actively encouraged academic entrepreneurship by implementing policies, procedures, and reward structures which promotes entrepreneurship and the linkages with industry and government bodies (Redondo and Camarero, 2019; Davey et al. 2016). From a bottom up perspective, this has resulted in increased pressures for individual AEs to extend their remit and become involved with external research collaborations (Alexander et al. 2016). Consequently, Carl (2020); O'Kane et al. (2015) and Rahim et al. (2015) all identify that the AE needs a broad range of skills and capabilities beyond their core research skills in order to commercialise their research. Indeed, Rubens et al. (2017) identified that not only are they AEs faced with scarce resource allocations, but Hayter (2018) identified that a perceived lack of business acumen and social capital skills are inhibiting the third mission open innovation activities for the AE.

There are a number of contextual factors that impact on the decision and motivation of AEs (Robertson et al. 2019). Contextual factors include moderating variables at the departmental and institutional levels at the university, and the wider national and international environments which can have an influence on the work of the academic scientist or engineer (Kenny and Goe, 2004). Davey et al. (2016) identified that the AE's immediate environment consists of their department and university, where the university has a set of linkages and interdependencies with the wider national and international environments. Kenny and Goe (2004) argue the AE is nested in layers of institutional embeddedness, each having a moderating effect on their entrepreneurship activities. Interestingly, they found, a perceived lack of support at the university level can be offset by encouragement and support at the department level, highlighting the different contextual layers evident within academic entrepreneurship.

4.1.2 Gaps within the UIC literature stream

Rajolo and Vadi (2017) identified that to date, the majority of research examining UIC has taken a macro or university, firm level approach. Therefore, there is a lack of research examining the role of the individual AE within the knowledge transfer processes between universities and industry partners. Given their important role in academic entrepreneurship, researchers (Jones and Coates, 2020; Carl, 2020 and Hayter, 2016) have called upon further research to provide a deeper analysis into the micro level of UICs, in particular on how AEs are supported (Carl, 2020) and how they overcome challenges (Jones and Coates, 2020).

Furthermore from the literature review, it is clear that research on UIC is lacking a fine grained analysis on the skills and capabilities needed by the AE when pursing academic entrepreneurship activities, particularly when needing to now demonstrate their impact. Carl (2020) identifies a need for further research on how AEs contribute to social innovation which should be determined empirically. Given the increased expectation and demand to delivering on end user needs and contributing to society, the AE is now faced with not only developing their technological knowledge but also how they can contribute to solving unmet needs that add value to society (Thomas et al. 2020) . Building on this, Cunningham et al. (2016 p794) identify the need for further research to examine '*how do AEs actually contribute to value creation and capability development within and beyond the academic environments'* which signals a need to explore how they can make more of an impact within society. In addition, to the individual skill sets required for academic entrepreneurship, Robertson et al. (2019) and Davey et al. (2016) have called on the need for further research to gain a better understanding of how contextual factors can influence the AE as they engage in entrepreneurship activities.

4.2 Synopsis of the OI and gaps in the literature

From the literature review in section 2.3.1, it is clear that as universities are transitioning from an '*ivory tower to entrepreneurial paradigm'* (Etzkowitz et al. 2000, p325). They have increasingly opened up their processes and linkages with stakeholders outside of academia. There is now a trend towards a more systematic approach on how firms collaborate with universities (Gassman et al. 2010) with the boundary between academia and industry becoming more permeable as the two converge on common goals for technological advancements and breakthrough innovations (Wang et al. 2016). With the university business model becoming more open (Etzkowitz, 2017), the traditional 'Mertonian' model that emphasises open science and basic research has been challenged by an alternative model of academic entrepreneurialism that encourages commercial exploitation of research (Owen-Smith and Powell, 2001; Murray, 2006). Consequently, AEs can find themselves torn between the traditional Mertonian ideals of basic science and the reality of an imposing market oriented logic (Lam, 2010). As a result of this duality, Cunningham and O'Reilly (2018) call on further work into the antecedents of academic entrepreneurship from a micro perspective. As entrepreneurial universities engage more in open innovation processes, this has resulted in them engaging with a wider range of stakeholders (West and Bogers, 2014). These open innovation processes require the AE to possess different types of knowledge and capabilities (Lichenthaler, 2010; Ahn et al. 2016).

For instance, the AE requires market knowledge in order to understand how to refine and commercialise their research. Rahim et al. (2015) and Hayter (2016) identified however, many AEs lack market knowledge, which requires them to seek external knowledge to complement their own prior knowledge and experiences in order for them to enhance their innovation performance. Furthermore, Neves and Franco (2018) found industry networks and partners are important relationships in how AEs grow their ventures; however, in their research the AEs struggled with finding the industry partners to assist them. Neves and Franco (2018) argue there is limited knowledge about how AEs successfully identify and establish such contacts. Therefore, as identified by (Hayter, 2016) there is a need to explore how AEs can develop the networks to engage in more open innovation processes with external stakeholders.

4.3 Synopsis and gaps of the ACAP literature

As discussed in section 3.2, absorptive capacity is a dynamic capability which refers to the ability to value, acquire, assimilate and exploit external knowledge to achieve organisational outcomes (Cohen and Levinthal, 1990). It is important for an AE as it enables them to acquire, interpret and leverage valuable external knowledge combining it with their own prior related knowledge to gain new entrepreneurial capabilities and outcomes which are necessary as the AE engages with academic entrepreneurship (Zahra and George, 2002). Prior research has identified that ACAP is a multidimensional construct (Jansen et al. 2005) which exists at different levels (organisational, group, project, individual). Whilst most often studied at the organisational level, there is a need to further explore the micro foundational aspects of ACAP (Volberda, et al. 2010; Sjodin et al. 2019). At the individual level it is rooted in individual's cognition, motivation, action and interaction (Volberda et al. 2010).

Within the general ACAP literature, there is a lack of research at the individual level of analysis with individual agency being downplayed as identified by Sjodin et al. (2019). Furthermore, Ojo et al. (2016) identify there is a need for further research to clarify the effects of antecedents on individual ACAP. Zahra and George (2002) identify that ACAP comprises of two subsets, potential and realised ACAP, which both have different value creating potentials. Whilst various studies have explored the antecedents of potential and realised ACAP (Zahra and George 2002, Fosfuri and Tribo, 2008). There is still a lack of research on how to convert potential to realised ACAP particularly within an UIC context as identified by Kobarg et al. (2018).

In an UIC context, the ability to develop ACAP is important due to the different academic entrepreneurial stages which require different ACAP capabilities (See table 8.3 in chapter 8 on the stages within academic entrepreneurship). Murovec and Prodan (2009) distinguished between science push and market pull ACAP, with science push driven by scientific capabilities and market pull driven by market requirements. Prior studies usually assume there is only one type of ACAP as highlighted by Volberda, et al. (2010); therefore Murovec and Prodan's (2009) research was influential in supporting the multi- dimensional view of the ACAP theory. From an academic entrepreneurship perspective, this difference is important as it highlights the multi -dimensional capabilities and knowledge needed in order to translate scientific innovations into market applications. The ACAP literature has overlooked market knowledge in the accumulation of ACAP (Scaringella et al. 2017). This research adds to this gap in the literature from a micro perspective. Furthermore, As a result of the inherent challenges involved in knowledge transfer, Hayter (2016) has identified the need of a broader understanding of not just the characteristics leading to technology transfer but also the capabilities needed by the AE to transfer knowledge across boundaries. Further research on these factors can help mitigate knowledge asymmetries between university and industry actors, and thereby increase the bidirectional flow of knowledge (Hayter, 2016). By utilising the ACAP lens, this research will extend the limited understanding of this phenonoem.

4.4 Synopsis and gaps identified of the DCAP literature

DCAP has been identified as a complementary dynamic capability to ACAP (Lichenthaler and Lichenthaler, 2009) when transferring knowledge between U-I partners. For this research ACAP refers to the ability to acquire, assimilate, transform and internalise external knowledge into the AEs work routines and process (Nonaka, 1994; Lowik et al. 2017) whereas DCAP refers to the ability to externally exploit internal knowledge (Lichenthaler, 2016). For the AE, it is therefore necessary for them to have developed their ACAP and translated their PACAP into RACAP before they can exploit knowledge through developing their desorptive capacity. In addition to the financial gains resulting in the commercialisation of their research, as identified by Montes and Bravo, (2018) DCAP has been found to generate non- economic benefits such as entry to new markets, greater understanding of market needs and making market assessments, building of contacts and connections outside of strong ties, and gaining valuable external knowledge to develop innovation capabilities and performance.

To date, there is a lack of research on DCAP (Behman et al. 2018). Linking back to the OI literature, inbound OI and ACAP processes have received scholarly attention (Ahn et al. 2016). However, there is a lack of research on the outbound OI processes, where desorptive capacity can be used as a lens which helps to understand how knowledge is shaped and refined to meet market demands and end user requirements (Lichenthaler, 2016). University research often generates new ideas and technologies used for industry (Villasalero, 2014). A vast amount of research to date, has focused on the outcomes of private firms within U-I knowledge flows, with little attention placed on the outcomes of the AE when working with private industry partners (Moretti, 2019; Boardman and Ponomariov, 2009). By using the DCAP lens, this research can provide new insights into what are the key capabilities and processes involved when the AE exploits their knowledge beyond the boundaries of the university. Furthermore, with limited research on DCAP Meinlschmidt et al. (2016) has identified the need for further studies to extend and illuminate understanding on this concept. Within the UIC context, little research has used both ACAP and DCAP as critical capabilities in knowledge transfer processes (Dell'Anno and Giudice, 2015). As U-I knowledge flows are bidirectional (D'este and Patel, 2007), there is a need for further research to examine the complexities and interplay between ACAP and DCAP with UICs which has received limited research attention (Ahn et al. 2016, Dell 'Anno and Giudice, 2015).

In summary, by combining the gaps in the different literature streams identified in sections (4.1 - 4.4) this research will provide new insights into the micro level antecedents and challenges influencing university-industry open innovation collaboration which is the overall aim of the research.

4.5 Conceptual model development

It is clear from the gaps from the different bodies of literature that firstly, more research is needed at the micro level of analysis on the AE, and on the ACAP and DCAP literature streams (Sjodin et al. 2019; Jones and Coates, 2020). Second, gaps in literature exist on what are the skills and competences needed by AEs as they engage in academic entrepreneurship (Hayter, 2016) and how contextual factors impact the AE as they pursue academic entrepreneurship (Robertson et al. 2019). Third, there is a need for further research on how AEs are supported within the commercialisation process (Carl, 2020). Fourth, there is a need for a broader understanding of how knowledge transfer happens within UICs and how the AE facilitates this

(Hayter, 2018). Finally, more specifically, due to the more open innovation processes which now exist among U-I partnerships, there is a need for further research which examines the absorption and desorption capabilities of AEs, which are critical capabilities needed to facilitate knowledge exchange in this context. (Dell'Anno and Guidice, 2015).

New theoretical developments can be gained from converging the different literature streams in order to develop theory which will help inform new insights into how AEs can bring their innovations to the marketplace. Moreover, the supports needed to achieve this within the entrepreneurial ecosystem in order to facilitate this can be identified. By examining the challenges the AE faces, (a key objective of this research), this research can provide the impetus for training and development initiatives to be implemented at the university level. Cunningham et al. (2014 p8) found that many AEs in their study had little support and training when it came to research leadership and management with many AEs '*self- learning or learning through experience'*.

Table (4.1) summaries the different literature stream gaps and shows the potential to inform new insights through combining the different lenses.

Table 4.1 – Gaps from the different streams of literature

UIC	OI	ACAP	DCAP
To date, most of the UIC literature has been directed at the macro level of analysis with the micro level receiving less academic attention (Rajalo and Vadi, 2017). What effect do contextual factors have on the AE (Roberson et al. 2019). Further studies are needed on how AEs can be supported in their role as transformational agents within entrepreneurial ecosystems (Carl, 2020). How AEs contribute to social innovation should be determined empirically (Carl, 2020). Case study research looking at the micro level of UICs and the challenges that are faced and any commonalities in overcoming them Should be explored. (Jones and Coates, 2020).	The majority of research within OI takes a firm centric perspective, this leaves room to examine the role of other actors within entrepreneurial ecosystems (Moretti, 2019). How AEs can develop the networks to engage in more open innovation processes with external stakeholders (Hayter, 2016). How AEs develop the skills and competencies to engage in open innovation and reduce knowledge asymmetries with industry (Hayter, 2016). Further research is needed on the processes and interactions between quadruple helix members. (Garcia-Teran and Skoglund, 2019).	Further research within the ACAP literature needs to be focused at the individual level. Sjodin et al. (2019). To date, research on ACAP has over relied on using R&D or scientific and technological knowledge as the primary way in which ACAP has been examined (Scaringella et al., 2017; Lichenthaler, 2016). There is limited research on the learning behaviours of AEs (O'Kane et al. 2015; Rasmussen et al. 2011).	Cunningham et al. (2016, p794) called on further research to examine *'how do PIs actually contribute to value creation and capability development within and beyond the academic environments'.* *'Few studies have focused mainly on desorptive capacities thus, a comprehensive integrated framework of capabilities is lacking'.* Behnam et al. (2018 p6). Desorptive capacity is in its research infancy and further research is needed to explore this topic. It has been neglected and is wide open for research opportunities. (Dell'Anno and Giudice, 2015; Meinlschmidt et al. 2016).

This research aims to fill these gaps by exploring the micro level factors influencing university-industry open innovation collaboration. In order to do this, a conceptual model has been developed which links the different literature streams which will form the basis of the empirical analysis. Through using the literature reviewed in chapters 2-3, potential themes will be identified; however, as will be discussed in section 5.8, this research will use an open coding process to allow themes to emerge naturally.

The conceptual model is presented below in figure 4.1. The model is processual and has been broken into three different stages and will be described from left to right. The model depicts academic entrepreneurship as a series of processes. The first stage looks at the micro level motivators and barriers facing the AE as they decide to engage in academic entrepreneurship. From an ACAP perspective, these factors act as activation triggers, which can be described as events which cause a specific response due to internal or external stimuli (Todorov and Duirsin, 2007). The second stage describes the ACAP processes which an AE undergoes as they first search, acquire and assimilate external knowledge and then subsequently, transform and exploit this knowledge. For the purposes of this research, exploitation under ACAP is used to explain how the AEs apply new knowledge to improve their work routines. The final stage of the model describes the exploitation of the AEs internal knowledge in order to gain both financial and non- financial benefits. The endpoint of the model allows the AE to develop the skillsets and capabilities necessary to successful transfer knowledge with UICs. Within the model, the arrows represent knowledge flows or processes.

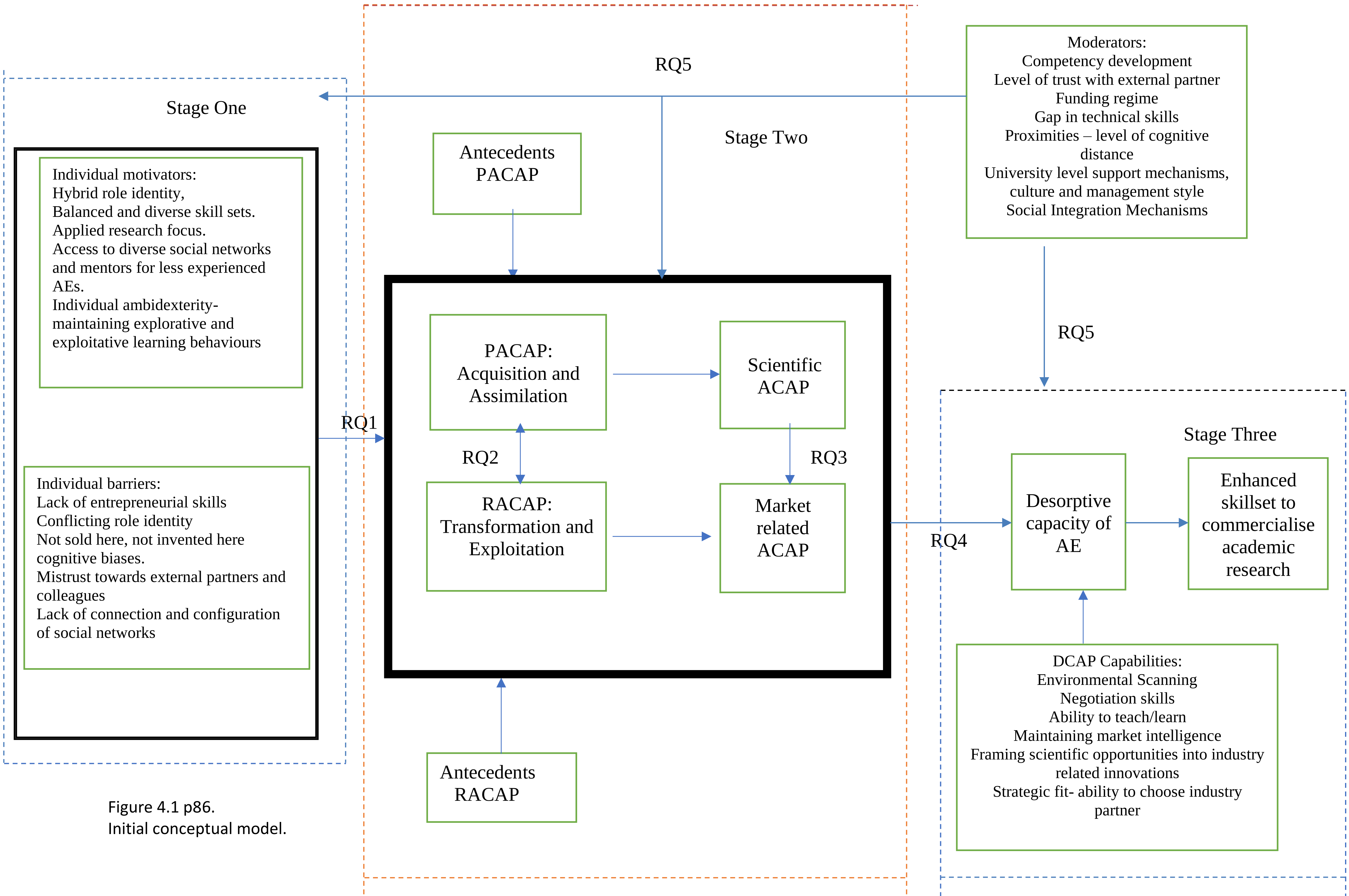

Figure 4.1 p86.
Initial conceptual model.

D’este and Patel (2007) found the decision on whether to engage with industry is a discretionary one for the AE. Therefore it is important to understand what factors influence this decision. Sections 4.5.1 – 4.5.4 discuss the micro level motivators and barriers which impact on the academic entrepreneurial activities of the AE. These factors are summarised below.

4.5.1 Role identity

The decision for an AE to commercialise their research requires them to extend their orientation above their traditional roles of research and teaching (Alexander et al. 2016). This requires them to take on additional duties that go beyond their traditional research skills (D’este et al. 2012). This is a challenging set of tasks and requires the AE to maintain agility and ambidexterity as they balance traditional duties with an extended remit of commercialisation activities. (Ambros et al. 2008). Jain et al. (2009) and O’Kane et al. (2020) have identified that the AE adopts a hybrid role identify which facilitates the shift in mindset and behaviours needed to balance traditional job duties with entrepreneurship. Baglieri and Lorenzoni, (2014) identified the ability of AEs to wear both hats (scientist and end user) enabled the AE to close the gap between the opposing logics of academia and market. In contrast, AEs that are not able to modify their role identities are conflicted with the opposing logics of market and science. Here the Mertonian orientation, academic norms and incentive systems which emphasises traditional science over academic entrepreneurship contribute to a role identity conflict for the AE. (Jain et al. 2009). Conflicting role identity affects the focus and performance of both research and entrepreneurship activities for the AE (Rahim et al. 2015).

4.5.2 Skill Set diversity

A balanced and diverse skill set can be beneficial in aligning the conflicting interests that arise from open science norms governing academia and proprietary technology norms governing industry (D’este and Patel, 2007). Human capital comprises of an individuals’ knowledge and skills acquired through their education, work experiences including on and off the job training and other life experiences (Becker, 1964). An individual possessing a high degree of human capital enables them gain superior cognitive abilities which contributes to enhanced work productivity (Goethner et al. 2012). Bozeman et al. (2001) built on the traditional human capital models (Becker, 1964, Schultz, 1971) and applied it to academic scientists and engineers. Their framework entitled Science and Technology (S&T) human capital, entails not only incorporating the AEs educational credentials but also looking at their '*tacit knowledge, craft knowledge and know how'*. (p5). Their model also highlights the importance of the AEs social capital as they engage with the commercialisation process. The S&T human capital framework argues the diversity of work experiences for the AE has an effect on their ability to form collaborative relationships and in the exchange of human capital with other actors within the UIC process (Gulbrandsen and Thune, 2017). Combining a wide variety of network ties and human capital (cognitive, knowledge-based, skills-based abilities) are important capabilities that are needed by the AE as they engage with commercialisation activities (Dietz and Bozeman, 2005). In comparison, if an AE lacks entrepreneurial skills, their ability to commercialise their research becomes more limited. Typically this AE lacks the experience and know how needed for the entrepreneurship process. Their social networks may consist of structural holes (Burt, 1992) and a lack of contacts outside of the immediate department/university inhibits their activities (Hayter, 2013). Gumusay and Bohne, (2018) found nascent AEs typically lacked access to skills and process knowledge which was found to inhibit them. This challenge can be reduced by experienced AEs opening up their own networks to nascent AEs interested in pursuing a venture (Hayter, 2016).

4.5.3 Applied Research Focus

AEs who have an applied research focus are more likely to collaborate with industry than basic science researchers (Kathoefer and Leker 2012). Applied research undergoes a process of transformation that converts basic scientific findings into potential market applications of a technology (Cassiman and Veugelers, 2006; Dasgupta and David, 1994). As a result, the AE has a strong propensity to engage with external stakeholders to acquire the skills, resources and know how needed in more downstream market orientated activities (Baglieri and Lorenzoni, 2014).

4.5.4 Cognitive Biases

The not invented here (NIH) and not sold here (NSH) cognitive biases can act as a deterrent against the AEs willingness to engage with academic entrepreneurship activities (Kathoefer and Leker 2012). NIH syndrome can be described as a prejudice against external technology, which leads individuals to prefer internal knowledge and internally developed technologies over external inputs (Antons and Piller, 2015). This bias can impede the knowledge acquisition and assimilation efforts of the AE as they exhibit tendencies to reject valuable external knowledge utilising internal knowledge from within the university alone (Dell' Anno and Giudice, 2015). Furthermore, a not sold here bias can inhibit the actions of the AE to engage in outbound technology transfer activities. Gumasay and Bohme (2018) found a *'notable mistrust at times hostility'* (p29) towards actors from outside of the university, where the nascent AEs in their study felt '*threatened and deceived'* (p30) by individuals and organisations working with logics and principles they did not share or understand.

Furthermore, this bias can stem from a perceived threat of loss of privilege and superiority that can develop with knowledge sharing activities from university to industry (Dell' Anno and Giudice, 2015). As identified, status and reputation among academics and their peer groups are important cultural norms and motivating factors for the AE (Antonioli et al. 2016). Any perceived threats of opportunism, can envelop the AE with NSH biases, resulting in barriers to engage with academic entrepreneurship.

4.5.5 Posture of Ambidexterity

When the AEs has the ability to maintain exploratory and exploitative learning behaviours, this can act as a driver for them to engage with industry partners on the commercialisation of their research (Enkel et al. 2017). The AE's ability to switch between the two modes of behaviours, enhances their capabilities when they engage with academic entrepreneurship (O'Kane et al. 2015). By maintaining an ambidextrous posture, the AE can identify opportunities for exploiting their proven research trajectories along with exploring and discovering new innovative breakthroughs and embryonic product developments (Gibson and Birkinshaw 2004; D'este et al. 2012). Their ability to maintain ambidexterity results in the AE being able to capture both sides of these paradoxical behaviours rather than a trade- off between the two. Therefore this strategic posture greatly enhances the capabilities of the AE (Enkel et al. 2017). Ambidexterity is further discussed in Section (3.11).

In summary, from section 4.5, the literature has identified many motivators and barriers which can potentially influence an AE, using an open coding process this study will add to the limited existing research in this area at the micro level, therefore the first RQ, as shown on Figure (4.1) in the conceptual model, will answer the following:

RQ 1- What are the micro level drivers and barriers which influences the decision on whether the academic entrepreneur decides to engage with commercialisation activities?

As identified, academic entrepreneurship is a discretionary act for the AE (D'este and Patel, 2007). By examining what are the individual level motivators and barriers that influence this decision, this RQ will extend our understanding on the micro level factors which impact on the propensity of the AE to engage with industry.

4.6 Conceptual model Development: Stage two

Once the AE has decided to engage in academic entrepreneurship, the ACAP model is activated. Here, the AE develops and accumulates the knowledge needed to commercialise their research. This process is likely to need a diverse skill set and external knowledge and know- how in order to develop the innovative technologies (D'este et al. 2012). ACAP has been conceptualised into two main subsets (potential vs realised) with differing value creating potentials (Zahra and George, 2002); therefore the conceptual model (figure 4.1) divides the ACAP model into these subsets with varying antecedents and outcomes for potential vs realised ACAP. The antecedents are discussed in chapter 3, section 3.5 and 3.6, to avoid repetition they are not discussed below. Learning is the underlying mechanism within stage two and stage three of the conceptual model, as identified ACAP and DCAP are not static concepts but rather evolve through learning (Todorova and Duirsin, 2007; Lichenthaler and Lichenthaler, 2009; Dell'Anno and Giudice, 2015). As the AE moves through the stages of the conceptual model, their learning adapts and enhances as they engage in learning processes to internalise external knowledge and subsequently exploit their enhanced internal knowledge. The learning literature is further discussed in sections (3.10 -3.10.8.3). The next section discusses the ACAP theory in light of the conceptual model and explains the different constructs and relationships as depicted in the conceptual model (figure 4.1).

4.6.1 ACAP

Potential ACAP (PACAP) refers to the individual internal processes of reflection, intuiting, and interpreting that an individual undergoes as they acquire, assimilate and make sense of external knowledge (Carrion et al. 2012). It involves two dimensions namely acquisition and assimilation. Acquisition refers to an individual's ability to identify and acquire externally generated knowledge whereas assimilation refers to the individual's routines and processes that allow them to interpret, analyse, and process the external knowledge (Zahra and George, 2002). An individual cannot exploit knowledge without acquiring it first, hence the PACAP processes have a direct link on the effectiveness of the RACAP capabilities for an individual (Zahra and George, 2002).

Realised ACAP (RACAP) reflects the efficiencies in leveraging externally absorbed knowledge (Carrion et al. 2012). It consists of the transformation and exploitation dimensions that are used to harness external knowledge in order to benefit from pecuniary and non - pecuniary gains (Zahra and George, 2002). Transformation refers to the capability of the individual to develop and refine the routines needed that facilitate the combining of existing knowledge with the newly acquired and assimilated knowledge; whereas exploitation refers to the individual's ability to refine, extend and leverage the externally absorbed knowledge (Zahra and George, 2002). For this research, exploitation of ACAP refers to the stage at which the AE has fully internalised external knowledge with improved learning outcomes and routines. From an ACAP perspective, an AE possesses a high degree of PACAP as these individuals are typically educated to the highest standards and are regarded as experts in their field of study (Rahim et al. 2015). They typically have developed specialised technical skills within a particular field of technology and have an in depth and extensive knowledge base within their niche area of expertise (D'este et al. 2012). However, the skillsets needed for PACAP and RACAP for the AE are likely to be different as ACAP is a process with varying capabilities needed (Sjodin et al. 2019; Zahra and George, 2002; Cohen and Levinthal, 1990). For the AE the ability to transform and exploit knowledge is more challenging as typically the AE lacks the skills and know how needed to exploit their early stage innovations (Rahim et al. 2015). The ability to convert PACAP into RACAP is of critical importance for the AE as although potential absorptive capacity is important, realised absorptive capacity is the primary source of value capture and creation (Zahra and George, 2002). RACAP can manifest itself for the AE by them developing their routines, rules, procedures and problem solving abilities needed for downstream business processes through interactions with key external stakeholders during the innovation process (Carrion et al. 2012). Within the conceptual model figure (4.1) the development of PACAP is shown as leading to scientific ACAP outcomes; whilst the development of RACAP is shown as leading to more market orientated ACAP, these terms are discussed next.

4.6.2 Scientific vs Market related ACAP

Within the conceptual model, scientific ACAP (further discussed in section 3.7) is the outcome of the PACAP processes that the AE undergoes. Murovec and Prodan (2009) identified science push ACAP is based on scientific information and driven by entrepreneurial universities based on scientific capabilities. However, it is argued to be not sufficient for recognising the market value of technologies and for exploiting them (Lichenthaler, 2016). In comparison, market ACAP (further discussed in section 3.7) refers to the accumulation of knowledge in bringing the innovation to the marketplace which is orientated towards meeting the needs of the end user, it is the outcome of the RACAP processes that the AE goes through. By converting the PACAP into RACAP for the AE, it enhances the AE's ability to evaluate and screen ideas as they are more able to transform existing routines into more established and refined ones which improves their innovation performance (Naqshbandi, 2016).

In summary, it is argued AEs already have accumulated high degrees of scientific knowledge and expertise, however how AEs develop their capabilities to convert their ACAP is underexplored and furthermore, how they accumulate market knowledge, in light of this
The second and third RQs will answer:

RQ2 -How do AEs develop the capabilities to convert PACAP to RACAP?

RQ3 What approaches are taken for the AE to develop market ACAP?

As identified in section 3.3, ACAP has been conceptualised into two main subsets (potential vs realised) with differing value creating potentials (Zahra and George, 2002). Prior research has shown the AE has a strong disposition in accumulating potential absorptive capacity with strong scientific and technical knowledge (Rahim et al. 2015; O' Gorman et al. 2008) but how is this knowledge realised into value creating ACAP? By investigating the skills, knowledge and capabilities necessary to cocreate innovations with industry successfully, *RQ2 will analyse how AEs* develop *the capabilities which are necessary for UIC technology transfer projects.* This RQ will also explore how the AE learns the skills and abilities to convert their ACAP, by analysing the underlying learning processes where a more fine grained analysis can be achieved. As identified in section 3.7, the development of an AE's technological knowledge is likely to not be sufficient to bring innovations to the market. By examining *the approaches which are taken to translate their technological knowledge into market related ACAP,* RQ3 will provide an examination into how this specialised knowledge is leveraged to enable it to be translated to meet market needs and provide value creation.

4.7 Stage three of theory development

As shown in the conceptual model (Figure 4.1) when the AE has developed their market related ACAP it is at this point where they have developed the capabilities to start exploiting their knowledge to industry partners (Dell' Anno and Giudice, 2015). In order for an AE to exploit their knowledge, they first must have developed their absorptive capacity (Dell' Anno and Giudice, 2015). As they develop their ACAP, and translate their PACAP into RACAP they combine external knowledge with their own prior related knowledge to enhance their own knowledge capabilities (Horvat et al. 2019). It is this enhanced internal knowledge, that can now be exploited in outbound OI processes. Hence ACAP and DCAP are complementary in nature and assist in the implementation of open innovation processes (Lichenthaler and Lichenthaler, 2009). Desorptive capacity refers to the ability of the AE to externally exploit their knowledge (Lichenthaler, 2010) (please refer to section 3.9 for further discussion on DCAP). Thomas et al. (2020) found the exploitation of knowledge by the AE requires them to actively scan their external environment in order to identify opportunities, by acquiring and maintaining market intelligence, the AE is able to make market assessments and refine their innovative technological outputs to meet market demands. By exploiting their knowledge in outbound open innovation processes (e.g. out licensing agreements) they are also signalling their technical and scientific capabilities to industry partners or potential partners (Ahn et al. 20016). Bravo and Montes (2018) found this can attract potential new partners and develop the connections for potential new collaboration ventures. Developing DCAP for the AE requires them to make their knowledge and innovations ready for external partners to use, this requires the AE to be able to refine their technological knowledge and innovative products towards a market orientated application (O' Gorman et al. 2008; Lichenthaler, 2016). As the AE transfers their knowledge outwards to industry partners, their ability to teach and learn from their collaboration partners is an important factors as differences in technical skills, culture, cognition, routines and expectations are likely to exist (Agrawal et al. 2001). As the AE exploits their knowledge, the industry partner must have the ACAP capabilities to implement the technological knowledge into their business processes (Fabrizio, 2009). Once the AE has successfully exploits their knowledge so that industry counterparts can use it in their business processes, they have developed the necessary skillsets needed to engage with academic entrepreneurship which is the endpoint of the conceptual model (Figure 4.1).

It is important to note, an AE may decide not to license their IP to a third party and instead create a USO. Here the AE is challenged with building a small company and developing a team to accompany them on the commercialisation journey. Nikiforou et al. (2018) argue that at the early stages of a USO, the team is homogenous in nature and is dependent on the personal network ties of the founder. Here, the AE is challenged with developing the correct team composition in their USO to enable their DCAP development (This is discussed further in section 8.4). As DCAP has been described as very difficult to acquire (Behman et al. 2018) and has been underexplored and neglected by scholars (Meinlschmidt et al. 2016) this research intends to extend the limited understanding in this concept within an academic entrepreneurship context, therefore, the fourth RQ (as shown in the conceptual model figure 4.1) will answer

RQ4 -What are the capabilities needed for the AE to develop DCAP?

When an AE wishes to exploit their innovation outputs, they require a DCAP in order to achieve this. By examining the capabilities needed in outbound OI activities for the AE, this research question will examine how the AE exploits their research to meet end user needs and make an impact with their innovation. This RQ will also explore the exploitative learning processes the AE engages with so that they can meet market demands and end user requirements.

4.8 Moderators

Within the conceptual model, a number of moderators [2] have been identified from the literature review as shown in Figure 4.1. It is argued these factors affect the strength of the relationship between the effectiveness of the ACAP and DCAP of the AE and knowledge transfer within UICs.

[2] A moderator is a qualitative or quantitative variable that affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable (Baron and Kenny, 1986).

4.8.1 Trust

An important moderating factor is the level of trust built up between the AE and industry partner. The role of trust is important in any collaboration but crucial between two parties from different institutional spheres (Thune, 2007; Ouchi, 1980) as in the case of UICs. Bjerregaard (2009) research highlighted the importance of trust, finding that trust was an important mechanism in facilitating knowledge exchange between U-I partners and reduced the impact of cultural differences. Bruneel et al. (2010) argues given the cultural, cognitive and institutional differences that exist between U-I partners, conflicts of interest are likely to arise, with a weak attitudinal alignment between partners. The development of operating routines and practices to manage the collaboration is of critical importance (Salter et al. 2009). Trust has been found to be the glue or central mechanism that helps mitigate conflicts within UICs and in the development of shared routines and practices (Sherwood and Covin, 2008). More specifically, trust allows for U-I partners to share commercially sensitive information and tacit knowledge, which in turn improves their ACAP and DCAP (Sherwood and Butts, 2004). Trust also reduces the fear that one partner will act opportunistically. If low levels of trust exist, U-I partners are likely to be less forthcoming with valuable tacit knowledge which impedes absorptive and desorptive capacities of UIC members (Bruneel et al. 2010). Conversely, when high levels of trust exist, U-I partners are more likely to engage in problem solving activities and knowledge exchange as members are confident they will be '*treated fairly and in a consistent way'* (Bruneel, 2010 p861). As a result, it is argued trust has a moderating effect on the strength of the relationship between the ACAP and DCAP of the AE and knowledge transfer.

4.8.2 Competency development

ACAP and DCAP are defined as dynamic capabilities (Lichenthaler and Lichenthaler, 2009), which are critical mechanisms underpinning the implementation of OI processes (Ahn et al. 2016). Capabilities can be seen as generic skillsets, whereas a competency is a more specialist ability or higher order know how in doing something, as a result, competence is an essential ingredient of being capable (Nagarajan and Prabhu, 2015). In order for the AE to develop their ACAP and DCAP, they must develop their competencies involved with academic entrepreneurship (Rasmussen et al. 2011). It is argued the development of entrepreneurial competences moderates the effectiveness of the ACAP and DCAP for the AE. (Please refer to section 2.4.2 for a further discussion on the capabilities and competencies needed within academic entrepreneurship).

4.8.3 University level supports

At the university level, the level of encouragement, supports and incentives for academic entrepreneurship has an influential effect on the AE's decision whether to engage with the commercialisation process (Davey et al. 2016). A university which implements clear frameworks, policies and reward structures which incentivises the AE to engage and create/ maintain linkages with industry, provides the environmental and cultural conditions which are conducive factors supporting academic entrepreneurship (Bercowitz and Feldman, 2008). As highlighted in section 2.2, on the role of intermediaries within UIC, universities have implemented infrastructures such as TTOs, affiliation with science and technology parks, incubators and research centres which helps support the AE as they commercialise their research. These intermediaries help facilitate commercial knowledge transfers of intellectual property resulting from university research through a legal agreement such as a license, patent or royalty agreement (Seigel and Wright, 2015). However, where there is a perceived lack of support at the university level, AEs can follow informal routes of commercialisation (Fini et al. 2018; link et al. 2007). Here the AE can use their previous business contacts and informal communication processes to develop their innovation outputs and both their ACAP and DCAP (Grimpe et al. 2009). Grimpe and Hussinger (2008) found that both formal and informal routes of commercialisation are complementary of each other where informal contacts improves the quality of a formal relationship.

4.8.4 Proximity

As identified in section 2.1, there is likely to be cultural, cognitive and technical skill differences between university and industry scientists (Belderos et al. 2016). A large cognitive distance between university and industry partners may impede the ACAP and DCAP of the AE, as they may not fully understand the requirements and business processes of their industrial partner (Kobarg et al. 2018). Nooteboom et al. (2007 p4) argue collaboration partners need to find the optimal cognitive distance when working with each other where there is '*sufficient cognitive distance to learn something new, but not so distant as to preclude mutual understanding'* Social integration mechanisms can reduce the effect of large cognitive distances, by ensuring members have developed trust, open communication and connectedness which helps facilitate the transfer of tacit knowledge and mutual understandings (Enkel et al. 2018). It is argued the level of cognitive distance has a moderating effect on the ACAP and DCAP of the AE.

4.8.5 Funding Regime

Broadly speaking, there are two funding streams available to the AE, public or private funding (Hayter, 2015). Public funding involves government backed initiatives to promote the commercialisation of university innovations to encourage regional economic development (Etzkowitz, 2017) where private funding can come from institutional investors such as venture capitalists or through high net worth individuals i.e. angel investors (Meyer, 2003). Cunningham et al. (2014) found a number of challenges facing publicly funded AEs as they work with public funding bodies. In their study they found funding agencies provided short notices for funding calls, inappropriate times for funding call deadlines within the academic calendar and delays in releasing contracts and payments, this created a tension between the AE and funding bodies. Shore and McLauchlan (2014) found AEs who successfully operate in the space between academia and industry are able to command external funding (private) for their research. This was typically found in AEs who founded USOs (University spin outs). They also found that increasingly government funding was invested into research themes that had a close correlation to market needs. This is due to governments wanting to see a return on their investment and benefiting the economic goals of a country. Holly and Watson (2017) identified many university start-ups emerge as a result of it being easier and faster to secure funding by the AE rather than if they applied for a research grant. This can lead to a lower probability of success for new ventures as the goal of the AE is to secure funding rather than venture creation. Robertson et al. (2019) has called on further research to analyse how contextual factors impact on the AE highlighting the importance of this RQ.

In summary, prior research has identified trust, funding regimes, proximity between collaborative partners, university level supports and competency development as potential moderators with UIC. Using an open coding process (further discussed in section 5.8) this research will provide new insights into the moderators within UICs from a micro level perspective.

RQ5 – What factors moderate the effectiveness of knowledge transfer between the AE and external stakeholders?

4.9 Conclusion

This chapter presented a synthesis of the relevant literature and theory streams and identified the gaps in the literature. This study is a micro level exploratory study into the antecedents and challenges of AEs within a UIC environment. By synthesising the relevant literature streams and identifying the gaps in the literature relating to the study, an initial conceptual model was developed. Drawing from the conceptual model and the gaps in the literature, five RQs were identified. This conceptual model will forms the basis of the empirical investigation of the study as further discussed in chapter five (research methodology). The next chapter is the research methodology chapter which is designed to show how the empirical data will be collected and analysed to address the research questions.

Chapter Five.
Methodology.

5.0 Introduction

In this chapter an appropriate research methodology is developed to address the aim, objectives and research questions derived from the conceptual model (figure 4.1). The rationale for adopting the different methodological choices for this study will be explained following the steps outlined in Saunder's et al. (2016) research onion, shown in figure 5.1. The research onion illustrates the philosophies, approaches, strategies, choices, time horizons and techniques and procedures that a researcher can chose from when conducting research. Each choice made by the researcher is explained within the different sections of this chapter.

Section 5.1 analyses the different philosophical choices a researcher can adopt. Section 5.2 analyses the different research approaches, with section 5.3 discussing the different research designs. Next, section 5.4 analyses the different research strategies where the case study strategy is further discussed. After this, the sampling strategy and selection criteria for this study are outlined. The final part of section 5.4 presents the case study setting and provides a detailed examination of the three case studies chosen for this research. Section 5.5 analyses the research design adopted for this study, with section 5.6 examining the data collection techniques used in this research. Section 5.7 provides an analysis on the interviewing strategy used in the research and a profile on each participant who took part. Next, section 5.8 explores the data analysis process used to group and categorise the data. Section 5.9 analyses the role of trustworthiness in qualitative research with section 5.10 analysing the ethical implications in conducting qualitative research, finally section 5.11 concludes the chapter.

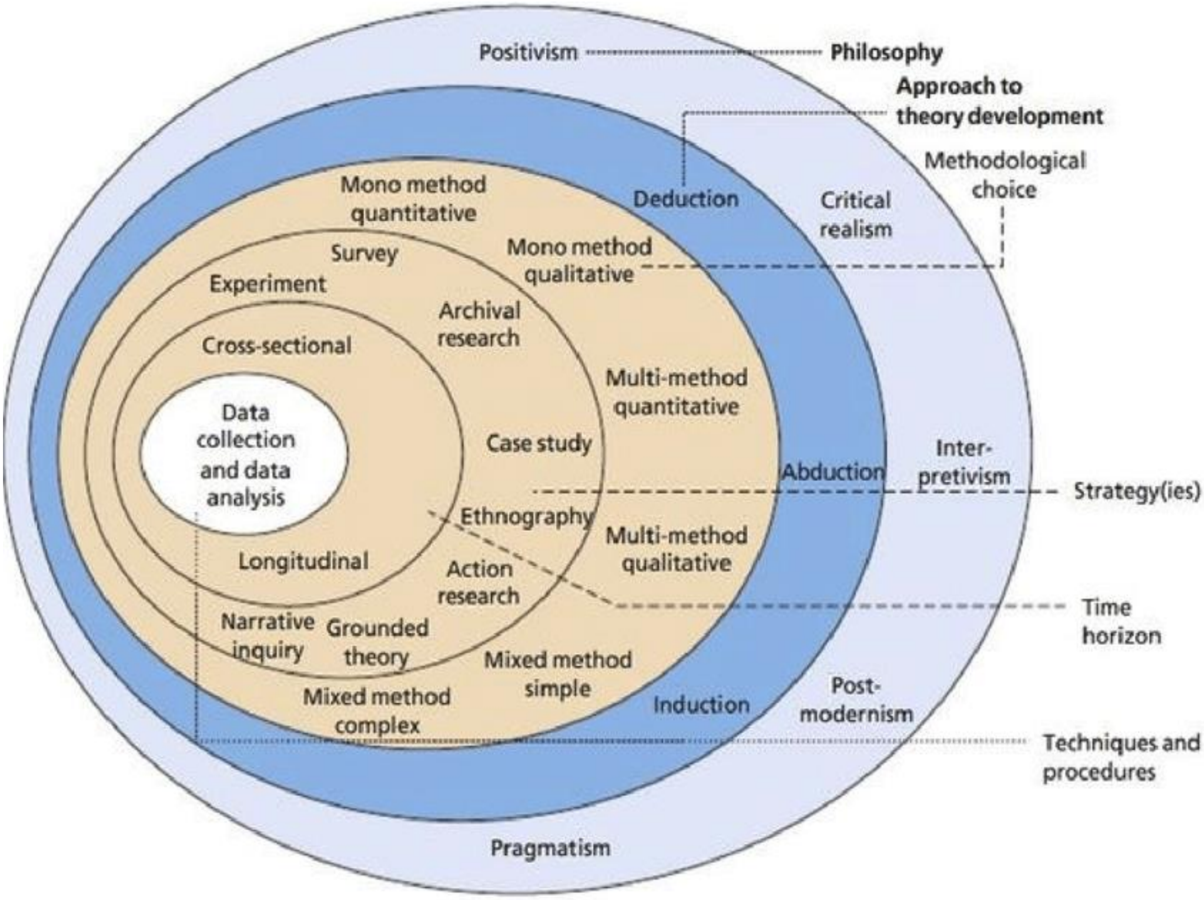

Figure 5.1 The research onion (Saunders et al. 2016).

5.1 Philosophical choices

Saunders et al. (2016) examine three main ways in which a researcher can think about their research philosophy; ontology, epistemology and axiology which helps to guide the overall research approach. Each of these philosophies contain certain assumptions, ways of thinking and views of the world and how social actors interact with the world, which have an influence on the research design and research process adopted for a research study. The ontological and epistemological choices will now be evaluated to help guide the research design and justify the methodologies chosen for this study.

5.1.1 Ontology

Ontology is a research philosophy that asked the question ‘what is’ for example ‘what is a thing’ ‘what can be said to exist’. It is involved with what constitutes reality, and questions whether something is real or illusionary (Symon and Cassell, 2012). The assumptions about the nature of reality (ontology) can be divided between subjective and objective views (Bahari, 2010). The objectivist view is that social actors '*exist in reality external to social actors concerned with their existence*' (Saunders et al. 2007 p108). This viewpoint argues reality is beyond our perceptual or cognitive structures and holds to the assumption that reality exists objectively and it's out there awaiting discovery by researchers (Symon and Cassell, 2012). The subjective view of ontology assumes that '*social phenomena are created from the perceptions and consequent actions of social actors*' (Saunders et al. 2007 p108). Here reality exists as a creation and manifestation of our consciousness and cognition (Symon and Cassell, 2012), and that a researcher's reality can change and be socially constructed (Bryman, 2012). This research takes a socially constructed ontological stance as the researcher has focussed on understanding the motivations, beliefs and assumptions from the participants; which could not be achieved from an objectivist view which views '*one true social reality experienced by all social actors'*(Saunders et al. 2009, p128). As this is a multiple stakeholder study, all the participants view the phenomena from different angles, with different work, academic and life experiences. Thus, in order to view the phenomena in a holistic way and incorporate diverging opinions in constructing reality, the subjective viewpoint was adopted as being the most appropriate research methodology.

5.1.2 Epistemology

Building on one's ontological perception, epistemology is a theory of knowledge and beliefs about how we know what we know. It asks the questions 'how can we gain knowledge' and 'how can we know' (Hansen, 2010). It therefore concerns itself with the '*nature, validity and limits of enquiry'* (Rosenau, 1992 p109). Epistemological assumptions can be viewed across the positivism – interpretivism scale (Saunders et al. 2016). A positivist epistemological stance is one where the researcher and the participants are independent entities, where the researcher discovers absolute knowledge about an objective reality (Scotland, 2012). This approach is likely to be used in a quantitative study where the researcher is likely to use existing theory to develop and test hypotheses (Saunders et al. 2016). This research approach requires a high degree of factual and descriptive analysis; however it has been critiqued by Saunders et al. (2016) in providing research that lacks richness and complexity in its view of organisational reality. A positivist viewpoint is based on the concept of realism which is the idea that objects have an existence independent of the knower i.e. there is an independence of reality from the human mind (Scotland, 2012). In comparison, an interpretivist epistemological position attempts to understand phenomena through meanings attributed to them by individuals rather than seeking an objective reality (Saunders et al. 2016). Interpretivists embrace the concept of relativism which is the viewpoint that reality is subjective and differs from person to person (Scotland, 2012). Interpretivism focuses on how individuals make sense of the world and their reality. The philosophy argues social reality is mainly determined by people rather than by objective or external factors (Easterby-Smith et al. 2008). This viewpoint is a move away from the deterministic explanation of human behaviour by establishing causal relationships between variables towards a more nuanced understanding of human behaviour, where it attempts to capture the complexities and dynamics of the social world (Reitch et al. 2010). Interpretivism allows the researcher to get up close to the participants and an ability to view the participants 'world' from their perspective, allowing the researcher to interpret their perceptions where appropriate (Leitch et al. 2010).

Given the overall aim of this research is to explore the micro level antecedents and challenges which influence university-industry open innovation collaborations and the objectives set out to explore, analyse and understand how AEs translate their scientific tacit knowledge into more market driven outputs meeting end user requirements, this research takes an interpretivist view. This was chosen because the researcher needed to understand the underlying themes of the phenomena which is not suited to an objectivist stance as each participant has their own view of the world and a unique set of experiences. The subjectivist approach enables the researcher to understand the participants point of view so the complexities and richness of the research data can be explored. Table 5.1 summarises the different viewpoints of the ontology and epistemology philosophies. The table differentiates the different assumptions underpinning each belief.

Table 5.1 Assumptions of positivist and interpretivist paradigms.

Assumption	Positivist paradigm	Interpretivist paradigm
Ontology The assumptions about the nature of reality (asks the what is questions). e.g. what is it like being a manager?	- Reality exists external to what is being observed. - Reality is considered out there and awaiting discovery. -Only one reality exists.	- Reality is socially constructed and is subject to change based on the subjective reality of the observed. - Multiple realities can exist.
Epistemology Theory of knowledge and beliefs about how we know what we know. (Askes the questions 'how can we gain knowledge') e.g. what does good look like?	-The positivist epistemology is one of objectivism. -The researcher and the participants are independent entities. - Governed by impartiality and discovering absolute truths. -Maintains an objective view of the phenomena.	- Interpretivists embrace the epistemology of relativism. - The researcher is part of what is being observed. - Governed by wanting to understand human behaviour, attempting to capture the complexities and dynamics of the social world. - Maintains a subjective view where the researcher tries to interpret and understand the participants viewpoints.

Adapted from Saunders et al. (2016), Easterby – Smith et al. (2008) and Symon and Cassell, 2012).

5.2 Research approaches

Drawing on table 5.1 from the previous section, Saunders et al. (2016) identified that a positivist paradigm lends itself more to a deductive research approach with the interpretivist paradigm lending itself more to an inductive research approach. In essence, a researcher can choose to test theory (deduction) or build theory (induction) or generate or modify existing theory with new data collection methods (abduction) when deciding on an approach to follow to develop theory (Saunders et al. 2016). If a researcher decides to inductively build theory, they are attempting to identify patterns in a particular data set in order to reach conclusions and build theory (Adams et al. 2014). Following an inductive method is more aligned to the tenants of interpretivism, where the researcher can build theory in an underexplored area of research to provide new insights and ways of thinking about the phenomena (Saunders et al. 2016). Inductive reasoning is considered highly relevant to address the aims and objectives of this research as it can allow the delving into underlying themes to gain a more in depth and holistic view of the phenonoem (Woo et al. 2018; Creswell, 1998). Conversely, if a researcher is trying to test theory (deduction) the researcher starts with a theory or hypothesis(es) before the collection of analysis of data (Adams et al. 2014), with the researcher operating from the general to the specific. Deduction is aligned to a more positivism philosophy where the researcher is able to confirm or disconfirm existing understandings typically using hypotheses (Easterby -Smith et al. 2008). For a researcher to deductively test theory, the data is analysed according to an existing theoretical framework i.e. existing theory and hypotheses must have already been developed in order to employ deductive reasoning (Kennedy and Thornburg, 2018). Deductive reasoning is often criticised for its lack of richness and underlying understanding of a research phenomenon where it uses a highly structured approach (Saunders et al. 2016). Finally, if a researcher is following an abductive approach, they are combining the inductive (moving from data to theory) and deductive (moving from theory to data) approaches of theory development. Abductive reasoning often comes about from a surprising or puzzling phenomenon where a context of meaning is being created (Zelechowska et al. 2020).

Inductive reasoning is considered highly relevant to address the aims and objectives of this research as it can allow the delving into underlying themes to gain a more in depth and holistic view of the phenomenon (Woo et al. 2018; Creswell, 1998). This research however, also follows the methodology of Plakoyiannaki and Budhwar (2021) who suggest that in order to inductively build theory it should be linked to prior literature. The researchers argue the use of pre-existing theory adds to the richness of understanding of a topic where the research can explain the causal relationships between constructs. Therefore an initial conceptual model has been developed (figure 4.1) as *a priori* themes derived from existing literature which formed the basis to inductively build theory. Furthermore, the gaps which are summarised in the theory development chapter (table 4.1) show how there is a need for further research on this topic to further develop the theory. As a result of this incompleteness, the research intends to discover new ideas and explore the topic from an inductive viewpoint to build theory in an underexplored context and aims to combine different theoretical lenses to provide new insights through an iterative process of interpreting insights with prior literature and a priori themes.

5.3 Research design

After the researcher has decided on the appropriate approach to their research, they next must decide on the design of their research (Saunders et al. 2016). A researcher has the option of three research designs to choose from for their research; qualitative, quantitative and mixed methods (Saunders et al. 2016). Quantitative research methods involves working with data that is structured, which can be represented numerically (Matthews and Ross, 2010). With qualitative research non numerical data is generated (Adams et al. 2014). If a researcher is following a qualitative research design, they need to make sense of the subjective and socially constructed meanings expressed by the participants of a study (Saunders et al. 2016). Finally, a mixed methods approach is where a researcher gathers data using both qualitative methods (e.g. unstructured interviews) and quantitative methods (e.g. statistical inferences) (Matthews and Ross, 2010). Mixed methods research can be conducted in parallel or sequentially, but they are not combined, i.e. qualitative data is analysed qualitatively, and quantitative data is analysed quantitatively (Saunders et al. 2016). An overview of the different research designs available to researchers is depicted in table 5.2. In table 5.2, researchers Hair et al. (2019); Saunders et al. (2016) and Matthews and Ross (2010) identify the differences between the different research designs, quantitative methods are typically used for large sample sizes where the emphasis is on testing data, qualitative data is used for smaller sample sizes where the emphasis is on the discovery of data and finally mixed methods can help generalise findings and provide a greater diversity of viewpoints (Hair et al. 2019; Saunders et al. 2016 and Matthews and Ross 2010).

Table 5.2 Overview of research design

Quantitative methods	**Qualitative methods**	**Mixed methods**
- Emphasis on testing data which is structured in nature. -Provides summary information on many characteristics. -High concern for representativeness (a representative sample possesses strong external validity in relation to the target population). -Strong emphasis placed on validity and reliability of measures used. -Large sample size > 50. -Ontological and epistemological approaches are positivist. -Research questions can be answered by counting events and statistical inferences. -Objective – researcher is not part of the research. - Ability to generalise from the data. - Researcher knows what they are looking for.	- Emphasis on the discovery of data. -Provides an in-depth understanding on a phenomenon with a few characteristics. -Can explore the underlying motivations and values of participants. -Less concern for representativeness. -Small sample size < 50. -Strong reliance on the trustworthiness of the participants. -Ontological and epistemological approaches are interpretivist. -Research questions can be answered by describing and explaining events. -Researcher may only have a general idea of what they are looking for with the research design being fluid in nature. - The researcher is an active member in the research as a social actor. -Typically not possible to generalise from the data.	- Can allow for meanings and findings to be further elaborated on or confirmed by combining multiple methods. -Can help to generalise findings. -Allows for a greater diversity of viewpoints. -When a first method provides insufficient data, the secondary method can provide an alternative to add validity to the study. -Mixed methods allows for a multi-dimensional focus with different attributes of a study examined. -Can lead to greater confidence in your findings i.e. the researcher is triangulating their results (use of different data collection techniques to enhance validity).

Source: Adapted from Hair et al. (2019); Saunders et al. (2016) and Matthews and Ross, (2010).

For this research a qualitative research design was adopted the rationale being that this design will allow for a richer examination into the phenomenon. In addition, the qualitative design is most aligned with the choices made in sections 5.1 and 5.2 of following a socially constructed ontological stance and an interpretivist epistemological position along with the approach to inductively build theory. The aim and the research questions in this study are exploratory in nature where the researcher sets out to analyse AEs who are social actors that engage and interact with many external stakeholders. The emphasis is therefore on the discovery of knowledge where the researcher aims to discover and infer new insights on the topic. In addition, the researcher set out to explore the motivations, values and beliefs of the participants to provide a rich understanding of the topic, therefore a qualitative research design is deemed most appropriate.

5.4 The research strategy

Once the design has been decided upon, the next step in the research process according to figure 5.1 is the research strategy. Saunders et al. (2016, p189) define a research strategy as a '*plan on how a researcher will go about answering his or her research question*'. The research strategy is the link between the philosophical choices made by the researcher and the choice of methods on how to go about and collect and analyse the data (Saunders et al. 2016). A number of different qualitative research strategies are outlined in table (5.3); these are ethnography, grounded theory, case study, action research, narrative research and phenomenological research. The choice of research strategy is guided by the RQs, aims and objectives of the study, the extent of existing knowledge in the area and the amount of time and other resources the researcher has at their disposal (Saunders et al. 2016). Table 5.3 provides an overview of the research strategies a researcher can chose from.

Table 5.3 Explanation of qualitative research strategies.

Ethnography.	Researcher observes and/or interacts with the participants in a real world setting, this can take place over a considerable length of time. e.g. extended participant observation where the researcher is observing the participants within their natural settings to gain a realistic picture.
Grounded theory.	Data collection starts with no initial theoretical framework, theory is generated from a series of observations.
Case study.	An empirical investigation within a real life setting using multiple sources of evidence. Can be single or multiple cases involved.
Action research.	Uses the strategy of doing research and taking action at the same time. Useful for answering 'how' questions.
Narrative research.	Promotes the concept of storytelling as a means to understanding the participants in a study through a holistic and extended viewpoint e.g. tell me about your life? style questioning.
Phenomenological research.	Phenomenological research looks at human behaviour, with a strong focus on the participants cognitive structures. i.e. their feelings, opinions, mental state etc. The researcher is trying to make sense of the participant trying to make sense of their social world. It is descriptive in nature, this approach differs from ethnographic methods in that it focuses on the individual experiences and not the collective (ethnography).

Source: Adapted from Saunders et al. (2016), Smith, (2004) Adams et al. (2014).

For this research, a case study strategy has been chosen as it has been identified as an appropriate strategy when the research is trying to gain a rich understanding of the phenomenon, case studies have also been found to have considerable ability in answering 'why' 'what' and 'how' type exploratory questions (Rowley, 2002). As this research is exploring an under researched area and converging different literature streams to develop new insights and understandings, the case study strategy was deemed appropriate. Case studies are further discussed in the next section.

5.4.1 Case studies

A case study can be defined as '*an empirical enquiry that investigates a contemporary phenomenon in -depth and within its real life context, especially when the boundaries between the phenomenon and context are not clearly evident'* (Yin, 2009, p18).The aim of case studies are to aid comprehension into an existing problem and to develop new understandings and theoretical outlooks and contribution from the analysis (O'Gorman et al. 2014). They serve as a valuable approach to theory development particularly when addressing why, how, what style questions (Hartley, 2004). Case studies can be used to achieve various goals such as providing description, testing theory or generating theory (Eisenhardt, 1989). The strength of the case studies analysis approach is the likelihood of generating novel theory and theory that is likely #¢#to be empirically valid (Eisenhardt, 1989), this is due to the fact that outcomes of such research are usually very close to the lives of the researched and thus perceived to be highly relevant (Stebbins, 2001). Case studies can be singular or multiple in nature (see section 5.4.3 for further details) and can focus on one or more entities such as organisations, individuals, departments, groups and processes (O'Gorman et al. 2014).

Although there is a commonality in the literature on what a case study is and its contribution towards theory development, the literature branches off between a more positivist and an interpretivist view within the research (O'Gorman et al. 2014). The work of Eisenhardt (1989) takes a more structured approach in using case studies to advance theory. Eisenhardt (1989) uses hypothesis testing research through propositions which are testable and the pursuit of facts through an inductive process. Moreover, Eisenhardt (1989) argues ideally there should be no theory to test or hypothesis drawn up at the start the research process in order to reduce the effects of bias by the researcher. This position is of a more positivist stance and is more relevant when there is limited knowledge about a phenomenon or where there is a lack of clarity with the existing theory (Yin, 2018). In comparison to the more procedural perspective of Eisenhardt (1989) the work of Corley and Gioia (2004) use their case study analysis with an interpretative focus, to try build an emergent theory from a perspective that tries to understand those who are living a particular experience. This approach from Corely and Gioia (2004) is more interpretivist where the authors are trying to apprehend the participants understanding of events (identity change and ambiguity). There are different types of case studies a researcher can chose from, this is further explored in the next section.

5.4.2 Case study types

The design of a case study can be exploratory, explanatory or descriptive in nature (O'Gorman et al. 2014). An overview of the types of a case study are outlined in table 5.4 below. These are exploratory, explanatory and descriptive case studies, it is important that the RQs, aims and objectives of a study align with the type of case study chosen, for example, if a researcher was trying to provide causal explanations between two constructs or explain how an event occurred they would follow an explanatory case study as outlined in table 5.4. (Saunders et al. 2016).

Table 5.4 Case study types

Type	**Description**
Exploratory	- Used when present knowledge and understanding on the topic is limited. -RQs are broad in nature and the use of hypotheses is rare. -Data collection can start prior to the generation of RQs. -Seeks to find out what is happening in a particular context, to provide new insights or ask new questions.
Explanatory	-Used when the researcher is trying to provide causal explanations. -Asks how did events occur? -Used when testing theory -Explains the relationship between variables.
Descriptive	-Provides a rich and comprehensive description of a phenomenon in the context in which it occurred. - Provides an accurate portrayal of a person, situation or event.

Source: Adapted from Saunders et al. (2016) and O'Gorman et al. (2014).

This research followed an exploratory design, the reason for this is that the RQs and aims of this study are how, why, what type questions. Here, the researcher is trying to understand and explore the phenomenon rather than test a hypothesis and goes beyond describing what is happening in the particular context. Therefore, to address the research questions and aims of the study, exploratory is deemed most appropriate. The next question within the case study strategy is whether the research is to follow a single or multiple case study approach.

5.4.3 Single vs Multiple case studies

Qualitative researchers who chose a case study design are challenged with the question, should they adopt a single or multiple case study analysis? This section highlights the advantages and disadvantages of using one over the other. For a single case approach a principle limitation is single case studies lack the ability to generalise conclusions, Yin, (2009 p15) asks the question – '*how can you generalise from a single case'?*. There are some situations however when a single case study is justified, for example, when the research represents a critical case and the researcher is testing a well- developed formulated theory, with a distinct set of propositions where the aim is to verify or dispute these propositions a single case is warranted (Hartley, 2004). Also if the focus is on an extreme case that is unique in nature, a single case can be justified due to the infrequency of the event, longitudinal studies can also justify a single case where the same case is analysed over a specific period of time, finally practical reasons can justify a single case where the researcher may have rare access to usually restricted contexts (O'Gorman et al. 2014).

For a multiple case study, disadvantages are around the high quantities of data collected which can be overwhelming, it is more time consuming to conduct and access to the participants can be more problematic especially over longer periods of time if continual contact is required (O'Gorman et al. 2008). Multiple case study analysis are said be beneficial to analyse within and across settings (Hartley, 2004) where results generated are more robust and generalisable (Eisenhardt, 1989). The selection of cases is based on replication logic (Eisenhardt, 2007 p25), where each case *'serves as a distinct experiment that stands on its own as an analytical unit'.* The reasoning around this is that according to Eisenhardt (1989, 2007) if all cases are under the same or comparable circumstances, the expectation would be that one would expect the same phenomenon to become apparent (Eisenhardt, 2007). Therefore, cases should be chosen to either predict similar results (literal replication) or produce contradictory results for expected reasons (theoretical replication) (O'Gorman et al. 2014).

This research followed a multiple case study approach based on the rationale being it provides the researcher the ability to analyse different cases to examine if any differences exist and if so why. The researcher used the replication logic to examine if all results were similar across all case studies and if not why? This strategy adds robustness to the findings. If the researcher had only chosen one case study, there would be no ability to compare and contrast across institutions and therefore could not provide a more comparative and conclusive analysis to the research questions. Multiple cases studies add validity, robustness and the ability to generalise which as identified is often cited as a limitation of single case analysis (Eisenhardt, 1989). Once the multiple case study approach was decided on, the researcher next decided on sampling considerations.

5.4.4 Case sampling strategy

Saunders et al. (2007 p204) state that sampling techniques "*provide a range of methods that enable you to reduce the amount of data you need to collect by considering only data from a subgroup rather than all the possible cases or elements*". For an exploratory study, non-probability sampling (or so-called non-random sampling) techniques can give a variety of alternative means of selecting samples based on the researcher's subjective judgement (Saunders et al. 2016). A non-probability sample refers to the chance or probability that every unit in a finite population is unknown; therefore, the researcher subjectively selects units that represent the population under the study (Etikan et al. 2016). For an exploratory study, it is suggested that non-probability sampling techniques help provide a variety of alternative means of selecting samples based on the researcher's subjective judgement (Saunders et al. 2016). Under non-probability sample strategies, a researcher can choose from quota, snowball, convenience, self -selection and purposive techniques (Saunders et al. 2016). For this research, a purposive technique is adopted. Using a purposive or judgmental sampling technique, requires the researcher to use their judgement to select cases and participants that will best enable the answering of the RQs (Adams et al. 2014). The technique is often used in case study analysis where a small number of cases are selected where the researcher selects these cases in the intention to gain rich and informative data (Saunders et al. 2016). Here the researcher selects participants who hold a high level of expertise and are informed individuals on the phenomenon. In addition, to the experience and knowledge of the participants, their availability and willingness to take part are important factors the researcher needs to consider (Etikan et al. 2016).

5.4.5 Selection criteria

The overall aim, objectives and research questions for this study addresses questions such as how do AEs translate their knowledge? How do AEs develop their capabilities to exploit their research? What are the moderating effects on the process? In order to answer these questions, the researcher needed to look at the phenomenon from a holistic and multiple stakeholder approach. This involved the collection of data from heterogenous stakeholders. The ecosystem within UIC involves many different partners working together synergistically in order for university research to make an impact and reach the end user (Davey et al. 2016). The quadruple helix argues the interaction of university, industry, government and end users (society) are the key players, who by working together are the driving force of innovation in the knowledge economy (Carayannis and Campbell, 2010). Consequently, this research adopted a multiple stakeholder view to gain a complete view of the phenomenon, by comparing and contrasting the different viewpoints within the ecosystem, the findings are layered with diverging viewpoints and opinions on the topic, which adds to the richness of the study. Therefore, the participant groups used in this research followed a purposeful sampling strategy which were decided upon based upon their knowledge, ability, experience and capabilities within the area under analysis. The groups that were selected for this study are further explored next.

1) AEs who had experience in university spin out formation or licensing deals with industry.

It was important for the participants of this study to have the relevant experience and knowledge on how the commercialisation process operates. AEs who had only engaged in softer engagement mechanisms such as contract research or consulting or who have patented a technology but gone no further with their innovation have been excluded from this research. The rationale being that in order to look at the interplay of ACAP and DCAP of the AE, it was necessary that the participants to have had the exposure and experience around commercialisation activities, where they were interacting with a range of stakeholders, or were budding entrepreneurs spinning out for the first time and could discuss the challenges and opportunities they were facing. When an AE has co-founded a spinout they are involved with activities such as company formation, competitor analysis, marketing and product placement, regulatory engagement, market research and analysis, the experience of these market activities could not be gained from an AE who patented a technology and went no further, therefore the selection criteria was a crucial part in making sure the researcher was talking to the appropriate participant in order to help address the RQs. The subject area for this research is STEM (Science, Technology, Engineering, Math), the reason being STEM research is a priority research theme for government funding agencies (E.U. Commission report, 2017). The Irish funding agency advocates the investment in STEM research in benefiting the competitiveness of the national economy as well as supporting the education and employment opportunities within the STEM sector. Within E.U. funding Horizon 2020 (H2020) projects there has been an emphasis on interdisciplinary research, with emerging technologies and nanotechnology a key funding stream within recent years with a focus on translational research (LERU, 2019). Given the strategic focus on scientific research from government bodies (Irish, E.U.), it is deemed most relevant that the subject area of this research is within STEM where there is a high emphasis on translational research and collaboration partners working together to achieve outputs from university research.

2) Technology transfer/ commercialization managers who have worked with AEs to help them commercialise.

The TTO is an influential office in the entrepreneurial ecosystem, they play a pivotal role in supporting the AE in the entrepreneurial process (Wright et al. 2015). Case managers within the TTO often act as boundary spanners interfacing and orchestrating a network of stakeholders, facilitating introductions and developing a commercial pathway for an AE's innovation (Schaeffer and Matt, 2016). For this study strategic level managers and operational managers are participants to gain a top level strategic overview of the office and where the university is positioning itself within the ecosystem, and case managers who work with the AEs more closely on the ground with day to day activities. Also given the strategic growth in state run research centres, a business development manager is a participant to gain an understanding of the inner working of a stage run research centre and the opportunities and challenges facing the centres.

3) Government bodies who fund university research/ technology commercialisation.

The government funding agency provides the investment for academic research to be commercialised. The agency provides specific funding streams for AEs who embark on the commercialisation journey. The state funder also offers soft supports around networking, mentorship, guidance and support, introduction of potential investors and business partners to the AE. They play a pivotal role in the entrepreneurial OI ecosystem, in this study both a strategic commercialisation manager and two specialists who work closely with the AE with operational tasks are represented.

4) Industry partners who have collaborated with AEs.

Industry partners in this study refer to companies both (SME and MNC) who have worked with university researchers on projects. Their view is of significant importance as they are approaching projects from a different angle, have different objectives and expectations. Public sector and private sector organisations often differ in cultures, objectives, missions, structures, timeframe and deadlines. when it comes to collaborative research (Abramo et al. 2009). The view of the industry participant provides the downstream (validation, integration and manufacturing) activities viewpoint and what the expectations are from their point of view.

The next section discusses the case institutions used in this study; they were all chosen due to their capabilities and leadership in commercialising STEM research. All three cases had considerable experience in commercialisation and were at the forefront of university-based innovation within the Republic of Ireland.

5.4.5 Case study settings

This research has a total of three case institutions which are universities within the Republic of Ireland - two universities were used at the pilot interview stage (X,Y) and a third university was added for the main interviews (X,Y, Z). The case institutions are outlined below in section 5.4.6 -5.4.8 and then a summary table is provided Table 5.5. This table provides a summary of important figures, amounts, priority research areas and capabilities under each institution.

5.4.6 Case institution X

University X was established in 1592 by royal charter and is based in the east of the Republic of Ireland. It is a research-intensive university which is ranked just outside the top 100 universities in the world (QS world rankings). The university has a student population of approx. 18,000 across all the main areas in the arts, humanities, social sciences, business, law, engineering, health and physical science categories. The university has a priority in research themes which are in nanoscience and materials, telecommunications, neuroscience. software, smart cities, cancer, international integration, the inclusive society and ageing.

Within the university the office of corporate partnership and knowledge exchange (OCPKE), is responsible for managing the university's IP, generating industry research collaborations and new venture creation based on the university's IP. Within the OCPKE are four divisions, corporate engagement with industry, (working with companies outside of the university to do research,) the traditional technology transfer office, an academic consultancy unit and also a spin out division. The reason for one office is to streamline the services and supports needed by the AE as they move from idea generation all the way to impact. The head of the TTO has four case managers who work directly under them. The TTO divides up the work done at the university into four separate areas with a case manager responsible for each area – ICT, engineering, medtech and pharma. The TTO also has a dedicated licensing manager and a dedicated spin out manager to assist the AEs in these areas. Also, there are a number of administrative support staff within the office. In the past three years University X has formed 12 spin out companies of which 9 were high performance start -ups (HPSUs) in total, 4 per annum. The university follows a model to purposely create HPSUs from their spin outs as it demonstrated a mark of quality and the university considers HPSUs to be their premier output of their IP. University X and Y share a venture fund with a VC company in Dublin valuing 60 million which exclusively focuses of commercialising research from higher education institutes (a first for Ireland). The university creates 80 IDFs per year which drives the innovation outputs from the IDFs 27-30 patents are disclosed per annum with 25-30 licensing agreements per annum over the past three years. The university has drawn down more funding from H2020 than any other university in Ireland and has won 50% of all of the country's ERC awards during H2020 (ERC grants are the most prestigious grants in Europe for individual academics).

The university has a dedicated unit for training on campus around the commercialisation process, this unit located in the business school offers short training courses and formal education programmes in innovation and entrepreneurship to students and staff at the university. This unit provides courses on IP protection and legal aspects pertaining to commercialisation, innovation design thinking business case planning and customer discovery training. Having the training all conducted at the business school allows AEs to avail of specialist knowledge and also there is the opportunity for AEs to take a sabbatical and do an MBA course (or similar) if they wish. The training unit offers short courses, workshops, networking events, 1-2-1 mentoring, and innovation and new venture creation masterclasses. Students at the university can also avail of this training for example students can take part in a undergrad certificate in innovation and entrepreneurship (the first of its kind in Ireland) available to all students across any discipline in tandem with their registered courses. University X also offers a student accelerator program to develop the skill set of up and coming entrepreneurs.

5.4.7 Case institution Y

University Y was established in 1854 and is based in the east of the Republic of Ireland. The university has a student population of approx. 34,000 with approx. 3,500 faculty and staff. The university is ranked within the top 200 universities globally (QS rankings). The university is a research intensive institution and its priority of research interests are in the six areas of Agri-Food, Culture Economy & Society, Energy, Environment, ICT and Health.

The head of the TTO office at University Y has a team of 5 case managers and one admin support staff member directly under them. The case managers have a dedicated area of specialism divided into ICT, food agriculture and vet medicine, life and medical sciences, mechanical engineering and material science and finally environment. The TTO is supported by the research office, the legal and contracts office and finance office and all offices report to the office of the vice president (VP) of research and impact. The TTO works very closely in particular with legal colleagues when they review the drafting of relevant agreements that would underpin their activities. The TTO is built around the mandate of identifying, protecting and exploiting IP these three pillars are fundamental activities of the office.

Over the past three years the university has had 80 invention disclosures per annum, 20-25 patent applications, 25 licensing deals and 5 spin outs per annum. The university has an enterprise manager whose specific role is to assist in helping develop start up formations within the university. Training at university Y around commercialisation is conducted by the TTO and include a range of training services from one day information days to an eight weeklong accelerator program. For instances, the TTO conducts sprint one day sessions where the TTO invite researchers to pitch their idea in order so case managers can evaluate it and provide guidance to the AEs. The university runs a commercialisation bootcamp to get researchers to think about a commercial plan around their research. The university also runs a customer discovery program for AEs a year or two into the commercialisation journey which focuses on the market opportunities for the innovation. Moreover, the university also runs an accelerator program which happens over a longer period of time compared to bootcamp where the AEs are challenged with developing a business plan for their innovation. The university invites a select audience of potential investors and business partners to the accelerator program to facilitate the meeting of the AEs and potential business contacts. Finally, bespoke seminars and information days are offered e.g. on the state funded commercialisation fund where the state funder are invited in to pitch their offerings.

5.4.8 Case institution Z

University Z was founded in 1845 and is located in the west of the Republic of Ireland. It has a student population of over 19,000 students with 2,800 staff and faculty members approximately, it is a research intensive institution, The university is ranked among the top 250 higher education institutes globally (QS rankings). The university has a priority of research themes in policy and society, creativity and culture, health and wellbeing, data and enabling technologies and the environment.

The university has a strong interdisciplinary research focus bringing together science, engineering and medicine. The office of the vice president for research (OVPR) is the office which is responsible for the university to maximise its research impact, the OVPR is comprised of two smaller offices – the research office and the innovation office (TTO). Both these offices report directly to the OVPR. The head of the TTO has four case managers and one deputy head that report directly to them. The case managers have responsibility for one area of specialism which is broken down into – ICT, life science, engineering energy and biomedical sciences and medical technology. The TTO also has a number of support staff, two in spin out supports, two in general administration, and two in student entrepreneurship, with the TTO employing an impact officer this year as a new role within the team. Over the last three years, the university has had 50 invention disclosures, 3 spin outs annually and licensing agreements of 15 per annum. The training offered by the TTO is mainly around IP considerations, what is IP, how to identify IP, how to protect it, also training on the commercialisation process, the university has invited the state funder in also to provide talks to the staff and students around the application funding process. The university has a student based entrepreneurship accelerator, which reports into the TTO which focuses on mentorship for less experienced student entrepreneurs with new idea creation. The university runs a needs led innovation program based off a program from a prestigious U.S. institution, which involves three core pillars 1) identification of a wide range of problems through clinical immersion, 2) inventing through brainstorming and concept selection techniques and finally 3) implementation through a development strategy and development plan. (These concepts are further discussed in the findings chapter section 7.25.1).

5.4.9 Case Comparison

Table (5.5) outlines the key components to STEM research activities among the universities in this study. Of interest to note, all three cases are classed as 'universities' by the Irish Universities Association (IUA), therefore they are not institutes of technology (IoT) or further education institutes. They are all research intensive as opposed to entrepreneurial institutions. The institutions all have similar outputs in numbers in terms of IDFs, licensing and spin out deals and all have a similar size of human resources at the TTO. There are nuanced difference between the institutions for example, how the training is provided and research priorities, however by in large there are core similarities among the cases studies. Therefore, this research follows the literal replication logic (Yin, 1994) that similar results are predicted across all three cases (Yin, 1994). The standard number of cases for literal replication to occur is between three to four (Yin 1994, p 50). Another dimension of replication logic is that not only are cases compared against each other but also the proposed theory (Bergen, 2000). A conceptual model has been developed in section 4.6 which encompasses the key theoretical constructs and variables according to the theory within the phenomenon. The findings are compared against the conceptual model to draw conclusions on whether there is a commonality between the theory and empirical evidence of this study which is analysed in the discussion chapter.

Table 5.5 Case comparison

Case Institution	**University X**	**University Y**	**University Z**
Incubator facilities on campus	Yes	Yes	Yes
Accelerator program	Yes	Yes	Yes
Orientation	Research intensive	Research intensive	Research intensive
Priority research themes	Nanoscience and materials, telecommunications, neuroscience, software, smart cities, cancer, international integration, the inclusive society and ageing.	Agri-Food, Culture Economy & Society, Energy, Environment, ICT and Health.	Policy and society, creativity and culture, health and wellbeing, data and enabling technologies and the environment. Strong medtech focus – university acts as innovation hub in the area.
IDFs per annum	80	80	50
Licensing deals per annum	25-30	20 -25	15
Spin out formations per annum	4	5	3
State funding body payment awards (2019) euros	40 m	34 m	28 m
TTO team size	1 strategic manager – 4 case managers with a dedicated licensing and spin out manager also.	1 strategic manager – 5 case managers and an enterprise manager dedicated to spin out development.	2 strategic managers (head and deputy head) and 4 case managers.
Training around commercialisation of research	Conducted by separate unit where TTO conduct some modules, however run by the business school.	Training conducted by TTO	Training conducted by TTO.
Student entrepreneurship and mentorship program	Yes	Yes	Yes

Table 5.5 Case comparison (continued).

Case Institution	**University X**	**University Y**	**University Z**
Participation breakdown scientists to engineers	3 engineers. 4 scientists.	4 engineers 3scientists	6 engineers.
STEM European level of funding	18m 2018. 19m 2019.	15m 2018. 17m 2019.	12.4m 2018. 10.5m 2019.
IDF Sections	Four main sections – technical description, disclosures, third party properties and list of inventors. Patent search – optional requirement.	Four sections - invention details, prior art, funding and inventor details. Patent search – mandatory requirement	Four main sections, project contributor details, invention details, prior art and funding sources. Patent search – mandatory requirement.
Training initiatives	Lean canvas modelling (problem definition, existing alternatives, solution, cost structure, unique value proposition, pathway to customer, unfair advantage, target customer and revenue stream). Training centralised conducted at business school.	Lean canvas modelling Commercialisation bootcamp, customer discovery programme, accelerator program based around market problem/need. Proposed solution/ technological innovation.	Lean canvas modelling Needs led innovation training program where AE learns: Disease state and existing treatments, End user requirements and evaluation. Market strategy and research Needs specification development. Brainstorming and introduction to product design. Clinical trial design. Funding Sources. Regulatory and reimbursement strategy.
Research centres HQs on campus.	Three state run research centres. Bioengineering, A.I. and communications technology.	Two state run research centres. Advanced manufacturing and Data analytics.	Two state run research centres. Medical devices and data analytics.

5.5 Research Design

The adoption of the case study strategy presented in sections 5.4.2 -5.4.4 informed the research design and process for this study. The research design of a study demonstrates how all the components link together, with a good design showing how these components work harmoniously together (Maxwell, 2012). In qualitative research, a component of the design may need to be altered or reconsidered given changes to other components in the design or new developments that occur (Saunders et al. 2016). The research design should therefore be a reflexive process at every stage of research journey (Maxwell, 2012). The research design for this project can be found in Figure 5.2.

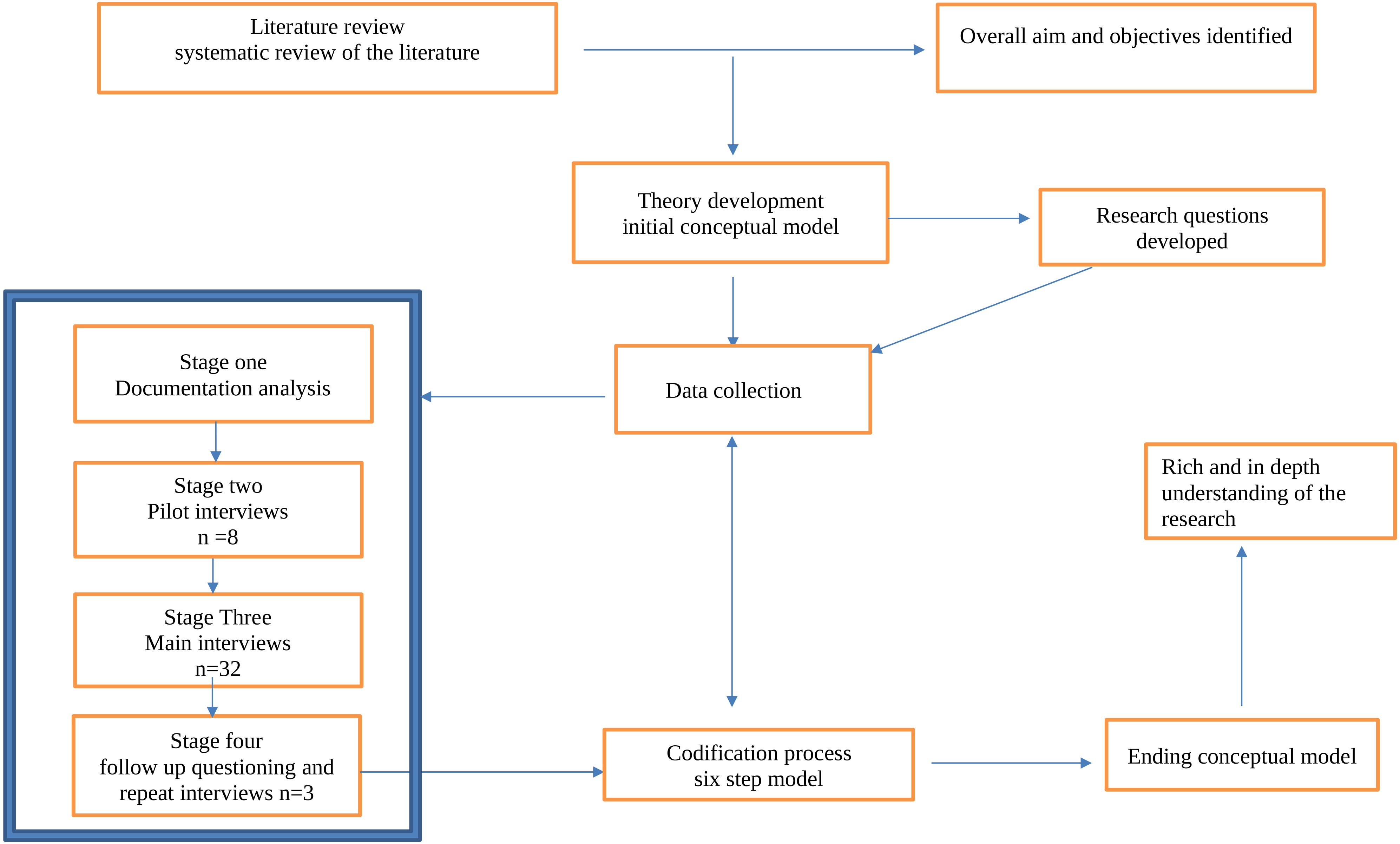

Figure 5.2 Research Design

5.5.1 Phase 1 – Literature review and conceptual development

The first phase in the research design (figure 5.2) involved a thorough review of the literature, which involved identifying, comprehending and appraising the relevant theoretical work within the literature. Research gaps were noted in an excel spreadsheet as the researcher worked through the literature to gain a full understanding of the phenomenon. The reviewing of literature initially took a wide stance to immerse the researcher into the topic, as the researcher understood the phenomenon more in-depth, the researcher identified seminal pieces of work in the area and the key theories, research papers and frameworks. The literature review process led to the identification of key research gaps within the streams of literature and provided the ability to build theory in key areas where further research was needed. Once a comprehensive review of the literature was analysed and appraised, the research aim and objectives for the study were developed. At the end of the literature review an initial conceptual model was developed and from this model, the five RQs were identified.

5.5.2 Phase 2 – Data collection

As outlined in figure 5.2, data collection began with documentary evidence to help the researcher to draw up the interview questions and also help select who the participants of the study may be. Subsequently, the interview process for this project, was broken down into three stages, the pilot interview stage (Sect. 5.7.1) a main interview stage (Sect. 5.7.2) and then follow up questioning and repeat interviews which took place after the main interviews concluded (Sect 5.7.3). Once the pilot interview questions were developed, the researcher trialled the questions on eight AEs to analyse the responses and check these responses against the RQs and objectives of the study. This resulted in modifications to some questions to enable a fuller response to the questions where a more storytelling “tell me about?” approach was taken. Bangerter et al. (2014) found questions on past behaviour elicited full and rich responses from participants when they were asked in a storytelling style. Questions from the pilot stage that were omitted were questions that asked about a topic area too directly, the researcher was receiving yes or no answers and needed to reassess how to get the participants to provide full and frank responses. This was achieved by adopting the critical incidence technique which is further discussed in section (5.7). Once the researcher was confident on the final interview questions, the main interview stage began, here 32 participants were involved from heterogenous stakeholders (AEs, TTMs, funding agency specialists and industry partners).

After the main interviews were complete, the researcher transcribed them by manually typing the recordings into word documents to start the analysis process.

5.5.3 Phase 3 - Data analysis

The data analysis process for this research is discussed in section 5.8. Once the researcher decided on the research design, the next step was to collect the data.

5.6 Data Collection

The data collection techniques for case studies can include observation, documentary analysis, and interviews (Saunders et al. 2016). This research uses semi structured interviews and documentary analysis which will now be discussed.

5.6.1 Documentation

Document analysis is the systematic procedure for reviewing or evaluating documents in order to '*elicit meaning, gain understanding and develop empirical knowledge'* (Bowen, 2009 p27). Documents can take a number of forms such as from press releases, institutional reports, survey data and public records. Document analysis is often used to verify findings and corroborate evidence from the interview stage of the research process (Bowen, 2009). This data can provide background information as well as historical insights into the cases involved, the researcher can then draw on this data, to contextualise data collected during the interviewing stage (Bowen, 2009). By combining document analysis and interviewing techniques the researcher can also triangulate their findings (triangulation refers to the approach to research where more than one tool is used to research a question. It provides substance and confidence to the findings through the confirmation of a proposition using two or more independent measures (Heale and Forbes, 2013). Table 5.6 outlines the documents used in this study. The documents included the use of websites, press releases, templates such as IDFs used by the TTOs, project management templates used by a research centre. A full outline of the documents used in this research can be found in table 5.6.

Table 5.6 Documentary evidence

University websites	Used to screen potential participants to identify if they match the selection criteria. Reading of biographies, research interests and track record, funding grant levels awarded, collaborating partners (industry and academic) Types of commercialisation activities involved with. TTO websites to download sample IDFs and NDAs to gain an understanding of what details are on these documents as they are discussed in the interviews. Annual reports read to obtain the funding values per institution by state funding used in cross case table.
State research centres	Project management planning tool provided by participant used to substantiate findings Problem statement planning tool provided by participant used to substantiate findings Market assessment report - number of publications and citation impact, engagement with industry, the types of interactions the centre had within STEM research and their impact agenda to gain an understanding of the research centre and its objectives.
Funding Agency	A sample evaluation form for reviewers to assess what they are looking for when approving an application, what are the main stages of assessment, and what are the key deliverables sought. A sample commercialisation grant application form, what are the main headings, how much detail is required, who takes part in the application process.
Press releases	The researcher read press releases on success stories of spin out activity, which garnered national and international attention. The press releases help the researcher to ensure they were talking to the right potential participants and could refer to the news story in the interview to further probe questions.
Business templates	A business canvas model was downloaded from a prestigious U.S. university, to seek out what the steps are in the model and what it tries to achieve, this model is a key framework with all three cases in their training exercises. Next a lean canvas model was downloaded to assess what the differences where between the two models and why a TTO may prefer one over the other, this was further probed in the interview stage.

As outlined in figure 5.2, once the documentation review was completed, the researcher moved onto the interviewing stage.

5.7 Interviews

The different types of interviews available to a researcher when interviewing are structured, semi structured and unstructured/ in- depth interviews (Saunders et al. 2016). With structured interviews a predetermined or standardised / identical set of questions are used to interview a participant, the researcher follows this set of questions exactly and does not deviate from the questions they have been outlined before the interview (Saunders et al. 2016). In comparison, semi – structured or unstructured interviews are non- standardised interviews (O'Gorman and MacIntosh, 2014). With semi – structured interviews, the researcher has a set of themes and key questions they wish answered from their respondents however they have the freedom to add or omit questions based on the answers they receive and also on the stakeholder type they are interviewing. Finally, with unstructured interviews the researcher wishes to explore a topic in general terms. There is no predetermined set of questions and the respondent is given the freedom to talk openly about their experiences (Saunders et al. 2016).

It is important to link back to the research strategy and aims and objectives of a study when deciding on which interview type to choose from. For example, if a researcher is using a quantitative method(s) e.g. survey, they are likely to use structured interviews, whereas if a researcher is following an exploratory study, semi structured or unstructured interviews allows the researcher the freedom to probe the participant on questions to gain their opinions, beliefs, experiences and values. These styles of interviews are likely for a researcher following an inductive approach (Saunders et al. 2016). The main advantage of using a structured interview, is in its ability to produce consistent data with minimal risk for bias that can be conducted quickly the main disadvantage however is it provides little opportunity for feedback and responses can be limited and restrictive (O'Gorman and MacIntosh, 2014).

The main advantage for semi structured interviews lies in their flexibility, the researcher can alter questions when they deem necessary to illicit more nuanced responses, the researcher can also prepare in advance and has a general list of themes and questions already set out. This is especially useful for researchers with less experience, the disadvantages are it's a time consuming process and resource intensive, it is open to researcher bias and may lack generalisability (O'Gorman and MacIntosh, 2014). Finally the main advantage with an unstructured interview lies in the ability to produce very rich information and can explore previously unknown themes that arise from the interview itself, the disadvantages are around the generation of irrelevant data and it's a very time consuming process, also it is open to interviewer bias (O'Gorman and MacIntosh, 2014). This research followed a semi structured interview format where the researcher had a set list of themes and questions outlined for each participant group (see appendix 3 for the all interview question schedules for this study representing all stakeholder groups).

The questions for the interviews were primarily open ended, which allowed the participant to provide an answer in their own way, free from bias or being led by the researcher. The researcher took the role of active listener (Saunders et al. 2016). Long questions were broken up so the researcher could gain a response to each aspect of the question. If relevant, open questions were followed up with probing questions to further pull out information that was deemed credible and important by the researcher. Questions also avoided technical jargon and theoretical concepts to ensure both the researcher and the participant had a mutual understanding (Easterby- Smith et al. 2002).

One approach to questioning which gets the respondents to think back and reflect is the critical incident technique (CIT) (Flanagan, 1954; Hughes, 2008). Here the researcher asks the respondent to describe in detail a critical incident[3] or number of incidents that are important to help the researcher answer their RQs. Interviews using CIT are usually semi structured in nature, where the researcher gets the participant to recall actual events, they have experienced rather than abstract concepts (Saunders et al. 2016). The benefit of this technique is that the responses are true and valid real world examples rather than assumptions or opinions that the participant may have. The researcher can probe questions around an incident to get more in-depth answers using questions like, 'tell me about a time when…. or thinking back to a project …. when something went wrong…. when something worked well'. For this study the CIT was used on all respondents asking them to think back to projects they have worked on or provided guidance on and to talk through the stages of development (for example idea generation, prototyping, invention disclosure, seeking funding, market research activities and company formation). By getting the participants to think back and provide story telling type answers the

[3] A critical incident is a 'retrospective event that generates an action which due to its retrospective perspective, can only be determined as critical afterwards' (Fridlund et al. 2017, p2).

researcher was able to get full and comprehensive answers to questions rather than direct questions which would provide short answers usually. The researcher learned this technique worked best as they moved through the interview process.

As identified in the research design (Figure 5.2) the interview process for this project, was broken down into three stages pilot, main and repeat interviews. At each stage, the researcher reflected on the responses to make sure the data being collected was able to answer the RQs effectively. This happened throughout the interview process until the researcher reached a point of data saturation (Yin, 2018). Data saturation refers to the point when the researcher can be reasonably assured that further data collection would yield similar results to confirm emerging themes and conclusions (Faulkner and Trotter, 2017).

5.7.1 Pilot interviews

The pilot interview stage included eight AEs across two case study academic institutions University X (3) and University Y (5). The pilot interview stage was conducted in Jan – Feb of 2020 and happened face to face. A profile of the participants can be found in table 5.7; which outlines their research interests, qualifications, job title, if the participants had industry experience before joining the university and the types of commercialisation activities they have been involved with. Pilot interviews can be defined as '*a small scale methodological text conducted to prepare for a main study and is intended to ensure that methods or ideas would work in practice'* (Kim, 2010 p2). There are many benefits to conducting pilot interviews. These include the ability to allow the researcher to analyse responses and make any adjustments or revisions to questions before they embark onto the main study, also they allow a researcher to test protocols such as data collection method and sampling strategy. This can be especially useful for novice interviewers to work as a training exercise. They also enhance the credibility of a qualitative study and can uncover ethical or practical issues associated with the study before the researcher moves onto the formal main interviews (Kim, 2010; Teijlingen and Hundley, 2002).

From the pilot interviews, it was concluded that some of the interview questions were not specific enough to pull out the data needed in answering all the RQs sufficiently. The researcher felt RQ1 and RQ5 had very good responses and a clear contribution came out in answering these RQs, however for RQ 2.3.4 some adjustments were needed to extract the specific data needed. All participants were contacted via email. They were sent an information sheet in advance in order to make informed consent on whether to participate in the study. At the start of the interview, participants were asked to sign a consent form to signal their agreement to take part in the study and to consent to the recording of their responses where the participants agreed to be recorded. Each participant had read the participant information sheet (see appendix two) prior to the interview and an introduction of the researcher via email.

Table 5.7 pilot phase participants

	Job Title and research interests.	Industry experience prior to joining university (Y/N)	Types of commercialisation activities involved with	Highest educational achievement And department affiliation Duration of interview
AE1X	Professor of Biochemistry specialising in inflammation and immunology.	No	Co -founder of two spin out companies Licensing agreements	Ph.D. Pharmacology Director of biomedical science institute University X 29 mins 25 seconds 8 pages transcribed.
AE2Y	Professor of advanced drug delivery and PI	Yes	Patent and licensing experience.	Ph.D. in pharmacology Dept of Veterinary medicine University Y. 33 mins 12 seconds. 11 pages transcribed.
AE3Y	Professor of translational medicine.	Yes	8 international patents held co -founder of spin off company.	Ph.D. in Immunology School of medicine, University Y. 29 mins 17 seconds. 8 pages transcribed.
AE4X	Associate professor school of pharmacy Director of drug discovery research.	No	International patents awarded and spin off company co- founder.	Ph.D. in Chemistry School of pharmacy and pharmaceutical sciences University X 53 mins 48 seconds 13 pages transcribed.

	Job Title and research interests.	Industry experience prior to joining university (Y/N)	Types of commercialisation activities involved with	Highest educational achievement and department affiliation. Duration of interview.
AE5Y	Professor of engineering	Yes	Co- founder of spin out company.	Ph.D. in chemical engineering, School of chemical and bioprocessing engineering University Y. 25 mins 40 seconds 6 pages transcribed.
AE6Y	Professor of chemistry and chemical engineering	Yes	Co -founder of spin out company.	Ph.D. in chemical engineering, School of chemical and bioprocessing engineering University Y. 29 minutes 23 seconds 7 pages transcribed.
AE7Y	Assistant professor of medicine.	Yes	In process of spinning out company – nascent entrepreneur.	Ph.D. in pharmacology, School of medicine, University Y. 30 mins 58 seconds. 8 pages transcribed.
AE8X	Professor of comparative immunology.	No	International patent Licensing deal	Ph.D. in immunology School of biochemistry and immunology University X. 30 mins 26 seconds. 8 pages transcribed.

5.7.2 Main Study Interviews

Stage two comprised of the main study where interviews were conducted with 20 AEs, across three case study institutions (seven from Case Y, seven from Case X and six from Case Z). Furthermore, other stakeholders interviewed included six TTMs (Technology Transfer Managers) – one strategic and one operational per case, one strategic manager from the state funding agency and a two person commercialisation specialist interview from the state agency. Finally, four industry participants who worked with an AE during a project. The total number of interviews during the main study stage was 32. In total 40 interviews were conducted across the pilot and main study stage.

The main interview stage was conducted between May and Sept 2020. The researcher finished up the pilot phase in Feb 20 and after a review was set to continue interviewing in late March. However, on the 12th of March, the government shut all universities, as part of their lockdown strategy in response to COVID-19. At this stage, it was unknown that COVID-19 would cause such disruption and therefore it was hoped face to face interviews could be resumed. However, as the situation extended, a decision was taken to move to online interviews using digital communication platforms. At this stage, a third case was chosen because of the innovative work Case Z had done with medical devices with a number of spin out companies emerging over recent years. The university was a seedbed for medtech innovation therefore Case Z was added due to the value they were perceived to bring to aiding exploration of the topic.

Initial contact for the main interviews across all 3 cases was initiated by email. The researcher identified participants initially through internet searches and reading the biographies of potential participants to shortlist potential candidates who met the sampling criteria set out in section 5.4.5. Once the researcher had conducted initial interviews, the snowball technique was used, where the researcher asked for further suitable candidates who may take part, this referral process aided data collection. The researcher attached the information sheet (see appendix two) and an introduction to the project, back and forth email communication was had with many participants to ensure the researcher was speaking to the right people again who fitted the criteria set out in section 5.4.5. Online interviewing has grown in popularity as an alternative method to traditional face to face interviewing (Gravlee et al. 2018). The benefits for the researcher are it's a less expensive form of data collection with no travel costs are incurred, it's convenient allowing for geographic flexibility, it can put both participants at ease in home surroundings allowing for a full and frank conversation (Gravlee et al. 2018). There are limitations to online interviews, where it could be argued that the ability to build up a rapport and read nuances like body language and raised intonations are easier to pick up in face to face settings (Gravlee et al. 2018).

The researcher informed all participants they were using their dictaphone to record the online interview. The researcher also informed the participants the recording would be transcribed manually leaving out any information that could compromise their privacy. In order to ensure the confidentiality of the participants, the data was anonymised by replacing names with abbreviations such as TTM1, AE1. etc. Table 5.8 outlines the profile of the participants who took part in the main interview stage. Like the pilot interviews, it includes the research interests, qualifications, job title, if the participants had industry experience before joining the university and the types of commercialisation activities they have been involved with for AEs. For TTMs, it includes their job title and job duties, their prior work experience and educational background. For the funding agency participants, it includes the same details as the TTMs (job title and job duties, their prior work experience and educational background). Finally, for the industry partners the profile includes job title and experience, which case institution they have worked with and the type(s) of project and their educational background.

Table 5.8 Participants in the main study – academic entrepreneurs.

	Job Title and research interests.	**Industry experience prior to joining university (Y/N)**	**Types of commercialisation activities involved with**	**Highest educational achievement and department affiliation. Interview duration.**
AE 9Y	Professor in mechanical and materials engineering and director of a research centre which employs 60+ researchers and operational staff.	Yes	Patenting, licensing and co-founder of spin out formation.	Ph. D in engineering. School of Mechanical and Materials Engineering. University Y. 33m 08s 8 pages transcribed.
AE 10Z	Senior lecturer in biomedical engineering and principal investigator at a research centre on campus.	Yes	In the process of setting up a second spin out after selling the first company, licensing deals, patenting.	Ph. D. in engineering School of biomedical engineering University Z. 32 mins 40 s. 7 pages transcribed.
AE 11Z	Professor in Biomaterials and director of a funded centre for research in medical devices. The participant has 25 years of experience in the field of biomaterials and has worked in academia for the past 12 years.	Yes	Co -founder of two spin out formations, licensing and collaborative research with industry.	Ph. D. in engineering (biomaterials) School of biomedical engineering at University Z. 25 mins 40 s 6 pages transcribed.
AE12X	Professor in microbiology. Research interest lies in pathogens and how they interact with a host and how they can manipulate the host.	No	Co- founder of two spin out formations.	Ph.D. in microbiology. dept of biology. University X. 39 m 42s 10 pages transcribed.

	Job Title and research interests.	**Industry experience prior to joining university (Y/N)**	**Types of commercialisation activities involved with**	**Highest educational achievement and department affiliated with. Interview duration.**
AE 13Y	Professor Of Proteomics. research focused around measuring proteins and their role in disease on a genome wide basis.	No	Co -founder of spin out company.	PhD in Biochemistry. School of medicine. University Y. 43m 23s 12 pages transcribed.
AE 14Y	Associate professor within the school of mechanical engineering. Runs a medical devices design group and is the director for the centre for biomedical engineering.	Yes	Licensing deals and patenting.	Ph.D. in engineering School of Mechanical and Materials Engineering, University Y. 28m 39s 8 pages transcribed.
AE 15Z	Senior research fellow and Principle investigator within innovation unit. Research interests lie in the design, development and manufacture of medical devices, 3D printing and medical device research.	Yes	Co- founder of spin out formation.	MSc in Ergonomics and medical device design. School of biological sciences design and manufacturing technology, University Z. 54m 43s 10 pages transcribed.
AE 16Y	Assistant Professor in mechanical and materials engineering. Main research interest focuses on all the core manufacturing processes across a range of different sectors.	Yes	Patenting and licensing deal.	Ph.D. in engineering. School of Mechanical and Materials Engineering, University Y. 55m 13s 18 pages transcribed.

	Job Title and research interests.	Industry experience prior to joining university (Y/N)	Types of commercialisation activities involved with	Highest educational achievement and department affiliated with. Interview duration.
AE 17X	Associate professor in computer science. Main research area lies in sensor driven human-machine interaction.	Yes	Co- founder of two spin out formations.	Ph.D. in computer science. School of Computer Science and Statistics at University X. 37 m 15s. 11 pages transcribed.
AE 18Z	Professor of medical electronics joint appointment between engineering and medicine. Co – director of a medical technology commercialisation program also a co -director of an innovation programme within a local hospital.	Yes	Licensing deals, co- founder of spin out and advisor to spin out formations within the commercialisation program.	Ph.D. Electronic Engineering MSc. in Clinical Research. Dept of Engineering & Informatics University Z. 55m 05s. 21 pages transcribed.
AE 19Y	Professor of and head of school in chemical and bioprocessing engineering. Research interests include membrane technology bioreactor modelling and scale-up computational fluid dynamics.	Yes	Patenting and co – founder of spin out formation.	Ph.D. in engineering school of chemical and bioprocessing engineering University Y. 28m 39s 12 pages transcribed.

	Job Title and research interests.	Industry experience prior to joining university (Y/N)	Types of commercialisation activities involved with	Highest educational achievement and department affiliated with. Interview duration.
AE 20Z	professor in medicine / consultant endocrinologist. Research focuses on the use of stem cells for tissue regeneration for diabetic complications, clinical specialism is diabetes.	No.	Co -founder of spin out formation, patenting, licensing.	Ph.D. Medicine. MB BCh BAO (Honours). Head of the Department of Medicine, director of research centre and dean of the college of Medicine, Nursing and Health Sciences at University Z. 32m 12s 12 pages transcribed.
AE 21X	Associate professor in mechanical engineering. Research activities are based on advancing the scientific understanding underpinning advanced manufacturing technologies	Yes	Patenting and on the basis of that spinning out a company for the first time as a co - founder. PI within a research centre at university X.	Ph.D. in engineering department of mechanical and manufacturing engineering in University X. 36m 47s. 14 pages transcribed.
AE 22X	Professor of tissue engineering and PI within a commercialisation centre based on campus. Research interests are in the field of tissue engineering which seeks to grow replacement tissues in the lab for treating damaged or diseased organs in the body.	Yes	Patenting, licensing and spin out co- founder.	Ph.D. in biomedical engineering. Head of the Department of Mechanical and Manufacturing Engineering. University X. 35m 23s 13 pages transcribed.

	Job Title and research interests.	Industry experience prior to joining university (Y/N)	Types of commercialisation activities involved with	Highest educational achievement and department affiliation. Interview duration.
AE 23X	Professor school of physics. Director of a research institute. Research interest are in condensed matter theory, structured theory and modelling.	No.	Patenting and licensing deals.	Ph.D. in Theoretical Physics. Department of Physics. University X. 49m 17s. 17 pages transcribed.
AE 24Z	Professor in electronic engineering, co-director of an innovation program and co-PI within a commercialisation centre at the university.	Yes.	Patenting, licensing, co-founder of spin out formation and advisor to spin outs.	Ph.D. in engineering. Department of Engineering and Informatics, University Z. 37m 38s 15 pages transcribed.
AE 25Z	Professor in Biomedical Engineering. Director and co-founder of a medical devices innovation programme.	Yes.	Patenting, licensing, co-founder of spin out formation and advisor to spin outs.	Ph.D. in mechanical and biomedical engineering. School of Engineering & Informatics University Z. 46m 25s 20 pages transcribed.
AE 26Y	Professor and head of biochemistry. Research interests lie in vaccines and role of antigens in preventing disease.	Yes.	Patenting and licensing deal.	Ph.D. in biochemistry. School of Biomolecular and Biomedical Science University Y. 40m 51s. 16 pages transcribed.

	Job Title and research interests.	Industry experience prior to joining university (Y/N)	Types of commercialisation activities involved with	Highest educational achievement and department affiliation. Interview duration.
AE 27Y	Professor of chemistry, Research interests lie in the general area of organic synthesis.	Yes.	Patenting, licensing and spin out co- founder.	Ph. D. in chemistry School of chemistry University Y. 40 m 11s 16 pages transcribed.
AE 28X	Professor in creative technologies. Research interest lie in visual computing and graphic design.	Yes.	Patenting and co -founder of spin out formation.	Ph.D. in computer science. School of Computer Science and Statistics. University X. 32m 13s 12 pages transcribed.

Table 5.8 Participants in the main study – TTO / Business development personnel.

	Job Title	Job Duties	Prior Industry work experience	Highest Educational Background. Interview duration
TTM1X	Head of the office in University X called the office of corporate partnership and knowledge exchange (OCPKE).	Head of four offices within OCPKE – corporate engagement with industry, the TTO, an academic consultancy unit and a spin out division. Managing the vertical integration of all of the services and supports that PIs need from concept to impact.	20 plus years, finishing up as a global R&D vice president, for a very large U.S MNC.	Ph.D. in chemistry. 45m 01s 16 pages transcribed.
TTM2X	Senior business development manager at a research centre based at University X.	Role involves building research collaborations, looking for where research from the academics may have application in industry. A need to understand PIs research and then try and go sell it to industry. Spending a lot of time working with industry partners to understand grand challenges and needs, problems and try to find a match with their 70+ PIs.	Role in trying to strike collaboration between biomedical and pharma companies and the research institutes in a South East Asian Country.	Ph.D. in molecular biology. 1h 03m 51s. 22 pages transcribed.
TTM3Z	Director of the technology transfer and innovation office in University Z.	Responsibilities are identifying the research, managing the research and ultimately looking to get that research into an impactful position through a spin out company or a licensing arrangement with industry(small, medium or large).	U.S.MNCs roles in various different capacities in financial services and I.T. for 30 years.	MSc in technology innovation and management. 30m 25s. 11 pages transcribed.

	Job Title	Job Duties	Prior Industry work experience	Highest Educational Background. Interview duration.
TTM4Y	Head of knowledge transfer at University Y.	Heads up a team of six and that includes one admin support and five case managers who engage with the PIs on a daily basis, case managers are divided into supporting PIs in distinct research domain areas, ICT, food agriculture and vet medicine, life and medical sciences, mechanical engineering and material science and finally environment.	18+ years in tech transfer roles and regulatory affairs.	Ph.D. in biochemistry/ MBA 1h 10 m 31 s 22 pages transcribed.
TTM5Z	Case manager in university Z focusing on engineering and medical devices area, previously a business development (BD) manager for a research centre within University Z.	12 + years at the TTO looking at securing IP, commercialising IP, working in a research centre as a BD manager before interacting with industry and procuring industry projects to work with their PIs which are co -funded with the research centre.	After studies directly into TTO role.	Ph.D. in engineering. 50m 02s 20 pages transcribed.
TTM6Y	Case manager in University Y within the area of physical sciences and engineering.	Responsible for fostering the development of IP pipelines in the physical sciences and engineering research areas and supporting researchers at grant proposal, drafting business plans and commercialisation roadmaps to ensure IP is commercialised.	worked in a MNC on tech transfer projects and worked on the university side on some early stage projects in engineering around industry engagement.	Ph.D. in Chemistry and MBA. 48m 49s 19 pages transcribed.

Table 5.8 Participants in the main study -government funding body officials.

	Job Title	Job Duties	Prior Industry work experience	Highest Educational Background. Interview duration.
FB1	Program manager of the commercialisation fund.	Manager of the commercialisation fund programme – over seeing 18 commercialisation specialists within the areas of life sciences, engineering, ICT, energy, manufacturing.	Manufacturing of medical devices, software engineering to develop databases and translating the engineering graphical information to give over to the software /I.T. team. Liaison officer between universities and this organisation (government body) dealing with funding opportunities.	primary degree in polymer engineering. 55m 31s. 16 pages transcribed.
FB2A & FB2B 2 person interview.	Senior commercialisation specialists of the commercialisation fund in the life sciences area (FB2a +FB2b).	Working more directly with research teams and researchers that are interested in commercialising their research. Involved with the translation of research out of third level with a commercial application.	Business development role within a start- up (FB2B). Service level contract with a university, initially as a researcher and then managing a research group in an applied research centre (FB2A).	MSc Biotechnology and Business (FB2B). Ph.D. in microbiology (FB2A). 1h 04m 03s 20 pages transcribed.

Table 5.8 Participants in the main study - industry partners.

	Job Title	Job Duties	Work experience with case institutions.	Highest Educational Background Interview duration
IndP1	CEO of SME in biopharmaceuticals.	patent portfolio management, growing sales via direct and channel management (distributors), R&D grant management, marketing and operations.	Worked with researchers in University X and Y under H2020 and FP7 projects.	MSc in experimental physics. 49m 40s 16 pages transcribed.
IndP2	CEO of SME in medical devices.	Developing the pipeline of products and building the IP portfolio of the company within the SME medical devices sector. Managing the operations of the company.	Working with researchers at University Z to access state of the art 3D printing capabilities to enhance the company's portfolio of products.	MSc in medical innovation Bachelor of medical science. 54m 05s 17 pages transcribed.
IndP3	Electrical process development manager within a medical devices MNC.	Responsible for developing tests and software solutions for the manufacturing business and digital transformation on site. The university engagement owner with many H2020 projects with academic institutions.	Works with researchers from Cases X,Y and Z within a research centre as a strategic partner.	Ph.D. in engineering 44m 25s 16 pages transcribed.
IndP4	Director of research and market intelligence at a computer software MNC.	15 + years at this organisation. Works within enterprise I.T. and technology management. Management of the I.T. portfolio which involves working with industry – academic consortiums and collaborative research projects with a particular university.	Working with University X researchers on a quantum computing project.	MBS in e-commerce. 30 m 26s 11 pages transcribed.

7.3 Follow on questioning

Once all interviews were transcribed, the researcher reflected over the transcripts and highlighted extra questions that would be useful to gain additional information. During the initial interviews, some restrictions on time were outside the researchers control and repeat questioning was an effective tool to gain further information. Three short repeat interviews were conducted, with the strategic level TTMs (TTM1X, TTM3Z, TTM4Y) at case institutions X ,Y and Z to gain some additional information from the participants. The repeat interview schedule can be found in appendix 3.

5.8 Data analysis

The data analysis process used in this research is thematic analysis, following the framework of Braun and Clarke (2006). This process is further discussed in the next section (5.8.1). When analysing data, the generation of codes is typically the starting point to the process (Saunders et al. 2016). A code is the smallest unit of analysis when analysing data. They are the building blocks for themes or larger patterns of meaning underpinned by a shared core idea (Clarke and Braun, 2014). Coding is a way for the researcher to analyse and interpret qualitative text data to derive meaning and understanding to the data (Elliott, 2018). It allows the researcher to map or index data to provide an overview of disparate sets of data (Creswell, 2015). This enables the researcher to make sense of the data in relation to their RQs (Elliot, 2018). Open coding (the reorganisation of data into categories) is generally the first stage of the coding process (Braun and Clarke, 2006). However, depending on which methodology a researcher is using they may also use axial coding (recognising relationships between categories) and selective coding (integration of categories to produce a theory) (Strauss and Corbin, 1998).

There are a number of ways a researcher can construct meaning and make sense from conducting qualitative research, these methods included grounded theory, thematic Analysis Interpretative Phenomenological Analysis (IPA) and narrative analysis (See table 5.3 for an explanation on these concepts). For this research, thematic analysis will be used. The rationale for this approach is that it allows the researcher to identify patterns in the data from an experiential perspective which seeks to understand what participants think, feel and do (Clarke and Braun, 2014). Given the research objectives and questions which are exploratory in nature and seek to examine also the underlying themes at play, this method will allow flexibility towards meaning generation and the ability to understand the experiences of the participants; therefore, is deemed appropriate (Clarke and Braun, 2013).

5.8.1 Thematic analysis

As identified in the previous section, thematic analysis is the process used to analyse the data in this research. Thematic analysis (TA) is the process of identifying patterns or themes within qualitative data (Braun and Clarke, 2006). As Clarke and Braun (2017 p297) state '*the aim of thematic analysis is not simply to summarise the data content, but to identify and interpret key but not necessarily all features of the data guided by the research question'*. TA is not tied to a particular epistemological or theoretical perspective compared with other research methods, which leads to a wide range of applications within the social sciences (Clarke and Braun, 2014). The work of Braun and Clarke (2006) is arguably the most influential work on thematic analysis where they suggest a six step approach on how to conduct thematic analysis which offers researchers a clear and concise framework. Clarke and Braun (2013) identify a common pitfall when using thematic analysis is to use the interview questions as themes. This lack of insight offers the researcher a lack of analysis with the data but rather provides just a summary and organisation focus to the data. As noted above TA is not tied to a particular epistemological or theoretical perspective compared with other research methods, (Clarke and Braun, 2014), its flexibility in its approach is highlighted as one of its main advantages (Nowell et al. 2017).

Other advantages are its ease of implementation where a logical step by step approach can be adopted with few prescriptions and procedures (Braun and Clarke, 2006). In addition, another advantage of TA is its usefulness for research involving participants with different viewpoints allowing for contrasts and comparisons to be made (Nowell et al. 2017). Finally, it allows a researcher to summarise key features in a large data set following a well- structured approach in data reduction (Nowell et al. 2017). On the other hand, flexibility noted as a core strength of TA (Braun and Clarke, 2006) can lead to inconsistency and a lack of coherence when developing themes derived from the research data (Holloway and Todres, 2003). TA lacks the academic attention and literature compared to other approaches for e.g. grounded theory, this can lead to novice researchers being unsure how to conduct a rigorous TA (Holloway and Todres, 2003). In light of this drawback, Table (5. 8) illustrates a processual framework provided by Braun and Clarke (2006) in how to conduct TA. This table consists of six steps in how a researcher conducts a TA. First, a researcher must familiarise themselves with the data, next, they generate initial codes to begin meaning construction. After this, the researcher searches for themes or broader categories from the initial codes. Next, the researcher reviews the themes generated and makes refinements upon further reflection. Steps five involves defining and naming the themes where a thematic map is generated to gain an overall picture of the data. Finally, the researcher writes up the report on the data analysis. This process is further explained in Table 5.9.

Table 5.9 Summation of the TA process

Steps to TA	**Description**
Step One: Familiarising yourself with the data	The researcher immerses themselves in the data, where they become familiar with all aspects of the data. Transcribing interviews can be seen as a very useful way to gain that immersion with the data. This phase requires repeat and active reading to identify meanings and patterns within the data.
Step Two: Generating initial Codes	This phase involves the production of codes from the data, here the researcher works systematically through the entire data set, identifying interesting aspects of the data that may form the basis of repeat patterns (themes).
Step Three: Searching for themes	After the initial coding has been completed, the researcher has a long list of codes generated across the data set. This phase refocuses the attention of the researcher on the broader sets of themes which involves sorting the codes into potential themes and considering how separate codes could be grouped together under an overarching theme.
Step Four: Reviewing themes	This phase involves the refinement and review of themes, on reflection some candidate themes may not really be a source of a theme or themes may merge into a more larger overarching theme. When reviewing the themes, the researcher must identify a coherent pattern to the themes and review if any themes are problematic.
Step Five: Defining and naming themes	Once the researcher has generated a thematic map of the data and is satisfied with this mapping, the researcher then defines and refines the themes that will be presented in the analysis.
Step Six: Producing the report	The final step is the write up of the analysis, here the researcher needs to provide a concise, coherent, logical and non -repetitive account of the data, where they choose vivid data examples to explain their argument.

Source: adapted by Braun and Clarke (2006).

Data analysis for this study was conducted manually and by using computer assisted qualitative data analysis software (CAQDAS). This research used NVivo 12. The process of data analysis followed will now be discussed. First, after all the interviews were transcribed; then the researcher started highlighting certain information that was perceived relevant to the RQs and objectives of the study. Next notes were taken on the general themes or understanding of what the interviewee stated. These reflective notes acted like bullet points on what had been stated during the interview. Next codes were identified and generated from the data (initial codes generated from this research can be found in appendix 1). These were generated with the focus of what data would help the researcher in answering the RQs. Subsequently, the phase of reducing codes to subthemes and overarching themes was initiated. This involved identifying salient themes or patterns in the data and making sense of what were the relationships between the variables. It also involved mind map diagrams where the researcher built a logical chain of events. After the sketching of ideas the researcher began to generate data structures, using codes, sub themes, and overall themes (where the emerging empirical evidence from this study is linked to existing theoretical conceptualisations) (Gioia et al. 2013) which enabled the researcher to provide graphical representations of how the starting point of raw data evolved to a position of overall themes within the data (Gioia et al. 2013). In addition, theoretical coding was used in developing the initial conceptual model (figure 4.1) where pre-existing theory was analysed to predict the causal relationships between the different theories in order to further build theory (Braun and Clarke, 2021).

After this process was concluded manually, the researcher then imported the transcripts, documentary evidence (outlined in table 5.6) and the repeat questioning from participants into the NVivo database. The main benefit of using NVivo was that once every line of data was coded in the database, then the researcher had all the data classified and in order under separate headings. Moreover, the retrieval of this data was much easier and quicker to find than sorting through the transcripts one by one (Creswell, 2016; Welsh, 2002). At this stage the researcher cross referenced the manual and database coding processes to make sure every detail was accounted for to provide as much richness as possible within the findings. NVivo is not methodological specific and can be used with many data analysis techniques e.g. discourse analysis, ethnography, grounded theory and thematic analysis.

The benefits of using CAQDAS are in its retrieval and classification of large data sets also it focuses the attention of the researcher to analyse the data more closely, line by line classifying the data into the correct category. If a researcher was to just manually code scripts they may casually read through the transcript and miss a small piece of data which can become very important to the context of the study. NVivo 12 also allows the researcher to generate mind maps, concept maps, comparison maps and charts to visually represent the data. These are useful for the researcher to draw upon to visually see the relationships between codes and themes (Creswell, 2016). However, it must be noted that the researcher is the main tool for data analysis. CAQDAS databases do not analyse the data for the researcher they merely assist in the data reduction process (Saunders et al. 2016). Other considerations are some researchers may not feel as close to the data, by '*putting a machine between the researcher and the data*' (Creswell, 2016 p165) also, there is the learning curve and time taken to understand the computer system and its operation. There are eight themes within this research, the data structures can be found in tables 5.10 to 5.17. These tables follow the Gioia et al. (2013) methodology who argue having first order themes, second order themes and aggregate dimensions to complete a data structure adds qualitative rigour to the data analysis process. This is achieved by adopting a holistic approach into how meaning is constructed (Gioia et al. 2013). The tables have three sections to them, first, a sample of codes derived from the interviewing process are outlined. Next, second order themes or subthemes are identified and finally, an overarching theme which relates to the subthemes and initial codes is presented.

Table 5.10 – Coding process for theme one – motivators.

First order codes	Second order themes (Sub themes)	Overarching theme
Making an impact to society (X), improve patient outcomes (Y), Cynicism on the value of publications (Z), useful in the real world setting (Z), I'm interested in technology (Y),helping solve industry problems (Y), no paper will ever improve a patient outcome (Y), a real desire to actually do something (Y), solving real problems (X), desire to pass on know- how (Y), higher citation impact (Y), access to knowledge and industry expertise (X), develop our own discoveries (X).	**Intrinsic motivators.**	**Motivators.**
Route to get funding (X), you only get so much money for doing basic research (Y), fund my lab and hire qualified people (X), move your projects forward (Y), blue sky research was unfundable (Y) thinking ahead – retirement (Y), long term vision (Y). Individual benefit (X) disposable budget (Y), changed the funding remit (Z).	**Extrinsic motivators.**	

Table 5.11 – Coding process for theme two – challenges.

First order codes	Second order themes (Sub themes)	Overarching theme
Valley of death (Y), animal data is not sufficient to get private funding (X), we can take the research only so far (X), funding ecosystem (Y), no choice in deciding whether to engage with companies (X), need to show diversified portfolio (X), peer reviewed (Z) difficult to convince others of the merits of your work (Z).	**Seeking funding.**	**Challenges**
Outlook was much shorter than ours (X), small projects in the beginning (X), difficult to commit to the student (X), industry has a very high expectation (X), getting the open door is the biggest challenge (Y), dealing with HQs outside of Ireland (Y) short time frames (X) small amounts of money (X) conclusions wouldn't support the data (X), quick turnaround times (Y) look see projects (X).	**Managing industry expectations.**	

Table 5.11 – Coding process for theme two challenges (continued).

First order codes	Second order themes (Sub themes)	Overarching theme
Jack of all trades (X), personal relations (Y) contacts that the academic or the institution has (Y), Lead and champion the innovation (Y), it's a full time job (Y) right place at the right time (Y), previous relationships (X), I couldn't find a CEO (Y), serendipity (Y), skillsets to add value (X) no one wanted the responsibility of being on my board (Z). All of it had to be done yourself (Y).	**Finding the people to build a team.**	**Challenges**
Platform technology (Y) multiple end users (Y), technology push vs market pull (Y), retraining (Z), Understanding the customer wants and needs (Z). From lab to clinic (Y) customer discovery and validation (Z).	**End user needs.**	

Table 5.12 – Coding process for theme three - idea generation.

First order codes	Second order themes (Sub themes)	Overarching theme
Discovery of new knowledge (Y), Technical feasibility (X) what does success look like? (X) How do I measure success? (X). a problem comes with it a set of values (X) Exploration (Y), deep technical ideas (X), interesting to explore (Y) the underlying science (Y).	**Curiosity Driven.**	**Idea generation**
Clinical input (X) Patient engagement (Z) solving real world problems (Z), it starts with a problem, (Z), talking to doctors, nurses and other health care workers (Z), you watch how they (clinicians) solve problems (Z), you go into the hospitals (Y), as an academic you can go off in tangents (Y), patient context (Y). improve the patient experience (Z), idea that's of real quality and impact (Z)	**Needs based solutions.**	

Table 5.13 – Coding process for theme four progressing the idea.

First order codes	Second order themes (Sub themes)	Overarching theme
Interdisciplinary projects (Z), Colleagues (Z) access information internally first (Z), team approach (X), Strong technical minds within the team (X), flesh out the concept (X) realising the idea (Y) iterative process (X), Testing the prototype (Z). really talented post doc (X). using expertise and knowledge that someone on your team has (Y), I would look within the university first (X).	**Understanding technical knowledge (outside domain of expertise).**	**Progressing the idea**
Assessing commercial potential (Y), Once reduced to practice, you want to protect it (Z) Invention disclosure form IDF (X) patent centric (Y), having a good relationship with the TTO (X) informal talks on invention progress with TTM (X). Capture the idea (X), Usually the templates will help you answer some questions you had (X).	**Invention disclosure.**	

Table 5.13 – Coding process for theme four progressing the idea (continued).

First order codes	Second order themes (Sub themes)	Overarching theme
Surveillance work (Y), public domain (Z), background checks (X) attractiveness of the market (X), more valuable if people don't know about it (Y), competitor products (Y) freedom to operate (Y), desk research (X), Search by classification (Y) using databases (Y).	**IP Landscaping.**	**Progressing the idea**
Gaining knowledge and recommendations from the TTO on market requirements (X), Working with the industry partner, guided on what is important for the company (X), working with an independent market research consultant to gain an unbiased validation of the need (X). Regulators – guiding innovation in terms of risk and safety (Y). Using the skill sets of founding team members to complement technical domain expertise (Y). Angel investor network – to gain market feedback (Z). Awareness that market and scientific knowledge are different and possess different requirements (Z). Engage with customers (end users). Talk to the customer. Customers who are engaged with industry offers both perspectives (Z).	**Understanding market knowledge.**	

Table 5.13 – Coding process for theme four - progressing the idea (continued).

First order codes	Second order themes (Sub themes)	Overarching theme
Patent attorney (X) drilling down into your innovation (Y), infringements (Z), the academic would often drive the process (X), case managers play a support role (Y). Patent budget is limited (Z), You learn from the process not the lawyer (Z), nationalisation (Y) initial patents (Y) TTMs checking where the invention is going and if the AE will be covered by the patent (Y). legal language (X) responding to objections (X).	**Patenting process.**	**Progressing the idea**

Table 5.14 – Coding process for theme five - learning.

First order codes	Second order themes (Sub themes)	Overarching theme
Knowing what industry are looking for (Y) GMP (Y) GLP (Y) network of ex colleagues (Y), past consultancy work (Z), my past role the focus was on the combination of skills (research and application) (Y), what worked in one project you apply it to another (Z) learning from past failures (Y).	**Learning from past experience.**	**Learning**
Trial and error (X) learning by experience (X), you couldn't of know that you have to have done it (Y), the necessity of being involved in it. (X), no formal training (X) started reading books (Y). constant learning process (Y).	**On the job learning.**	
Thinking outside the box (Y) thinking left field (Y) I don't know how I came up with that idea (Y) I think different to colleagues (Z), more critical of projects (Z), I have a completely different perspective (Y). I don't think you can teach how to be innovative (Y).	**Change of mindset.**	

Table 5.15 – Coding process for theme six - training.

First order codes	Second order themes (Sub themes)	Overarching theme
Business canvas model (X), workshops (X), bootcamp (Y), writing a commercial case (Y) writing a business plan (Y) clinical immersion program (Z), lean canvas model (Z). IP protection (X), brainstorming sessions (Z). Accelerator specific to spin outs (Y) Monthly newsletter (X).	**Internal training.**	**Training**
Keen for post docs to get the skills (X), learning around customer discovery and customer validation (Z), the business concepts can be applied to a scientific or technical innovation (Y) before you build anything you talk to the customer methodology (Z), case histories (Y) networking opportunity (X), I was sharpening up my skill set all the time (X), I do a lot of groundwork before development now (Z).	**External training.**	

Table 5.16 – Coding process for theme seven - networking.

First order codes	Second order themes (Sub themes)	Overarching theme
Getting recommendations from the TTO (X), introducing AEs to potential business partners (Z), local decision making (X) quicker response than TTO (X), nearly all the industry contacts we have come through the research centre (X). we also host roadshows (X), invited audience to listen to AEs pitch their business (Y).	**Formal networks.**	**Networking**
Richer opinion (X) blunt answers (Z) real agendas (X), similar experiences (Z), looking for contacts (X) looking for information to be shared (Y) asking questions (X) looking for collaboration on projects (Y), Better grasp on the market (Y).	**Informal networks.**	

Table 5.17 – Coding process for theme eight - university level environment.

First order codes	Second order themes (Sub themes)	Overarching theme
The university still don't have a reward mechanism for commercialisation (X), viewed with suspicion (X) severally limits the prospect of promotion (X) not following the traditional metrics (Z), it is taken into account but it is not very highly weighed (Y), promotional criteria (X), no incentive (X), it's not a measure of importance inside the university (X) can't get lecturer grade 2 (Y)	**Promotional opportunities.** '	**University level environment.**
It was not possible due to legal constraints (X), I got quite frustrated (X) communication with the legal department didn't lead to anything (X), the national IP protocol document is prescriptive only (Y), many IP terms are open for negotiation (Y) long discussions and delays in the process (Y). templates suggestive for use are open to interpretation (Y).	**Admin and legal hurdles.**	
Resistance to blind patents (X), we have to convince the TTO its worth patenting (Z), all the work is on the individual academic (Y), I really work with them than against them (X), that 15% shareholding that Y has in the spinout blocked further investment in the company (Y), fairly rigid and standard T&C (X) no room to manoeuvre with how much equity the university will take (X), the university drives the metrics (Y).	**TTO.**	

5.9 Research trustworthiness in qualitative research.

Qualitative research has been met with some criticisms that it lacks academic rigour and enables bias to creep into its methods. Hence, the researcher needs to demonstrate concise, methodical, consistent and exhaustive methods in how research is reported and how findings are substantiated (Nowell et al. 2017). With quantitative research it is argued that these issues are less of a concern given this type of research can produce quantifiable data which is either correct or incorrect and the data supports the claim (Saunders et al. 2016). Drawing on Creswell (2016), a number of measures were followed to add rigour and trustworthiness to the research process, namely peer debriefing, audit trails, transferability of research, dependability of research, reflexivity and credibility and eliminating researcher biases.

1) **Peer debriefing -** provides external validation to the research and the process. In this study this was achieved by regular supervision meetings on the progress of the study, formal assessment points along the research journey and at the participation of colloquiums to gain new insights and perspectives (IAM 2019, EURAM, 2020).
2) **Triangulation of findings -** use of different data collection techniques to enhance validity) (Saunders et al. 2016). This research uses both documentary evidence and interviews (with further repeat interviews) to substantiate findings.
3) **Researcher bias** – where the researcher at the outset of a study clarifies any biases, prejudices or past experiences that may shape the direction of the research (Creswell, 2013). For this research (as identified in section 5.7) the researcher took the role of active listener, where an objective stance was taken and where the researcher did not influence or try to sway the respondents in any particular way. Open questions were used, and any personal views of the researcher were not brought into the research process to maintain impartiality.
4) **Prolonged engagement with participants** – building a relationship with the participants and allowing for trust to form allows for a more free flowing discussion on the topic (Creswell, 2013). Long before any interview took place, the researcher had back and forth emails with the participants about the study, and about what the researcher wanted to achieve. This started in Sept 2019 and ended at the follow up emails in Jan 2021, therefore the researcher has built up an engagement with the participants.

5) **Transferability –** here the researcher provides in -depth rich data in their findings, it is up to other researchers if they wish to seek transferability and to make that judgement call (Nowell et al. 2017). For this research, using a multi case method based on replication logic, the research has added robustness to the findings and generalisability of inquiry.

6) **Member checking -** the verification of transcripts or early interpretations of findings (Carlson, 2010). For this study, the researcher sent back the file of the interview to the participant to verify that it was a true and accurate reflection of the interview.

7) **Reflexivity –** researchers are encouraged to maintain a self- critical account of the research process, the use of audit trails adds to the validation strategy of reflexivity (Creswell, 2016). After each interview, the researcher wrote up a reflective note on the interviewee, e.g. what stood out in the interview, what was the temperament of the interviewee, what came up that was surprising or interesting, and how links between what other interviewees stated started to emerge? This research also includes data structures where there is a clear chain of evidence of how themes emerged from the raw data (codes).

5.10 Ethical considerations

Research ethics can be defined as '*standards of behaviour that guide your conduct in relation to the rights of those who become the subject of your work or are affected by it.* (Saunders et al. 2016 p239). Ethical considerations are a critical component in the work of a researcher and their research design. Participants taking part in a study have rights around consent, anonymity and non- disclosure of information that may be perceived as commercially sensitive information (Saunders et al. 2016). It is the role of the researcher to let the participant know the guidelines around research ethics and integrity. Often the codes of conduct around ethical considerations of a research project are determined by the university (Saunders et al. 2016). For this research, the researcher submitted all interview questions, a protocol document providing an overview of the project and the methodological approach intended and an ethics application form to the Ulster University Business School ethics filtering committee. The ethics filtering committee reviewed all documents to make sure the research was in adherence to the university's ethical codes of conduct and that no breaches had occurred. Once the committee provided their feedback, the researcher made the minor changes to the research design and once approved, the researcher started the data collection process. Throughout the research process, the researcher gained informed consent before any interview took place and provided assurance of agreed anonymity and confidentiality. Data was stored in accordance to GDPR guidelines which represent the best standards of practice with respect to the transmission, retention and disposal of personal data.

5.11 Conclusion

This chapter has presented a detailed analysis of the methodological choices and approaches taken in conducting this research. In summary, this research took a socially constructed ontological stance and an interpretivist epistemological position. The research was exploratory with the aim of inductively building theory in an under-researched area. Data collection comprised of four stages, documentary review, pilot interviews, main interviews and repeat interviews. The interviews consisted of a mix of heterogenous stakeholders who were experienced and very knowledgeable participants within their fields. Participants included AEs, TTMs, funding agency specialists and industry partners. Data was analysed using thematic analysis where the researcher developed data structure to demonstrate how the data evolved from initial codes all the way through to overarching themes. The next chapter will present an analysis of the findings from the pilot study.

Chapter Six.

Analysis of findings: Pilot study.

6.0 Introduction

The purpose of the pilot interviews were to test out the interview questions and analyse the responses where the researcher could change certain questions to enable obtaining rich data. Questions that did not elicit appropriate responses in aiming to answer the objectives and RQs of the study were modified which determined the structure and guide for the main interviews. The findings from the pilot study are presented below under six different themes - motivators, challenges, training, progressing the idea, learning, and university level environment. These themes were derived using the coding procedure outlined in chapter 5 tables 5.10 -5.17. The participants who took part in the pilot interviews were presented in table 5.7. After each theme is discussed, a summary table is then presented.

6.1 Theme 1 Motivators

The first theme was motivators. This theme looked at what motivated the AEs to engage with academic entrepreneurship. From the pilot study, scientific passion, personal enjoyment, desire to promote health and wellbeing and social responsibility were the core motivators as to why the AEs engaged with commercialisation activities. Each will now be discussed.

6.2 Intrinsic motivators

All participants from the pilot study were motivated intrinsically. Extrinsic rewards or incentives were not mentioned as a motivator during the pilot study. The interviewees stated that the intrinsic motivators of improving patient outcomes and the health and wellbeing of the public was the dominant driver as to why they engaged in commercialisation activities. AE 7Y stated their biggest motivator was seeing '*the benefit to health, seeing an impact of your findings, that it is actually clinically useful, or meaningful not just the small cohort of people who read inside your paper. Financial is a secondary motivator'.* AE 1X remarked '*we want our research to count for something I suppose, and in my case I got into this area because I wanted to make new medicines'.* Similarly, AE 4X discussed their commitment to their project and the opportunities it presented as their main driver stating '*I would say scientific passion is the key driver, we paid our own way, got in the doors at some of the biggest pharma using our own passion for this project and really good science, when we spoke to people they linked us to other people so networking was the other big driver'.*

AE 3Y commented on the duty and sense of social responsibility they feel working under a translational research work remit '*people like me in applied research have a duty and responsibility to not just publish papers but if there is a potential from our research to improve the quality of life, and for people to live longer, I've invested my own money in it and it's much more work and often not given much credit at the university in fact it's often seen as a conflict of interest when it isn't.'* AE 6Y commented on the intrinsic enjoyment they get out of commercialisation as their main driver as the participant stated '*the buzz is the main motivator for me, I am a person who is motivated by and enjoy the interaction between industry and research. I think industry can be poor at innovation at times, especially in technology sectors. In the university you have the freedom to explore new ideas and new opportunities, it's about understanding how things work and how does it work for me, which interests me'.* AE 5Y stated the main motivator for them was the interest from a post doc student which motivated the AE to engage with the commercialisation project *'the reason that motivated me was that the opportunity just arose. I had a post doc student who was interested in doing it. So, to some extent that was the motivation and it was an interest to see what we could do really'.*

As shown in Table 6.1, the participants were motivated to meet their duty and responsibility as a publicly funded AE, to respond to the needs of end users and to solve industry problems.

Table 6.1 - Summary of theme one – motivators.

Theme	**Sub theme**	**Sub elements**	**Conceptual model stage**	**Corresponding RQs and OBJs.**
Drivers	Intrinsic motivators	-Scientific passion. -Personal enjoyment. -Social responsibility. -Post doc had an interesting idea. -Desire to promote health and wellbeing in the community.	Individual drivers, stage one of the model.	RQ1 OBJ1.
	Extrinsic motivators	-No evidence of extrinsic motivators.	Individual drivers, stage one of the model.	RQ1 OBJ1.

6.3 Theme 2 Challenges.

From the pilot study, key challenges identified were learning a different language to interact with external stakeholders, time constraints and managing investor expectations. A key challenge which was identified from the pilot interviews was the different skillsets and mindsets that are needed to engage with entrepreneurship. AE 1X '*it's a different skillset to be honest. I've learned over the years how to pitch things to them (pharma companies), they are very aware of things like market value and the diseases we work on and the commercial propositions, so that has been a challenge because I've had to learn a new language'.*

AE 6Y also commented on the challenges of learning a different language as they interact with business stakeholders '*I certainly learned the way to communicate effectively with different stakeholders. So, presenting to our board, or new investors sometimes they wouldn't be scientifically literate so I think communication skills would be one, because it is a different language, the commercial language is different, so I've learned that'.* AE 4X commented on the different viewpoints of investors and scientists and the difference in ways of working that can emerge as a challenge '*I found that when VCs come in how quickly they want to get rid of founders, they have an exit strategy from the day they come in. They also don't want to be dependent on the founder, they find them irritating and tied up in the detail, but we are bound by rules of scientific integrity and professionalism, which means that you don't cut corners easily, whilst in business with pharma sometimes they don't seem to ask a question because if the answer isn't good you won't get the investment, to my mind as a scientist, you ask the questions, you work with the data, and it's a very different mindset coming from two different sides of the room and when you meet, you don't meet in the middle, because they take most of the territory'.*

AE 5Y found it difficult around the '*marketing aspects of the spin out and being able to position what we do in an effective way'.* These tasks were learned on the job by '*doing it wrong and then hiring professionals who could do it right'.* AE 4X discussed the financial implications of running a small company as a particular challenge stating '*one of the things we spent a lot of time on were things like legal advice, quality systems, accounting and auditing, those supports should be centralised and consolidated. You have to deal with all this, unless you can get someone in who can run your company, your money gets diluted very easy in company related matters, and if you don't have science you don't have a company but if your dividing your* *budget to pay for a company you have less science. That's a hugely important equation that nobody seems to be using'.*

All AEs in the pilot study cited time constraints as a main challenge. In particular AE 7Y who was spinning out a company for the first time, identified overload to be a major concern '*I think the university has not thought about that enough, how do you already take an academic who is already well overloaded and ask them to spin out a company without taking some workload away. Which is more important to the academic institution that I spin out a company or that I sit on committees, something has to give along the way and this is a major hurdle in my commercialisation pursuits'.* AE 5Y commented on not following the traditional academic metrics and the challenges this possesses *'I have sacrificed an academic career that has been my key challenge, so there is pressure on me to publish more but I have held off on that. I think if you are after commercialisation, it takes your focus away from publishing, If you are pursuing an academic career the metric you need to follow is publications – publish or perish! Expecting somebody who is following that path to also try and go after commercialisation is too challenging, it's a completely different field, so I think I've been successful because I have not followed an academic career, although I'm an academic I'm not following that path'.*

The findings as summarised in Table 6.2, show that, AEs found learning the language to interact with the business world and understanding market needs and demands as the biggest challenge. They also noted the different mindsets needed when working with investors as being a challenge, where these individuals have different expectations and outcomes. All AEs noted time pressures to be a challenge. Furthermore, trying to follow the traditional metrics alongside commercialisation activities was identified to be challenging.

Table 6.2 - Summary of theme two - challenges

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs
Challenges	Learning a different language and set of skills.	-Learning how to pitch ideas/concepts to industry. -Developing communication skills to speak in layman's terms to non-scientific people.	Individual barriers – stage one of the conceptual model and as a moderator over the entire conceptual model.	RQ1, RQ5. OBJ1.
	Managing the different mindsets and expectations from investors.	-Managing the expectations of investors who want results and an exit strategy. -Industrialists try to short cut the process, scientists work through all problems and back it up with the data.	Individual barriers – stage one of the conceptual model, Acts as a moderator over the model as may inhibit the development of knowledge capacities also.	RQ1, RQ5. OBJ1.
	Time pressures/ Sacrificing traditional metrics.	-The university has not given enough thought on the work overload of nascent AEs. -Going after the publication metric and commercialisation is too challenging.	Individual barriers – stage one of the conceptual model development of market ACAP (stage two) and DCAP (stage three).	RQ1, RQ5. OBJ1.

6.4 Theme 3 Training

A number of the AEs identified that they have engaged with training courses or formal education courses to help build their skillsets around the commercialisation of academic research. Internal training refers to training activities within the home institution whereas external training refers to training conducted off campus. For example, AE 3Y had developed their business acumen and skills by attending courses on financial regulation and financial planning to understand the financial aspects of grants and also in understanding regulatory aspects of the pharmaceutical industry off campus. AE 7Y completed the commercialisation bootcamp at the university, the participants learning takeaways were around '*problem analysis it makes you think whether does the customer perceive the problem that you perceive to be the problem, a lot of research we have come up with solutions for but whether the wider community actually agrees with these problems is not really known, so this course created the awareness and let me know what the end user is looking for'*. AE 5Y completed the campus company development program, in order to acquire knowledge around setting up a company and commercialising a technology. The course helped the AE to acquire the skills around business planning, the customer pitch and marketing strategy, legal and tax issues, technology validation and IP protection strategies and funding opportunities for spin out companies in the early stages of development. Table 6.3 summaries theme three as shown below.

Table 6.3 - Summary of theme three – training.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs
Training	Internal training	-Getting the pitch right workshops. -Building the right team and get networked. -Customer discovery and validation. -Value proposition workshops. -End user needs. -Company start up program. -Commercialisation bootcamp.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.
	External training	-Learning the business aspects of pharmaceutical innovation, regulatory, financial planning and with grant applications as given examples.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.

6.5 Theme 4 Progressing the idea

AEs in the pilot study emphasised the voice of the clinician in identifying where the unmet need is and how their innovations can evolve based on this information. AE 4 X commented on this '*you need to know what the clinicians need for the patients, where is the unmet clinical need? You can target a disease, at several stages of its pathway, but there is one massive area where there is an unmet need. We would know of this from constant discussion with clinicians'*. AE X4 also remarked the state funder helped with a market report to allow the AE gain some understanding on a current state of the art information report *'the state funder will help you draw up a state of the art report on the needs of the sector, not the industry, again beginning with clinicians and then who are the major players in the area, but at the rate in which pharma change their own specs it's very difficult to plan in advance'*.

AE 6Y found the supports at the TTO useful to an extent, the participant remarked '*there has been benefits from the technology office, but they are limited, as they are trying to provide support for a broad range of academics with a broad range of interests and abilities. I found TTO good when you go from initial concept to company formation, and that's as far as they take it. They can introduce you to potential business partners, initial advice about writing business plans and conducting market research'*. AE 2Y as well as clinical input involves patient groups in their research stating 'y*ou're required now to get involved in patients groups. So if you're doing medical projects for H2020, they are asking how do you involve patients groups in your research. So, you are doing a lot of surveys, your bringing patients in getting samples and you're also doing a lot of outreach work'*. AE 1X also stated '*we have patient volunteers often give us samples for us to test and they are very engaged in the process'*. AE 1X commented on the TTO's role of introducing the academic to the CEO of their spinout stating '*the tech transfer office they have really been effective, they were the ones who introduced me to X who is the first CEO of the spin out, he came through that route. The university would have protected the IP from my work and that's about licensing so that's a key source around this type of activity. Then when I got into it, I began to meet investors and potential business partners myself'*.

AE 7Y commented on the feasibility grant mechanism as a way to gain market research understanding for their spin out venture '*there's a feasibility study that I'm applying for that* *brings in a commercialisation specialist who helps with market research, and this will help hugely in acquiring this knowledge. I've learned to try not be a jack of all trades'.* From the pilot study, another key way in which AEs learned about market knowledge was through working with companies and the interaction that this brings. For example, AE 5Y found from working with industry a deeper understanding around their needs. The AE remarked '*one of the things we learned was what it is exactly industry want, just understanding their real needs and it may or may not be what they articulate but understanding their real needs and also being better able to market our services based on those interactions'.*

AE 2Y found the industry partner would bring robustness to their methods at the university lab and have a greater insight to the end user needs and delivery on a final product. The AE found '*pharma companies are always looking for TPPs (Target Product Profiles) so they come at a project where they have an end goal in sight, they know what their formulation has to achieve. They are very interested in quality attributes, so they are looking at physical chemical properties, of what you are making. Also, they are checking all these characteristics but they are doing it in a deeper way, that we would be doing as an academic, and they have got the gear and the facilities to do it, so process, reproducibility and scalability in any medical device or pharmaceutical formulation that's an angle they bring strength'.* AE3Y learned a lot from company interactions with trust being an important factor in the success of the relationship, also the participant's lab acted as an intermediary between different industry players allowing the academic compare '*their diagnostic platform material'* the participant stated ' *you learn a lot from working with industry partners but you have to be very fair and honest in dealing with them and if they are not happy that something should be published you have to honour those agreements. It can be tricky to manage but usually industry are happy to work with academic labs that are often the alpha test site or honest brokers between industry that don't often interact directly. It's a very privileged position'.*

AE 2Y employment contract allowed them to spend 20% of their work time on private consulting. They found this to be very beneficial to gain an understanding into what industry are working on currently and the trends in the market, this came about from attending conferences as the AE stated '*I'd meet people at conferences that would know the area that I'm working in, and their company would be in that area and they would want outside expertise in it'.*

AEs would use their network to make sure they are talking to the correct person within industrial companies, for example, AE 7Y would use their network to '*get to the key opinion leaders in the company so you make sure you are talking to the right person'* with AE 6Y *'I would use my informal network predominately in finding the right person in the organisation, once you find that person where you can have that high level dialog with, you can share the knowledge that way, but the knowledge doesn't always translate through all the levels of the organisation , sometimes you need what I would call ' an interpreter' who interprets high convoluted technical language into simpler instructions'.*

As summarised in Table 6.4, AEs work very closely with clinicians in identifying the unmet clinical need in a particular area, they use this knowledge to refine their offering and to meet the end user demand, they work with the clinician at the start of the project and then when moving into the testing phase. The AEs also used patient groups and patient samples to gain feedback on how their commercial offering would be received from this cohort and also to gain feedback on product testing.

Table 6.4 - Summary of theme four – progressing the idea.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs
Progressing the idea	Clinical input/patient engagement	-Working with clinicians to identify the unmet clinical need. -Patient volunteers. -Using Patient samples. -Surveys – outreach.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model)	RQ2, RQ4. OBJ 2,3.
	TTO supports	-Meeting potential business partners through the TTO. -Writing business plans. -Drafting patent applications. -Help with market research activities.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model)	RQ2, RQ4 OBJ 2,3.
	Industry engagement	-Can act as an alpha test site, testing the products end to end from a technical viewpoint, where the AE gains access to industry technologies to test them and brokers the relationship between industry partners. -Industry also bring skills with the end goal and delivery of the project, this can focus the mind of the AE on what the partners needs are and how to achieve them.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model).	RQ2 , RQ4. OBJ 2,3.

6.6 Theme 5 Learning

AEs in the pilot study learned primarily from past work experience and bringing that learning into their current role or learning on the job. AE 2Y commented on the importance of their past work experience within a pharma company in gaining transferable skillsets; '*well I suppose I'm an unusual academic in that I came from the different direction, from pharma into academia. I would have a lot of skills I was trained in so project management, for example, I was trained in that, at the pharma company I worked for. Also running joint ventures with American biotech companies that's another area of training and also presenting to investors so that was all part of the training and that's been a big advantage for me coming into academia when you are trying to generate money from a lot of the same sources'*. AE 2 Y also found the ability to network from their past work experience as beneficial, the AE remarked *' obviously I came from pharma in 2001 so I had a network, X is a very big company, it has threads throughout the Irish economy, so there is ex colleagues in venture capital and I bring that with me. We have also ex company people in the department of Education and in European Commission posts, so I bring a network of contacts that has really helped. As I came from pharma, I had a network of researchers in big companies based all around the world, so I think that has been a huge benefit that I have that other academics don't'.*

AE 6Y also commented on the benefits of prior industrial work experience '*I do think the time that I have spent in industry and the contacts that I have been able to bring back with me has been very helpful, there definitely wouldn't have been such of a commercial success if I hadn't gained industry experience'*. In contrast, AE 5Y commented on all the tasks in their spin out as being *'on the job learning basically'*. Through trial and error and learning by doing the AE learned the do's and don'ts relating to a successful spin out company. The AE also commented on the fact that in the spin out, all the work tasks were completed individually where the AE stated, '*I think the biggest gap that the university doesn't understand is that the academic has to do it all themselves'*. The participant felt the TTO '*had their limitations mainly around limited budgets and human resources'*. Theme five is summarised below in table. 6.5

Table 6.5 - Summary of theme five – learning.

Theme	**Sub theme**	**Sub elements**	**Conceptual model stage**	**Corresponding RQs And OBJs.**
Learning	Past work experience	-Connectivity and networking. -Project management. -Presenting to investors -Running joint ventures.	Exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3,
	On the job learning	-Trial and error learning. -USO activities. -Little support from university.	Exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.

6.7 Theme 6 University Level Environment

This theme relates to the impact the university level environment has on the abilities of the AE. AE 4X identified that they felt that there was a blurring of lines between the role of the TTO staff and themselves as the scientist when interacting with industry, '*people who are in those posts now at the TTO also have doctorates in very specific areas and often align with your own, their job is to interface with industry and help you commercialise your results but I find that they tend to speak for you, because there is such similarity in the level and type of qualification, you get people crossing the line in those discussions between the academic and industry. Nobody can tell anyone else the type of work I can do for anyone else unless I give the a very specific brief, there is something wrong with this dialog because the researcher isn't central to it'.* AE 3Y commented on the training offered by the university as not being tailored enough to assist nascent entrepreneurs, '*they all give the same courses, which are all very early stage but there is very little to guide potential entrepreneurs into not making common mistakes, so they don't sign agreements early on, for a very small amount of money, where they will not be able to seek further investments. I would say the quality around the guidance of innovation and entrepreneurship is extremely low and there is a lot of potential to improve it. They often don't give practical guidance to young entrepreneurs on how to not make mistakes. The support from the university is not pitched at the right level'.* When asked how this could be improved AE 3Y remarked '*this can be improved by mentors, who have already done multiple companies, made the mistakes like I have, and actually guide each other'.*

AE 2Y found the TTO not to be as fast paced and responsive as industry, the AE remarked '*the TTO by their nature are quite sluggish. The industry people want things to work a lot quicker, so turnaround times on IP agreements tend to be slow because you have a public sector mentality working with the private sector with a sense for speed and it doesn't always match. I would say that, that is something that could be improved'*. AE 2Y also felt the university could do more in helping academics hear about what companies current interests and objectives are, the AE stated, 'I *think the university could do more in bringing companies in to talk about their research and what research they are interested in, so I think its two way. The companies are interested in hearing about what the academics are doing but we need to hear what the industry guys are doing, in so far, as they can talk about their research'.*

The pilot AEs also noted the difficulty in promotional opportunities once following a commercialisation focus and the pressures to publish. AE 6Y argued universities '*need to hire academics who have worked in industry, there seems to be an either-or mentality with going after a purely academic career or a commercial one'*. Also, AE 4X found '*you can't have the same success in an academic career if the academic institution doesn't recognise the incredible input that needs to go in to bring research through the commercialisation route. We were commercially sensitive, still are, managed to get more money but you can't publish because somebody else sees it and you compromise your IP'.* Table 6.6 summarises theme six university level environment.

Table 6.6 - Summary of theme six – university level environment.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs.
University level environment	TTO	-Blurring of lines between TTO staff and the AE.	Acts as a moderator in the conceptual model.	RQ5. OBJ4.
	Training	-Training pitched at too high a level and too generic, need to provide practical advice on mistakes made by experienced AEs.	Acts as a moderator in the conceptual model.	RQ5. OBJ4.
	Other domain experts	-AEs would like to see other domain experts with more generalist backgrounds/ industrialists, come in and give talks in the university, where the AE develops their connectivity and gains some learning through osmosis.	Acts as a moderator in the conceptual model.	RQ5. OBJ4.

6.8 Conclusion

This chapter has presented the findings from the pilot study under six themes which emerged from the data analysis (section 5.8). Each theme included AEs from case institutions X and Y. After each theme, a summary table was provided which links the theme to the conceptual model and RQs. The findings helped improve the interview questions by adding clarity and removing ambiguity. This structure also established a guide for contributing to the analysis of the data from the main interviews as shown in the next chapter.

Chapter Seven. Analysis of the findings: main study.

7.0 Introduction

This chapter presents the findings from the main study which comprises of documentary analysis, 32 main interviews and 3 follow up interviews. It builds upon the preceding pilot interview findings chapter in addressing the key issues and research questions derived from the conceptual model. The analysis is presented under eight themes, based on the data coding process outlined in the methodology chapter, section 5.8. The structure of this chapter is as follows, first, there is a short summary of the conceptual model (as derived in Chapter 4 Section 4.6) which is used to guide the analysis. Second, each case is analysed separately under the eight themes with summary tables outlined under each theme for each of the three cases (Cases X, Y and Z). Third, all three cases are cross examined to highlight similarities and differences within the findings.

7.1 Conceptual model

As presented and discussed in chapter 4, the conceptual model (Figure 4.1) which underpinned the empirical data for this study, is designed as a series of processes. Viewing the model from left to right, it first depicts the micro level challenges and motivators that face AEs as they engage with the academic entrepreneurial process. Next, the model illustrates the learning processes AEs engage with which range from the searching and acquiring of external knowledge, to the internalising of that external knowledge in response to a problem or stimuli. The third phase then explores how the AE exploits this newly combined knowledge and information i.e. the development of their DCAP in order to derive commercial and non - commercial benefits from their innovations. The model also consists of moderators (discussed in the theory development chapter section 4.10) and a number of antecedents are identified which may relate to both PACAP and RACAP (discussed in chapter 3 section 3.5 and 3.6. The model is presented again below in figure (7.1) as it will form a basis to explore and interpret the findings.

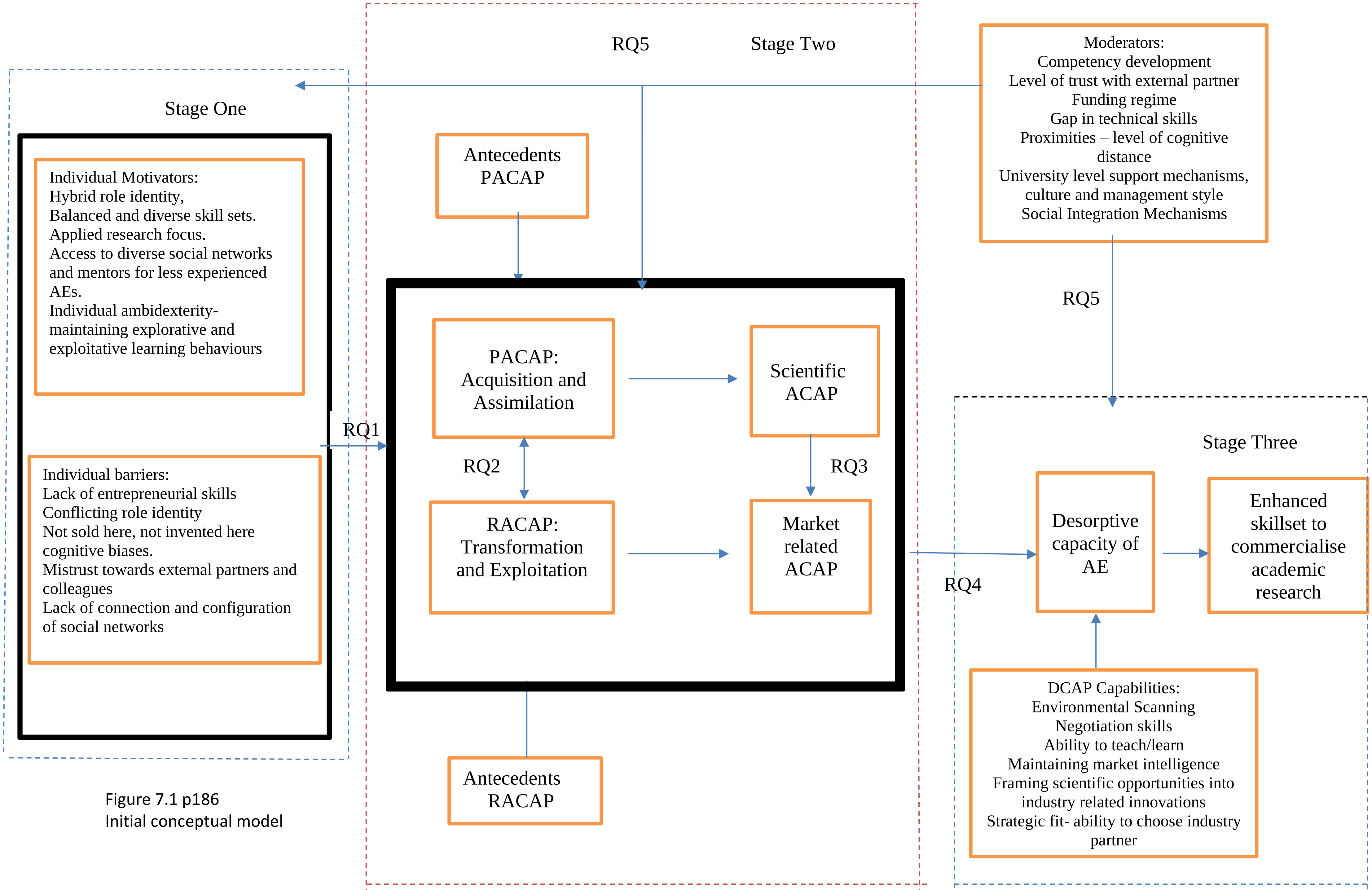

Figure 7.1 p186
Initial conceptual model

7.2 Case X – findings

An overview of Case X is described in chapter 5 section 5.4.6. The findings for Case X are now presented in the proceeding sections 7.3 -7.10.3. These core themes identified were motivators, challenges, idea generation, progressing the idea, learning, training, networking and university level environment.

7.3 Theme 1 Motivators

This theme is broken down into intrinsic and extrinsic motivators. The intrinsic motivators from Case X were found to be, 1) to problem solve, 2) to improve patient outcomes, and 3) the enjoyment derived from industry interaction. The extrinsic motivators were found to be the financial benefits the AE can receive from commercialisation.

7.3.1 Intrinsic motivators

The majority of AEs identified that they believed they have a social mission and therefore wanted to make a direct impact with their research in relation to improving the health of the public. Their desire to make a real-world impact was found to primarily motivate AEs to engage with commercialisation activities. AE17X stated '*the main driver for me is impact in the sense of I see so many great ideas withering on the vine for want of execution, and for me writing papers and citations is fine but if the project dies, no impact is ever had, but to be able to build a product and have an impact on people's lives and put it into their hands is the ultimate*'. Many of the AEs suggested that they wanted to solve health problems that will improve therapies and medical devices. For example AE12X stated '*the way we approach this is that we are solving problems – real problems with real solutions. Purely academic projects can be a little too lofty and theoretical, which isn't any help on the ground, so particularly in the area I'm in medical devices it has an immediate impact and effect and you can see if it has worked or not. Solving real problems has led onto the commercialisation, because if you fix something that is broken and fixed it well, naturally there is a product thereafter'*.

Whilst the AEs in Case X had a strong desire to help patient outcomes, they realised that the vehicle to get there is through commercialisation. For some AEs at Case X, commercialisation offered them a route to funding. It was suggested that funding bodies promote a model of innovation based on industry engagement and the commercialisation of academic research as a determining factor to access funding. AE 23X stated ' *I would say at a personal level, it's common to a lot of us that we have no choice, because in Ireland at the moment you really need to show the funding agencies that you have a diversified portfolio of activity'.* When asked what motivated them to commercialise their research, AE 22X responded *' I would say at the very beginning it was a route to get funding, to start up research activity, as the years went on, I realised that the only way of doing what I did to translate into the clinic was doing something that had commercial potential that could be either licensed or turned into a spin out company'.* AEs within case X also noted a desire to help solve industry problems as a motivator to why they engaged in commercialisation. AE21X provided the example of how their research team helped clients from the automotive industry stating '*we make lightproof coatings for glass for applications in the automotive industry but we would never make a windscreen'*. Industry problems can be related to health but also encompass a wider remit with AEs working with partners from different sectors such as the A.I. automotive and recycling as examples within Case X. AE 12X commented *'I have worked a lot with industry, where they would come with specific problems that we could solve and this helps improve their productivity, this is a motivating factor for me, I enjoy that interaction'*. Working with large industry partners was said to enable the AE to access potential new routes to market on what they are working on in the lab and also to access the expertise and resources that large MNCs can bring to a collaboration.

7.3.3 Extrinsic motivators

The core extrinsic motivator for case X was the financial benefits of commercialisation. The financial rewards of commercialisation was suggested to allow many AEs fund their own research and labs enabling the hiring of staff, with some academics noting the personal financial rewards available as part of a USO (university spin out) venture. AE 28X commented on motivators to engage with academic entrepreneurship '*there is also with a start -up company and a co -founder of that there is the motivation to make money, you benefit from the economic benefit of the company equally also with tech transfer if you patent the technology and it gets licensed out, there is some individual benefit from that'.* However, despite the financial benefit of commercialisation being attractive, the intrinsic motivators were found to be the most important motivator for the participants in university X. Table 7.1 summarises theme one for Case X.

Table 7.1 Case X - Summary of theme one

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and objectives (OBJ)
Drivers	Intrinsic motivators	-Problem solving. -Real world impact. -Social responsibility. -Engagement with industry – new routes to market -Means to get funded.	Individual motivators, stage one of the model	RQ1, OBJ1.
	Extrinsic motivators	-Means to make money – economic benefits.	Individual motivators, stage one of the model	RQ1, OBJ1.

7.4 Theme Two: Challenges facing the AE as they engage with commercialisation processes.

This theme looks at the challenges facing the AE as they engage with the commercialisation process. It addresses RQ 1and OBJ 1. For Case X it is broken down into three sub themes seeking funding, managing industry expectations and finding the right people to accompany the AE on their commercialisation journey.

7.4.1 Seeking funding

Seeking funding was an individual barrier for all AEs; especially at the stage of moving from pre-clinical data to human clinical trials for respondents at Case X. The AEs identified that they faced challenges with applying for and securing very competitive public funding calls and also securing the private investment to further progress their innovations. AE 23X noted that it was challenging to accessing funding to progress their innovations and ideas *'we can get funding to take a technology from a concept to a pivotal pre -clinical study, an animal study where you are testing your device or implant in a large animal to see if it's any way effective in treating a particular condition in the animal. When you are looking to raise VC funding especially in the medtech sector, a lot of cases that animal data may not be sufficient to gain VC or additional funding. so you need some kind of human data to support getting VC funding, so there is definitely a gap in the funding system'.*

One way university X overcame the funding challenge is that they set up a fund in conjunction with university Y and private investors to help get the funding in place for their AEs. The TTO at university X identified '*regarding access to funding, Ireland is not well served, we are not New York we are not London so we went and created our own fund to solve that problem and that's been incredibly successful, that's probably been the biggest issue up until 2017'*. AE 28X identified that they utilised this funding stream within their spin out venture, '*we went out to investors and talked a lot to investors and the TTO helped a lot with that process, finally we got it through X fund who gave us 600,000 on top of that x gave us 250,000 so 850,000 in total in start- up funding'.*

Many of the AEs at Case X identified that they used the commercialisation fund by the state funding agency as their first point of contact when seeking funding. AE15X stated ' *The first point of call is the commercialisation fund, so you would apply for the 15k feasibility grant first to build a case around getting the larger tranche of funding'.* AE 21X found having an initial conversation with the state funder about their ideas as being useful ' *you almost always put in an ad hoc expression of interest where you would talk to the people in X and they would sound that out with you, based on how you interact with them, they might suggest, 'yes, I think it might be a good idea to apply for the comm fund' and then you fill out a fairly extensive application form'.*

The governmental funding agency used in this study provides the commercialisation fund which is targeted at academic innovations and the supports needed around them to promote their development with a view to developing a spin out company. The fund provides a range of supports to the AEs as they engage with the commercialisation process. FB2a stated that the funding agency do not take a hands off approach, they are very much involved in the process and offer supports to the AE during the process. FB1 described the support services they provide including the provision of mentors, introductions to potential business partner if needed, keeping the teams informed on the relevant investor meetings for attendance /participation, providing showcasing events around the start- ups and consultancy support – e.g. regulatory consultancy supports. They also have a dedicated commercialisation specialist assigned to the AE who can assist them. AE 15X described the benefits of working with the state funding commercialisation specialist, '*dealing with the comm specialist from X, they are what I call a proper scientist, where is your data, where is your statistical inferences, confidence levels etc, the specialist really pushed back on me to prove what we were saying, which helped immensely because by the time we got to the end of it we had a good business case, a realistic profit and loss model, fantastic feedback from our trials – 95 % preferred our device which is a testament to hitting all those milestones along the way'.* This quote from AE 15X demonstrates that not only are the funding bodies providing the investment but also that the AEs get to work with specialists in academic commercialisation from a business and market opportunity viewpoint. This external assistance can provide the market knowledge that some AEs are missing coming from highly specialised scientific backgrounds.

7.4.2 Managing industry expectations

Managing industry expectations was reported as another challenge faced by AEs. AE23X, identified that building the relationship with an industry partner takes time. This can be a challenge when projects are of a shorter time scale or especially at the beginning of a working relationship. The expectations by industry on quicker turnaround times and a focus on delivery presented a challenge for AEs to staff their research teams. AE 23X remarked *'here a Ph.D. lasts for four years I would say the typical project lifespan with a company is 18-24 months. Some are renewed so it can continue but I don't know from the outset so it's difficult to commit to the student and I don't want to commit if I can't essentially'*. The AE stated that companies want individuals who can hit the ground running; however more nascent AEs need time for training and longer life spans in project times where the industry partner does not share the same concerns.

AE 12X commented on the different end goals between university and industry counterparts stating '*another challenge is that scientists tend to be incremental in their advances, A leads to B to C and to D. Some industrialists what I found is they would do the part A and B miss out everything in between and then arrive at X,Y and Z – the conclusions but the data wouldn't support it, it might indicate a certain way but it wouldn't support it so they are trying to shortcut it, so that was a challenge'*. AE 12X also remarked that sometimes the investment that the industry partner has budgeted for a particular project is very restrictive, again affecting the management of the project. AE12 X stated '*I had a call last week with a company and they want to do a particular piece of work with me and a colleague in X and they mapped out what they want done and I was looking at this saying this is a year project, it's a post doc or at least a RA, and we asked what is your budget and they said 15,000 euro and immediately we said this is not feasible'*.

Alternatively, from the industry perspective, industry partner 1 found AEs lacked skills around project management. Industry Partner 1 (IndP 1) stated '*we have had situations in the past where we got involved in projects that had very good science but very poor managers and as a result the projects often went off track and that was a real shame because the science was good'*. As a result of prior experiences with AEs, the company is now more critical of who they engage with, they want to see a proven track record for example '*one of those criteria would be if they had prior experience in managing projects like FP7 or H2020'*. Also the industry partner stated '*we don't join projects on the invitation of academics unless they have prior experience'.* As a result of the poor project management witnessed by the organisation they now are more stringent with their measures around project management '*now we are much more critical by doing risk assessment at every point in the project to make sure timelines and deliverables don't slip'*. From the AEs point of view, the short timescales, shortcutting processes or unrealistic expectations and getting nascent AEs up to speed on projects are challenges faced regarding the management of projects. From the industry perspective, AEs did not share the same bottom line focus of having an end product and results, where a strong focus is on risk assessments and meeting deadlines.

7.4.3 Finding the people to build a team

AEs reported that it was a challenge to find the correct team with the appropriate skillsets to accompany them on the commercialisation journey. They specifically mentioned finding a CEO, business advisors and external investors for their USO, as being challenges. TTM1X confirmed this challenge when they remarked '*the biggest challenge for us is getting the executive talent to add to that team, so where do you find it? there is not a lot of in Ireland, that's why a lot of spin out companies, my theory, in USA, get a much higher bounce in the beginning is because they are using tried and trusted executive talents than the venture industry in Ireland, and that's in pretty short supply here'*.

The strategy at university X was to allow the AE and potential business partner(s) to work together as early on as possible to allow each party get to know each other. This allowed trust and a working relationship to develop. A reason for this was given by TTM1X ' *there can be a reluctance on the part of the AE to give over their fledgling company to someone else as it's very much seen as their entity where an AE could be working on the project 10 + years, whereas if they co-research together, then there is a relationship built up at the end of that and it makes the transfer of who's who seamless whereas if you just introduce somebody at the very end and say they are going to take your technology, the academic can be a bit reluctant to let go so it's better to create a relationship early on in the commercialisation process'*. AE 17X stated that due to personal differences on the direction of the company, the AE and business advisor did not see eye to eye and this was found out quite late in the process, which ultimately set the USO back a year in its progress. This finding highlights the importance of building the academic–business advisor relationship. AE 28X identified that proving their technology was mature and capable of addressing the market need to external investors was challenging despite having lengthy meetings with potential investors. AE 21X stated a challenge was working with the outside investors because although they were scientists they were very commercially driven, the AE therefore found a challenge of '*trying to reign in their enthusiasm or to some degree their recklessness because the science wouldn't support it, that was a challenge'*.

In contrast, when an AE can connect with the correct people with varying skillsets, there was evidence that the AE was able to learn from those individuals, developing new skills and market knowledge. AE 12 X described the influential role the business advisor to their spin out played ''*they brought a whole different set of skills and outlook, they were a sales rep for a lot of MNCs - the attitude and the approach to things was different, learning that if you have the best product in the world but not an effective sales team, it's not going to go anywhere'* Furthermore, the AE remarked *'I never did a profit and loss model in my life so that was a shock to the system and forecasting, so most of my learning was on the job learning.'.* AE 28X commented that the TTO and a market research consultant helped them to develop their market knowledge '*I went over it for a couple of months together with the TTO and market research consultant, to get a understanding of the mindset of how technology is used from this other side of the fence and adapt our offering'.* AE 15X stated it was only when external investors came on board, one with a specialism in marketing, that the AE conducted market analysis based on sales in Europe and U.S. Table 7.2 summarises theme two for Case X.

Table 7.2 Case X - Summary of theme Two.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs
Challenges	Seeking funding	-Human clinical data needed to raise VC funding. -Setting up private fund with case Y and private investors to overcome the challenge.	Individual barriers – stage one of the conceptual model and as a moderator over the entire conceptual model.	RQ1, RQ5. OBJ1.
	Managing industry expectations	-Relationship building. -Projects are of a shorter time scale -Staffing issues – hiring of Ph.D.'s. -Industrialists trying to shortcut the process.	Individual barriers – stage one of the conceptual model and as a moderator over the entire conceptual model.	RQ1, RQ5. OBJ1.
	Finding the people to build a team	-Reluctance of the AE to hand over their research / fledgling company. -Introduce the business partner and AE early on to build a relationship.	Individual barriers – stage one of the conceptual model Development of market ACAP (stage two transformation and exploitation) and DCAP (stage three).	RQ1, RQ3, RQ4. OBJ1.

7.5 Theme 3 - Idea generation

This theme relates to how AEs come up with ideas when they were engaged with the commercialisation process. It is linked to theme one 'intrinsic motivators' as many of the ideas that AEs came up with are to solve problems facing industry, a motivational factor for AEs. The findings suggest from Case X that ideas emerge from academics identifying a specific market problem that needs to be addressed or to a lesser extent from curiosity.

7.5.1 Curiosity driven

Some of the AEs at Case X identified that their ideas were generated through curiosity and wanting to explore a fundamental concept. It was suggested that they are driven by wanting to understand the underlying science and process involved. They were trying to understand what is going on beneath the surface of a problem. AE 17 X identified that having ideas of an exploratory nature presented extra challenges for them as the problem was not clearly defined and no sets of metrics were available to use in gauging successful outcomes. AE 22X commented '*I would say my ideas are predominately curiosity based, having said that I'm aware of the clinical problems in my domain, we are usually developing for a broad clinical problem and then once you have the solution, hone in on the commercial application of that'.* AE 21X used their research interests and also what could be of interest to industry (using prior industry work experience and their engagement with industry on past projects) when generating ideas *'we are working on some deep technical ideas that would be rooted in my ideas of what I think is interesting to explore and what I think is potentially relevant to industry with my knowledge of industry'*. AE15X remarked on the nature of the ideas they work on '*I'm not a true academic in the sense that product design is a very hands on discipline. It's blue sky thinking and concept ideation and understanding user needs. it's very pragmatic information I'm working with'*. AEs found their ideas combined exploratory thinking and design; however, they also took into account the relevancy to industry or end user needs when coming up with ideas.

7.5.2 Needs based solutions

For the majority, it was found that AEs come up with ideas to solve predefined problems in a market context. They acquired this knowledge through clinicians primarily, but also by using their own academic expertise and interactions with industry and patients. By engaging with these stakeholders, it was suggested that the AE learned what the unmet clinical need is, i.e. what doctors and nurses are seeking to help their patients, or what would be beneficial to a clinician at a particular moment in time. AE 15X described that one of their ideas emerged after a local hospital got in contact with the design team at the university to come up with an idea to solve a problem, the participant noted *' the idea came about from a child with CF arriving into the hospital with their current device which had turned black, that was swabbed in the hospital and was found to be pathogenic. That was brought to her consultant who then talked to a microbiologist and the feedback was we obviously need something that is disposable. So the hospital contacted me in the school of design, and I came up with an idea which worked excellently'.* AE 22X found the knowledge from clinicians on what they like or do not like as very helpful to developing ideas. From the findings it was identified that the clinician is providing valuable information on what the end user requirements are, therefore the AE is learning how to convert their scientific knowledge into a more market and end user centric focus. AE 22X stated when working with clinicians '*in our case, it's been feedback on products we developed and then testing it out, saying ' I like this part, I don't like that part' this isn't going to work in a clinical situation because of X,Y,Z. so it's that kind of user feedback which allows us to iterate an idea based on that feedback'.* AE17X discussed how they came up with an idea quickly and sketched it out; here the individual had many years of industry experience and knew what type of information to seek out, the participant stated *'I had quite a commercial mindset on what are the key questions that I have to ask here. it's called the M.A.N. approach. you have to find the money, the authority and the need. So I immediately went to my idea and said where is the money in this, where is the need in this and who would have the authority to make these decisions. So identify who your customer is, how much value they would place on it. As I roughed it out I did it in a more commercial template and then I saw the commercial potential'.* Table 7.3 summarises theme three for Case X.

Table 7.3 Case X - Summary of theme three.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJ.
Idea generation	**Curiosity Driven:**	-Exploring a fundamental concept or the underlying science. -Difficult in assessing the metrics and success of such projects.	Acquisition phase of ACAP – stage two.	RQ2. OBJ 2, 3.
	Needs based solutions:	-Coming up with solutions to solve existing problems. -Identifying what the unmet need is. -Interaction with clinicians, nurses, patient groups, health care workers, industry partners to help solve problems.	Acquisition phase of ACAP – stage two. (Identifying the unmet need).	RQ2, OBJ 2,3.

7.6 Theme 4 Progressing the idea

This theme identified how AEs were progressing their ideas after the idea generation stage. This involved the AE understanding knowledge that is outside their domain of expertise and working with a range of stakeholders to gain the knowledge and skill to progress the innovation.

7.6.1 Understanding Technical / scientific knowledge

The findings identified that AEs go to their colleagues within the university as a first point of call, to help them comprehend additional knowledge from a discipline outside their expertise from a technical/ scientific viewpoint. For example, AE 23X identified who they approach for knowledge outside their expertise, '*I would say mostly you talk to colleagues, I usually seek advice from colleagues that are a little more quantitative than me'*. AE 21 X noted on the technical side, industry wouldn't have much of an involvement at this stage of the process and rarely provide technical ideas.

AEs in case X also commented on using the knowledge and skill of team members within their research group such as post docs and Ph.D. students in order to bring an innovation to a prototype stage. AE 23X stated '*it's definitely a team thing, in that there are guys who are able to do strong technical work and we are usually on a fairly fixed path so they do come up with clever things but they wouldn't rock up with a brand spanking new idea that they want to progress. We would be on a path and it would be contributing to those results'*. AE 21X described how past projects have reached prototype stage '*so it's between me and the team, in engineering you are making something, so in that case we need to make something work so normally the team are able to do that and we use outside companies for practical engineering work like something that's too big to get done in the workshop or will take too long'.* AE17X commented on the team approach in bringing their innovation through the prototype stage *'most academics have an army of students they actually do most of the coalface work. So I worked with a visiting student we collaborated on the prototype, they did the coding and I did the design work and directed it. I did most of the algorithm and they implemented and tested and we reviewed together. So we worked closely together and the student is a co signatory on the patent'*.

7.6.2 Invention disclosure

Once the AE wants to move forward with the innovation and protect it, they file an IDF (Invention Disclosure Form). The IDF at university X challenges the AE to think about the market potential and application of their invention, i.e. who will want this invention and why? What market need is it addressing? Who are my competitors? Do I need to change any aspect of my invention, so I don't infringe on patents already granted? It also challenges the AE to search for market related knowledge i.e. conduct patent searches and literature searches to list keywords or terms relevant to the invention and identify any other researcher (academic or industrial) who is working in the field i.e. identify the competitors. As optional requirements, section C asks the AE to attach competitor papers, abstracts, review articles in the field and also to go onto the European patent office database.

7.6.3. IP landscaping

IP landscaping refers to patent searches to make sure an AE can sufficiently protect their research. It is done primarily using databases such as the EPO (European Patent Office) database. The IP landscaping work that the IDF at university X sets out can be completed alone by an experienced AE or the AE can work with a TTO case manager to help fill out the application form. AE 17X conducted IP landscaping themselves stating '*I did desk research myself, I had industry experience I knew how to use the tools to search for databases, so that was helpful. You learn a lot yourself by looking at patent databases and products, if you just look at the academic literature it can be quite misleading – it might not actually work its highly novel but completely impractical data, whereas less so in the patent database, where the information is more critical than in a journal'.* At university X, when the TTO case managers look at a piece of IP, they also do landscaping work. TTM 1X identified '*we do the background checks, look at the market and the attractiveness of the market, and that's the skill set of the case manager. and then make a decision how we are going to support it, will we PCT (Patent Cooperation Treaty) it, will we go big on it, will we keep it small, and sometimes there is a decision to not patent it because it's more valuable if people don't know about it, basically keep it secret'*. It was identified that the IP landscaping work is an important skill for the AE to master as it provides them the knowledge on what IP is already out there and who is working on what. This information and skill then helps inform the AEs if they need to modify their design due to infringement issues or freedom to operate. TTM 1X stated patent searching is an optional requirement at Case X, with more experienced AEs capable of completing the tasks with more nascent AEs working with a TTMs who have the expertise. Therefore, the level of experience of the AE emerged as important in relation to this sub theme.

7.6.4 Patent process

AEs cannot write patents they need external expertise to help them file patent application with the applicable patent protection offices, which ensures their innovation is protected and legally binding. AE 23X found patent attorney interactions beneficial to acquire the legal language required in the patent application process, which the AE lacked. AE 23X also found value in the patent attorney responding to the objections from the patent offices as a useful engagement. AE 28X commented *'I hold 45 patents with my old job I was quite used to talking to attorneys but they translated our technical language into a more techno-legal language and that was a very good interaction, it was arranged by the TTO office who had these contacts to lawyers that we didn't have ourselves'*.

7.6.5 Understanding market knowledge

The AEs reported that they seek market knowledge from a range of sources (sources of knowledge can be found in table 7.5). AE 28X stated that their first point of contact for market knowledge would be the TTO, '*it would firstly be to the transfer office, because they have a lot of expertise and connections and can point me in the right direction for more, they can do specialised market studies if we wanted to venture out to another area we could get people on board with that'*. Similarly, AE 22X remarked '*on the commercialisation projects that we have done, we have gone to the TTO and said look we need someone to either write a business case or do market research, in those cases they have had personal experiences of consultants that would have particular expertise skillsets, and based on their experiences or a case manager in the TTO with their experience of consultants which has driven our decision'*. AE 17X identified that end customers are useful to gain access to market knowledge, *'mostly I learned from the end customers so infection control teams in hospitals, I learned a tremendous amount there and from the W.H.O. their patient safety program, so in terms of defining customer need that was really important. Other people I learned from are companies in the industry working in aligned areas, so like infection control products, there was a lot of knowledge translated in trade shows and conferences, these events where you would meet people in the industry, so there are constant conversations going on, my own colleagues in the spin out also I was learning form them too'*. AE 21X reported that their industry partner helped them accumulate market knowledge, where the company had a greater grasp of the market than the academic and their research group. They aided identification of opportunities, advised the AE on what they are happy to publish or what they wanted to protect in terms of IP. Liaising with industry helped the AEs to get an insight into '*future industry needs'*. This is a valuable source of learning where, when working on future project, the AE can exploit their learning and thus develop their DCAP with future projects.

An important element in helping the AE understand market knowledge was conducting market research on the commercial proposition. An AE can work with an external market research consultant under the state feasibility study, where an external independent consultant assesses the opportunity from a market perspective. AE 28 X commented on the use of working with a consultant in helping them understand the market they were positioning their product, '*if you hire an external consultant that was fruitful we had good and intense discussions with the person that opened our eyes and gave us a good understanding to the market, as academics we didn't have any concreate real experience of these things so it helped us to streamline our thinking from the technical world into something more market orientated'*. AE 21X identified that market research consultants asking probing questions within the research process can provide new insights, '*the reports on the market are relatively straight forward to get hold of but the insight where you might send a feasibility consultant to talk to a number of people and bounce ideas off them and various bits and pieces, so we do use that, so my model, at the moment is use the comm fund feasibility grant for your idea and evaluate it and based on that go for the comm fund properly'*. Here the AE is looking for market feedback from potential customers or end users to refine or take note of any issues in order to enhance their commercial proposition. The commercialisation specialist (FB2a) at the funding body stressed the importance of the timing and the framing of questions as critically important aspects of the independent assessment. If the consultant goes out to the market too early or the questions are not framed correctly, the results from the research won't be as good as they could have been. Table 7.4 summarises theme four for Case X.

Table 7.4 Case X - Summary of theme four.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs
Progressing the idea	Understanding Technical / scientific knowledge:	-Ask a colleague. -Read the literature around the concept -Work with the research team. -Industry don't provide much assistance here.	Development of scientific ACAP And the assimilation of technical knowledge.	RQ2. OBJ 2,3.
	Invention disclosure	- IDF – four sections -technical description, disclosures, third party properties and list of inventors.	Develop their market ACAP (stage 2 of the conceptual model) and developing their DCAP (stage 3 of the conceptual model).	RQ2, RQ4 OBJ 2,3.
	IP Landscaping	-Work with a TTM or complete the landscaping work independently. -Background checks. -Market attractiveness checks. -Patent searches. -Working with databases.	Develop their market ACAP (stage 2 of the conceptual model) and developing their DCAP (stage 3 of the conceptual model).	RQ2, RQ4. OBJ 2,3.
	Patent process	-Engaging with the patent lawyer helped with the technical legal language required. -TTO would help draft patent applications. -Lawyer was helpful when the patent offices had queries / comments on the patent application.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model).	RQ2, RQ3,RQ4. OBJ 2,3.

Table 7.4 Case X - Summary of theme four (continued).

Progressing the idea	Understanding market knowledge	-Gaining knowledge and recommendations from the TTO on market requirements, who to work with and support. -Learning from end users – defining the customer need. -Working with the industry partner, guided on what is important for the company, the market need and what IP to protect and which to publish. -Market research – working with an independent consultant to gain an unbiased validation of the need.	Assimilation (understanding) and Transformation stage of ACAP. Developing and refining the market proposition of the innovation. DCAP – taking the knowledge gained from working with the stakeholders to exploit the innovation.	RQ2, RQ3,RQ4. OBJ 2,3.

7.6 Theme 5 - Learning

Learning is a continuous process throughout the ACAP and DCAP processes. This theme relates to how AEs internalise external knowledge, and progress to the exploitation stage of ACAP. At this stage, the knowledge has been built into their routines and they learn to exploit their innovation in the marketplace (which leads to the development of DCAP). The sources of knowledge for the AEs from Case X are summarised in table 7.5.

Table 7.5 Source of knowledge from Case X.

Scientific Knowledge (Theme 4).	**Market knowledge (Theme 4, 7).**
Ask a colleague. From within the AE's research group. Read around the literature. Academic conferences.	Technology transfer managers. Business development managers. Clinicians / healthcare workers. Business advisors. Investors. Patent agents. Market research consultants. Industry partner. Peers. Commercialisation specialists at funding agencies

7.6.1 Prior work experience

TTM 1X remarked that AEs who have prior work experiences bring with them a set of abilities and knowledge practices which helps them in their commercialisation activities. Past work experience also included industry work experience, where the AE gained valuable insights into what an industry partner is looking for in projects and what their expectations are. AE 17X from past industry experience was very comfortable using patent databases, stating '*I had industry experience I knew how to use the tools to search for databases, so that was helpful'*.

AE 21X, based on their knowledge of industry from past work experience, reached out to industry on how they think their work has relevancy to them. Based on this outreach, the AE built the relationship and demonstrated the potential of their work to the industrialist. AE 23X stated what learning they have gained from prior industry engagements '*what industry brings on the projects is a lot of contextualisation to a project so they are much better than us at explaining why it was relevant, what we were trying to do and what sensitivity this work was touching on'* Furthermore, AE 23X stated that industry partners are much more problem orientated. The AE gave the example where they had worked in an experimental modelling group of the industry partner and through their exchanging of ideas led to the development of problem-solving ideas which then the industry partner would test and validate. Overall, it was found that from past work experience AEs gained valuable industry knowledge. This led to advantages for the AE's commercialisation activities such as it facilitated their ability to reach out to industry contacts and prove the relevancy of their research to industrialists. Furthermore, prior work experience helped to accumulate knowledge on the direction and focus of specific problem(s) facing the industry partner which helped the AE to come up with solutions to subsequent related industry problems.

7.6.2 On the job learning

The majority of AEs involved in spin out firms for the first time identified that they largely learned by doing. AE 22X identified '*it's mainly on the job, It's been a very imperfect process, I'm trying to think of an example where it hasn't been on the job learning, the process has been very informal, it has been trial and error and learning by experience'.* Through trial and error practices and learning from these experiences, many of the AEs identified that they were challenged with conducting business tasks for their spin outs alone with little support. This was found to be especially true at the start of their venture. AE 15X stated '*you have to be a jack of all trades. So I was the R&D team, I was the quality team, I was the regulatory team, I was the sales team, you don't get support, on the project we got half a million euro, I was funded for two years to work and that was it'.* AE 12X identified *'you learn on the hoof as you're interacting with people, through on the job I learned how to build a good rapport with people I worked with, to be supportive and helpful, its gained me the ability to integrate with people and speak their language'.* All AEs at Case X stated the primary way they learned was on the job in relation to their spin out company.

7.6.3 Change of mindset

In order for the AE to succeed in their entrepreneurial role, the AEs described that they needed a change or different way of thinking. AE 28X described the challenges of thinking in a different way '*the most difficult part was turning the technical idea into something that fits into the market to adapt a different way of thinking rather than speaking and describing things in technical terms you are using market language and that was a process of learning'* AE 17X discussed the differences they noticed between themselves and some colleagues '*some of my academic colleagues perceive a conflict of interest as they only see company formation as a means to make money and I have never seen a successful company with that mindset. Traditional academics assume I am back in the university to steal IP. I can make my own IP, so there is a very negative culture among some academics which has to be overcome and they perceive a massive conflict of interest'*. This quote demonstrates that not all academics think alike when it comes to commercialisation and its priority within the institution. All AEs at Case X found their academic role and entrepreneurial roles as complementary, as AE 17X described '*knowing what's important industrially feeds back into academic knowledge especially when you are teaching students as part justification as to why you are doing it'*. Some AEs noted a process of learning as they changed their mindset from a purely technical scientific way of thinking, to a market orientated mindset. This process was aided by the complementary nature of their academic role and entrepreneurial role. Table 7.6 summarises theme five for Case X.

Table 7.6 Case X - Summary of theme five

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs
Learning	Past work experience	-Knowledge on what an industry partner is looking for. -Ability to reach out to industry. -Learning around the relevancy and contextualisation of the problem.	Exploitation phase of ACAP and the development of DCAP.	RQ2,RQ3,RQ4. OBJ 2,3.
	On the job learning	-Trial and error learning. -Informal process. -You learn as you interact with people. -Gained the ability to speak the language. -Challenged to think around market concepts.	Exploitation phase of ACAP and the development of DCAP.	RQ2,RQ3,RQ4. OBJ 2,3.
	Change of mindset	-Thinking in a market context rather than a technical one. -Influential role of the TTO. -Some of the AEs colleagues perceived a conflict of interest with the traditional academic mindset.	How AEs translate their PACAP into RACAP in the conceptual model and also how they develop their DCAP	RQ2, RQ4. OBJ 2,3.

7.7. Theme 6 – Training

This theme is broken down into training provided within the university (internal) and then from external sources. AEs also commented on their further education to help support them within academic entrepreneurship. Each university in this study provided training and support around the commercialisation of an AE's research.

7.7.1 Internal training

TTMX 1 stated the university used a dedicated unit to provide training around commercialisation activities for AEs, which includes modules on IP considerations, U-I contracts and negotiation and legal aspects of commercialisation of research provided by the TTO. The training unit used the business canvas model to assist the AEs in business planning and learning the language to write a business plan. The AEs also learned how to improve grant applications, how to pitch their research to a business audience and how to interact with business people. There were dedicated licensing and spin out managers within the university to assist in bringing the innovation to these endpoints.

Many of the AEs found the training at the university to be very theory driven with not enough practical advice given. They preferred peer learning and gaining pragmatic advice. AE 17X stated '*within the university there is a lot of theory thrown around but less practical advice, a lot of people in commercialisation in universities either have never been a start -up founder or have worked in large companies where they have a large infrastructure around them*'. The AE described their on the job training as much more hands on and practical '*with a start -up you are right at the coalface, so when you are actually dealing with customers, employees, technology problems, addressing issues keeping the light on, making sure wages are paid, dealing with stakeholders all of those things you have to make it work, so you learn incredibly fast in that environment, and you learn what works and what doesn't very quickly'*. AE 15X found the training was too generalist and not specific enough to their domain of expertise ' *one of the big limitations in some of these workshops is that it is very difficult to give information to someone in life sciences versus someone working on business side or law school, the advice is not going to be relevant to all, so the knowledge base in the college, they are coming from all over the disciplines'*. Several of the AEs identified that wanted to see more practical advice and knowledge on the commercialisation process. They cited this as a limitation to the training at the university. The AEs and TTMs at Case X welcomed the option for AEs to take a sabbaticals to undertake formal training such as an MBA.

7.7.2 External training

TTM 1X encouraged the AEs to participate in training programs outside the boundaries of the university. TTM 1X identified that if AEs only gain knowledge within the university, it can be quite an insular opinion. They encouraged AEs to avail of supports both inside and outside the university. AE 17X completed an MBA on a part time basis, where they used this formal training to go along with their prior industry work experience to be more trained in the skills needed to work with industry. AE 12X has completed a post graduate diploma in business strategy and AE 15X completed a short course on people management; which focused on managing people and relationships in the workplace. The AE found this particularly useful in external stakeholder management. Table 7.7 summarises theme six for Case X.

Table 7.7 Case X - Summary of theme six.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs.
Training	Internal training	-Dedicated unit to conduct training Learnings around IP considerations U-I contracts, negotiation and legal aspects of commercialisation of research.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.
	External training	-Gain knowledge outside of the university which can be an insular opinion. -Develop business skills with formal training such as MBA.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3

7.8 Theme 7 – Networks

It emerged that having networks was fundamental for AEs to gain the connectivity to progress their innovation to the marketplace. Formal networks refer to the network the AE has within its home institution, i.e. with the TTO, research centre, colleagues, research team and other support staff. Informal networks refer to the ties the AE has developed outside the home institution, for example distributor, manufacturing, clinician and industry network types.

7.8.1 Formal networks

When working on a project, AEs interacted with the TTO at varying frequencies. All meetings pre COVID -19 were face to face as the TTO is based on campus in close proximity to the AEs. With regard frequency, TTM1X from university X stated '*it depends on the stage of the project, if it is at the IDF assessment and patenting stage, a meeting is scheduled weekly. Once the patent has been filed there is less frequent interaction with interaction becoming more frequent again if it gets to licensing phase. If it's company formation, it's much more intense with regular meetings every week for a 6-9-month period as the AEs go through the seed funding phase'*. AE 17X described the informal friendly approach taken when dealing with the TTO and the benefits of such an approach '*because I had done a spin out company I had a very good relationship with the TTO on a personal level and I think that is one of the CSFs having a good working relationship with tech transfer they are very much having a helper attitude rather than a guardian attitude. If you see them as the police you are less likely to engage with them'*.

It was identified that AEs at university X often went to the TTO to gain a recommendation on a market research consultant or business advisor that they could potentially work with. In addition, the senior business development manager at university X stated that often *'AEs come to me to look for advice on a project plan or a commercialisation plan'*. The BDM had created two project management templates as tools used within the centre to help AEs and industry on planning the project. Within the planning tool for AEs, they were challenged to answer questions around value proposition such as, Define the problem? Define the market? What is the state of the art? How will their research change things? Will it be a step change or disruptive? Will it lead to an improvement of an existing product or process e.g. cost saving? How much closer to a potential solution will this work, if successful bring you? What will be required next? These questions challenged the AE to think of the commercial case of their innovation. It helped the AE to learn about the market and its landscape. It was suggested that in particular, more nascent entrepreneurs can use this to refine their commercial offering i.e. the project planning tool first develops the learning (ACAP) around the business case and secondly how to exploit that learning (DCAP).

The BDM sent out a monthly newsletter to all AEs within the centre which identified opportunities. They also held a series of information days with industry partners to allow for networking and introductions to take place. Their team also employed an open door policy where the team are on the ground interacting and helping the AEs with queries. When asked what were the benefits of being affiliated with the research centre, AE 22 X stated *'it's the soft supports so the business development team, the admin team, they are really useful and I guess through that you build these to interact with industry in better ways, so it's much more professional, so nearly all the industry contacts we have come through the research centre'.* The research centre in university X had a local level approach initially when supporting AEs with their research concepts. The director of the research centre AE 23X stated that because their business development team is closer to the researchers essentially *'it's better advice that is given to the AEs compared to the TTO, also the research centre has a capacity being a little higher than the TTO, which enables a quicker response for the AEs'.* These are key considerations on why the BD team try to act locally in the first instances. The BD team at the research centre are in close contact with the TTO. There is a bi-weekly meeting with the TTO and contracts office taking place in university X, where the state of play regarding contract negotiations and licensing/ spin out outputs were discussed.

7.8.2 Informal Networks

The AEs identified the benefits which could be availed from their informal networks. Informal networks for Case X include investors, peers who have spun out a company already, industry contacts, consultants and clinicians previously worked with. This sub theme relates to how formal and informal networks differ in terms of knowledge acquired, what is learned and how it benefits the AE. AEs noticed a difference in the type of knowledge and advice they were getting between their formal and informal networks. With their informal networks, AEs were getting far more detailed information and advice. AE 21X commented on this stating *'the informal network advice is much richer, it's a very real business, the guys are trying to make money, or they have real agendas like success agendas for the companies. So it's much richer* *for what you need, the TTO is strong for what you need there but the informal network is where the industry guys would like to look at your solution'.*

Some AEs identified that they would choose their informal network as the first point of call when seeking advice or guidance on questions of a practical nature. They found the TTO was quite general in their advice as they have to cater for a number of disciplines and staff members, whereas when they used their informal network advice was more specific to the area they are operating in. For example AE 23X stated *'the TTO has to cater for a large range of activity, so most of the time they are not into the specifics of what you are doing, most of the time, the informal network people come from similar experiences. Also your own network is more suited for establishing new connection from your own circle of people that you know.'* AE17X stated they would learn from informal contacts who have been through the process before and cited these contacts as key source of learning*; 'I would have informal mentors who I would sit down and have coffee typically these would be other CTOs or founders of companies and typically what was happening is that we would be exchanging knowledge whether it was on crossing the cassam, the innovators dilemma, the lean start up and we would chat over it, those informal learnings were critical'.* Table 7.8 summarises theme seven for Case X.

Table 7.8 Case X - Summary of theme seven.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs.
Networks	Formal networks	-IDF and patent stage weekly TTO and AE meeting. -Interaction more frequent again at licensing stage. -Spin out regular meetings every week for 6-9 month period. -Seeing the TTO with a helper attitude rather than guardian attitude. -Research centre – monthly newsletter, information days and operates an open door policy.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.
	Informal networks	-Offers knowledge that is more rich and market driven. -Businesses have real agendas that are driven on success. -More appropriate for developing new connections -Industry more interested in your solution.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.

7.9 Theme 8 - University level environment.

This theme relates to decisions and policies taken at the university level that affects the behaviours of the AE. Within Case X, the university level factors identified by the AEs to have impacted them were, lack of promotional opportunities, high levels of bureaucracy and resource shortages.

7.9.1 Promotional opportunities

It was found that within Case X, commercialisation activity was not recognised within the academic career structure when an AE pursued a promotion. This was identified by the AEs to be a challenge to them pursing commercialisation activities. AE 17X stated '*what I found is if the academic themselves gets involved in it that severely limits their prospect of promotion. Commercialisation activity is not recognised within the academic career structure. In fact you are viewed at with suspicion, whereas if you get your post docs to do it or you license it off that's seen as a much better approach'*. AE 21X stated *'there is a lot of effort required to spin out a company, and basically it's not exactly a measure of importance inside the university'*. TTM1 also stated the lack of promotion for entrepreneurship activities stating '*we have professors here who have done four spin outs, two of them very successful and they don't get promotional rewards because of that, and I think that is a big failing and it's not just X, I believe it to be everywhere. That's a big shortfall, we need universities to add that into their promotional criteria for academics'*. The AEs wanted to see a quantifiable measure such as number of patents granted used as criteria when evaluating promotional opportunities.

7.9.2 Administration or legal barriers

AEs found some hurdles within the administrative or legal aspects to commercialisation, with IP regulations cited as a barrier to why they could not work with an industry partner. TTM1X understood the frustration that this might cause with AEs; however, they identified that it was important that the necessary agreements need to be put in place before the AE can start the work. This was reported to be a lengthy process due to the involvement of many offices including the legal, contracts and the finance office. AE 28X commented on this stating *'we have interest from an industry partner to work with us but due to IP regulations or other problems it was not possible or the communication between the legal department just didn't* *lead to anything so I got quite frustrated with the legal department, the technical people were very enthusiastic about doing something but it was not possible because of some implications of that nature'.*

7.9.3 Resource shortages

The business development manager (TTM 2X) at the research centre cited that resource shortages was the key reason why AEs or industry partners may express some level of frustration. TTM 2X identified '*the real regulating step is where we hit contracts and negotiations around collaborative research agreements and we got only one contracts manager with a backlog of projects, some level of frustration can creep in from the PIs and some of the companies'*. It was identified that the state funded research centres were not independent entities. They had to rely on the lead admin partner within each of the centres, from the signing of contracts to the drawing up of NDAs. The BDM further explains '*I understand the reason why, its cost specific and we can rely on the larger infrastructure at the universities, however there is conflict between the universities goals and the centres goals they don't always mesh, and independence for the centres would certainly help with engagement with industry'.* Table 7.9 summarises theme eight for Case X.

Table 7.9 Case X - Summary of theme eight.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs
University level environment	Promotional opportunities	-Commercialisation activity is not recognised within the academic career structure. -It's is a big failing on the part of the university.	Acts as a moderator in the conceptual model, can inhibit or de motivate an individual to engage with commercialisation.	RQ5. OBJ4.
	Admin or legal barriers	-Agreements need to be put in place by the TTO which involves the coordination of many offices, can delay the start of projects or even they may never start.	Acts as a moderator in the conceptual model, can frustrate or de motivate an individual to engage with commercialisation.	RQ5. Obj4.
	Resource shortages	-level of frustration can build up with delays in project start times and completion timelines from AEs and industry partners.	Acts as a moderator in the conceptual model, can frustrate or de motivate an individual to engage with commercialisation.	RQ5. Obj4.

7.10 Case Y.

An overview of Case Y is described in chapter 5 section 5.4.7. The findings for Case Y are now presented in the proceeding sections (7.11 -7.18.3). The core themes identified for Case Y were motivators, challenges, idea generation, progressing the idea, learning, training, networking and university level environment.

7.11 Theme 1 Motivators

This theme is broken into intrinsic motivators and the intrinsic rewards the AE derives from engaging in commercialisation and the extrinsic benefits. The intrinsic motivators from Case Y were found to be 1) to improve patient outcomes and make an impact with their research beyond paper publications, 2) intellectual curiosity, 3) wanting to solve problems for industry. The extrinsic motivators were found to be the financial benefits the AE can receive from commercialisation.

7.11.1 Intrinsic motivators

AEs at Case Y noted the impact of a publication could never rival the impact that a medical treatment or device could have on people's lives. AEs at case Y were highly motivated to improve patient outcomes. AE 13Y commented on this stating '*I spent all my life in academia where we do research that improves patients outcomes and patient lives but of course no scientific paper will ever improve a patient outcome, they will never read it very few people will actually read it so I have a real desire to actually do something rather than just write about it and talk about it and that still is my major motivator'.* AEs at Case Y commented that producing papers with industry derived less of a research impact compared to commercialisation, however, it was identified to still be a valuable tool. AE 9Y stated that '*often papers with industry have a higher citation impact than those that are purely academic'*. This higher citation impact can signal expertise and know how in a specific area for the AE and reach a further audience than if it was just purely an academic paper. It could be suggested that publishing with industry could be a way in which an AE can develop their DCAP through ensuring translation of knowledge to a non -academic audience. The BDM at the research centre stated that '*often times a company representative will contact the AE, having seen a publication and they will contact them directly'*. Industry partner 1 identified that when they are co-authoring papers with academics, they prefer to work with them on shorter publications, such as application notes, white papers, and articles due to academic paper publications requiring a large body of work that can take a year or two to get out into the public domain. They prefer to co- author on a shorter time scale. AEs at case Y also noted a desire to help solve industry problems as a motivator to why they engaged in commercialisation. It was identified that they are curious as to how they can help solve challenging problems facing industry and pass know how on. AE 16Y commented '*I'm very interested in solving problems for companies, and passing on know-how, I have always been interested in understanding things better so I would like to see that translated all the way through'.* Working with large industry partners enabled the AEs to access potential new routes to market for research they are working on in the lab and identified that they can benefit from the expertise and resources that large MNCs can bring to a collaboration.

7.11.2 Extrinsic motivators

AEs at Case Y noted the extrinsic benefits of engaging in academic entrepreneurship, from funding their research to financially benefiting themselves. The AEs at university Y noted these were secondary motivators but still important considerations. AE 26Y remarked on this '*…not money for me but research money. There was very little money for basic research after the crash, minimum money, so it was a way of being able to continue research and move your projects forward'*. AE 27Y agreed '*so of course there's a money driver, I'd be foolish to discount that, but it was in a manner that was not obvious, in the very blue sky research that I wanted to do it was completely unfundable in Ireland, I felt if I was the principle in a company I could get the company to fund me to do that, and also when I retired there would be a funding stream for that, so that was a long term driver for me'.* Table 7.10 summarises theme one from Case Y.

Table 7.10 Case Y - Summary of theme one.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs
Drivers	Intrinsic motivators	-Drive to improves patients outcomes. -Lees impact derived from publications. -Co authorship of papers, higher citation impact, a form of collaborative output. -Desire to solve industry problems.	Individual motivators, stage one of the model.	RQ1. OBJ1.
	Extrinsic motivators	-Financial benefits to fund the AEs research and lab. -Spin out funded blue sky research. More choice after retirement.	Individual motivators, stage one of the model	RQ1. OBJ1.

7.12 Theme 2 challenges facing the AE as they engage with commercialisation processes.

The core challenges which participants from Case Y found were, seeking funding, managing industry expectations and building the entrepreneurial team around them. Each will now be discussed.

7.12.1 Seeking funding

Similar to Case X, most AEs stated it was a challenge to access the funding to progress their innovation from pre- clinical data to conducting human trials. The AEs stated private investment often required human data however seeking the funding to progress the innovation to this stage was a challenge. AE 26Y commented on this stating '*to get human data you're talking half a million euro minimum , bare bones type of study, 1.5 -2 million you really need to do that, there is a valley of death, so you have your vaccine you have your animal studies done you have shown its effective, to get real interest you have to have human data, and somewhere you need to find this 2 million and that's a huge barrier'*. It was identified that the state funding agency reviews every application on a case by case basis but typically they want to see an application for funding at a Technology Readiness Level (TRL) 3 stage. This means they '*want to see projects at a lab scale, we do support proof of concepts (POCs) but there has to be a commercial step change involved not just purely technical POCs*'. AE 26 Y was in the process of taking their innovation from TRL3 to TRL5 in order to get additional funding. They identified that they had hoped that when they meet all their technical deliverables, the funder will continue to back them.

AE16 Y commented on the valley of death situation where after 24 months the participant was exiting the state funding mechanism and seeking private investment on their USO '*another challenge, is having to produce a rapid process in a machine and that requires a lot of capital investment to get something that's market ready, You're at a stage where you are outside the commercialisation fund realms and starting to look for private capital so you're in that death valley as they call it in terms of investment of cash flow between the commercialisation fund and a high tech engineering business'*. The commercialisation specialist (FB1) stated they do provide follow on funding after the commercialisation fund. They identified that approximately 10% of applicants avail of this and the value is 250,000 euros. FB 1 would also '*bring in* *investors to show what the investor is looking for'* and would assist the AE and their team in seeking private investment. Also, as part of the evaluation process to award the commercialisation fund, private investors were part of the evaluation panel and provided independent feedback on whether they were likely to invest. Therefore at an early stage, the commercialisation fund is assessing the commercial proposition of the innovation.

When working with AEs on the funding application process, TTM 6Y remarked that it depends on the level of experience with the AE on how much support they require when seeking funding *'it depends on the PI I had two calls that went in a few months ago, so one of them was with a PI that did a comm fund previously and sold a company so they only needed minimal support, they understood what the business case was, the comm fund is very different from other research project, it really only asks one or two pages about the research, and the rest of the questions are around what is the market opportunity, who are your competitors, and why is it different? so for some of the PIs who haven't engaged with that, we do a lot more handholding and work through the application'.* AE 27Y commented on the restrictive nature of the commercialisation fund, *'the comm fund that's a good fund, I was on that committee until 2008, that's quite a good thing only its extremely restrictive in what it will fund, it's restricted in sense that it will only fund something if it leads to direct job creation in Ireland, it has to be applied to an Irish company. If it's a global market you are addressing and Ireland is only a small part of that global market and /or if your licensor is going to be outside of Ireland, it's not fundable by X'.* FB2A stated about this '*we require innovations and technologies to have international reach, in Lifesciences our biggest markets are the US and the EU, however we require the commercialisation to have an economic impact in Ireland, that is create jobs in Ireland and/or at a minimum sustain jobs for companies in Ireland. We are not happy to have a technology licensed to an overseas company as there is no economic impact in Ireland'.* If the AEs main market is an international one and there is little evidence of job creation in Ireland, the AE may need to access a different funding mechanism, this can act as an additional challenge of seeking funding for the AE.

7.12.2 Managing industry expectations

Managing industry expectations was acknowledged as a challenge for many of the AEs at Case Y. It was identified that differences in culture, expectations, timelines and outcomes are among the reasons why UICs can present challenges. AE 26Y discussed the difficulty of limited time when working with industry as a challenge '*you do learn but time is limited with them, when you want information they are stretched for time so it's the hardest part getting that interaction'*. AE 16Y found finding something which the company considered to be worthwhile to engage with the academic partner as being a core challenge. AE 16Y stated '*what I've noticed is companies are great at saying yes, that's very interesting but there is always something better for them to do more strategic, that's one of main challenges, its finding something that's of strategic interest to companies*'. AE 16Y also identified that when provided with feedback from MNCs, it was usually not at a local level but came from HQs usually in another jurisdiction. This made it difficult in getting the answer they needed to progress the project as decisions on product development were made elsewhere and not in the remit of the division the AE is working with. Another challenge the AEs face within UIC was to sufficiently de-risk their innovation in order for the industry partner to want to work with the AE and ultimately license the technology. TTM 4Y described the market readiness of university innovations as being relatively low on the TRL scale and requiring further work and validation. The TTM stated what can happen is the industry partner may want to work with the university in a collaboration and work with the originators of the IP to bring it along in the development.

From the industry partner perspective, Industry partner 3 stated that lower TRL projects tend to be kept internally and developed inhouse; '*If we have a TRL 1-3 we are probably going to keep that inhouse and figure that out ourselves, business have their own R&D departments themselves, so we would expect that we would cover off a lot of those in that space'*. However, industry partner 3 (IndP3) stated they do sign up to university projects where they have a potential interest in, or that could possibly become of interest to them in the future.
Industry partner 2 (IndP2) commented on the higher risk attached to technologies on the lower TRLs stating ' *if you have a TRL 3 are you likely to have research published in a peer reviewed journal? , are you likely to have IP granted? you know very unlikely!".* Key markers (to assess the level of risk) Industry partner 2 was looking out for from academic projects were if the technology was patented, if pre- clinical testing had been completed and published, and if the prototype had been reduced to practice i.e. that it was workable, robust and producible. The AE is therefore challenged with de -risking their innovation to a point where key markers have been met which can incentivise the industry partner.

7.12.3 Building the entrepreneurial team

At the early stages of the USO, participants remarked on the little support they received. This meant that they had to do a lot of the tasks themselves, learning as they go along within their venture. They cited sales, HR and regulatory engagement as examples of work tasks they completed themselves early on in the venture. AE 27Y stated that when they spinned out their company '*all of it had to be done yourself*'. In order for AEs to learn from other experts in different fields, they need to work with different types of individuals with different skillsets. AE 27Y remarked ' *I had to go out and be the sales person in companies that we were trying to sell to, I was making trips to do that, I had to do all the science work as well and the recruitment, everything was done by me'*. The AEs cited learning from mistakes was common in the early days of their spin outs. AE 19Y commented on their first USO and the level of work involved would have to be taken into consideration if deciding to spin out a second time '*everything was done by me, I was asked to start a number of other companies based on a technology and you really have to think twice about that given my previous experience'.* AE 13 Y also stated, '*building the team to come with you on the journey is another challenge'.* AE13 Y cited luck and the right timing in meeting individuals who were influential in the success of the spin out. For example, the AE cited the relationship with the clinician as very influential. *'Serendipity plays a huge part in this, we were really fortunate that the clinician is a globally recognised expert with psoriatic arthritis and also that we work very well together, the clinician has now been working with the spin out and we've done some work in the spin out which means that the company can file its own IP and the university is happy with that'.* Table 7.11 summarises theme two from Case Y.

Table 7.11 Case Y - Summary of theme Two.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs.
Challenges	Seeking funding	-Finding the funding to have human data to prove effectiveness. -Funder wants to see a commercial step change and not just a technical POC.	Individual barriers – stage one of the conceptual model and as a moderator over the entire conceptual model.	RQ1, RQ5. OBJ1.
	Managing industry expectations	-Managing unrealistic expectations from industry, quick turnaround times, small budgets. -Often have to deal with HQs and not the local level division of MNCs – results in delays.	Individual barriers – stage one of the conceptual model, Acts as a moderator over the model as may inhibit the development of knowledge capacities also.	RQ1, RQ5. OBJ1.
	Finding the people to build a team	-Jack of all trades challenge. -On the job learning where AE was conducting tasks outside their domain expertise. -Difficulty in finding the right people.	Individual barriers – stage one of the conceptual model development of market ACAP (stage two) and DCAP (stage three).	RQ1, RQ3, RQ4. OBJ1.

7.13 Theme 3: Idea generation

All AEs within case Y found their ideas came from a needs-based solution to fulfil an existing problem. Unlike case X, curiosity wasn't mentioned as a component in their idea generation. This meant AEs were seeking out specific knowledge to answer a predefined problem. AEs within case Y identified that their ideas were generated to address a specific problem. They identified that they knew it had commercial potential due to their experience from past projects, past work experience and working with clinicians. AE14Y stated *'a lot of our projects, would involve working with clinicians to identify a perceived clinical need, so the ideas are needs driven as opposed to a more fundamental curiosity driven one'.* AE 13Y identified that when they recognised the commercial potential in their innovation, this motivated the participant to engage with the commercialisation process '*the first patent I filed was on a way to develop reagents to measure proteins and it became apparent that there was another way of doing that, and I ended up really interested in that technology because it became apparent to me that it was applicable in an end user market i.e. could be applied in hospitals'.* AE 13Y also remarked on the important expertise of the clinician with idea generation stating '*guided by what the clinician says are the important unmet clinical needs, we identified a panel of proteins that could discriminate between psoriatic arthritis and rheumatoid arthritis. He always told us that would be valuable'*. AE 13Y also commented on the clinician advocating independent verification on the need '*so working with the rheumatologist was really important in guiding that unmet need but at the same time, X is conscious that we validate their guidance against other rheumatologists and they are well connected'.* AE 16Y drew on their vast experience (20 years) within industry to use when coming up with ideas that meet end user needs. AE 16Y stated *'I have experience in industry so, I know where they (companies) are coming from their needs and so on, I also look for solutions also. I believe the best potential for new technology comes out of a better understanding of an existing problem. so I would see myself as very much in that role and I'm looking for linkages'.* As shown in the summary table 7.12, the results from Case Y found that primarily idea generation came about from working with clinicians and using past experience.

Table 7.12 Case Y - Summary of theme Three.

Theme	**Sub theme**	**Sub elements**	**Conceptual model stage**	**Corresponding RQs**
Idea generation	**Curiosity Driven:**	No evidence of curiosity driven ideas from case Y.	Acquisition phase of ACAP – stage two.	RQ2.
	Needs based solutions:	Identification of a perceived clinical need. Working with clinicians. Applicable in an end user market, Using industry experience to understand where companies are coming from and coming up with ideas to solve their problems.	Acquisition phase of ACAP – stage two. (Identifying the unmet need).	RQ2,

7.14 Theme 4 Progressing the idea

AEs at Case Y progressed their idea through developing their scientific and market knowledge. This involves key landscaping tasks, disclosing the invention, engaging in the patenting process and working with a range of individuals and groups to progress the innovation.

7.14. 1 Understanding Technical / scientific knowledge

In order for an AE to progress their idea often further technical knowledge was needed. Even if the AE held a high level of expertise in the area, the evolving and multidisciplinary nature to translational research often led to the AE seeking further knowledge to progress the innovation. AEs at university Y went to colleagues as a first point of contact on gaining further scientific or technical knowledge. AE 26Y identified that that if they needed any assistance on a technical or scientific subject matter they '*would talk to colleagues, and read some background literature in that area, but talk to colleagues would be the main thing'*.

7.14.2 Invention disclosure

A fundamental role of case managers at case Y discussed by TTM 6Y was looking to move research from a '*purely fundamental research question to understanding if there's an applied commercial side to the research*. The commercial potential of the research was assessed formally on the Invention Disclosure Form (IDF) submission made by the AE and reviewed by the TTO. If the TTMs believe there was commercial potential, the case manager then worked with the AE to design a roadmap on how best to go about commercialising the research (TTM 6Y). Section 1 of the IDF at Case Y asks questions relating to the technology that challenges the AE to think from not a purely technical or scientific mindset. The template is framed to answer questions such as: What problem is the technology solving? Identify technologies already used to solve this problem? What are the problems with existing technologies used to solve this problem? How does the AE's invention overcome these? What is the most inventive aspect of the technology? List companies who may be interested in your technology? These questions challenged the AE to think about their innovation not from a purely scientific viewpoint but to include the customer, the need and competitors into their evaluation of the offering. Unlike Case X, where patent searches are an optional requirement, the IDF template at Case Y required results from patent searches and is a mandatory task with evidential support required.

7.14.3 Sub theme 3 – IP landscaping

For case Y, it was identified that when filling out the IDF, IP landscaping is a critical task. This was identified to be a task which can be completed alone by the AE or in conjunction with a TTM (TTM4 Y). It was found that the TTMs at Case Y help when an AE is conducting more advanced searches with patent databases such as '*patent search by classification'* (TTM 6Y). This search provided a more in-depth analysis of what is out there in terms of existing patents. The case manager then created a map of who is doing what in that space, looking at companies and where they are bringing their technologies. TTM 6Y stated '*they don't understand an advanced classification search, they enter their keywords and get back 10,000 patents, as the patent progresses and as they go through search reports they need to be able to make sure they can pull it up and understand the technology, rather than asking the TTO how do I find X, it would be very much lead by the TTO'.* The case manager and AE then combine the patent searches with market reports which helps assess whether they create X technology in Y years will it be a potential market offering wanted by industry. Advanced patent searches are an example of where the TTO can assist the AE in progressing their idea. AE27 Y described how themselves as the PI did a lot of the work independently in their patenting process *'getting the invention disclosures together and then moving towards patent, to be honest a lot of the leg work has to be done by me as the PI so the patent searches I would end up doing, the TTO would set up a meeting with the patent attorney but it's usually the PI that ends up doing a lot of the heavy lifting on it and that's been my experience'.* AE 13 shared similar views '*it became apparent that if it was going to be commercialised I was going to be the person that was going to have to do it, the TTO don't have the capabilities to take the massive portfolio of patents they get and find the route to commercialising them.* AEs cited resource shortages as a reason to why they felt a lot of the work was left with them to complete.

7.14.4 Patent process

The role of the patent agent was to provide assistance and guidance on how best to protect the AE's innovation (TTM 4Y). The case manager played a supporting role to the AE – patent attorney interactions. They wanted the AE to lead the conversation as it is the AE who knows the technology best. The case manager was there to make sure whatever direction the AE wanted to take the technology they would be protected by the patent. Also TTM 6Y identified that it was important that time is being spent well and that the AE is getting value from the meetings due to the TTO funding it. AE 27Y discussed the '*jack of all trades'* approach to the inception of their spin out in terms of patenting the participant stated '*I had to draft the patent, we engaged the patent people and they edited a draft based on what I had said and I went back to them, back and forth discussions and I had to know about patenting to be able to have that discussion'* In comparison, AE 19Y discussed the supportive role the TTO played '*I think with drafting the patent, they provided good advice on how to do that because that would have been fairly new to me at the time. It's a skill and as an academic you need expert advice and as it progressed further they would of hired a patent attorney external to X, to process it even further'*.

7.14.5 Understanding market knowledge

AEs at university Y gained market knowledge from clinicians, industry partners, co -founders, the TTO, from regulatory engagement and involvement in research consortiums. AE 26Y discussed the information gained from working with clinicians '*we would get patient samples from them, they are always very good at knowing what's important from a medical point of view, as an academic you can go off in tangents so they give you good grounding on what the key problem is for patients. We also get clinical data from them, you can try for something in the lab and find that's very interesting but if it doesn't really work with the patient sample or in the patient context then it's pointless at the end of the day'*. AE 26Y also gained market knowledge from regulators in terms of the safety aspects of their work and what the regulatory body were expecting to see from their work. This guided them in making sure their innovation was safe for market approval. In contrast, AE27 Y saw working with regulators as a '*necessary evil' - I learn what I have to do, to satisfy them, that's what I learn whether that's a valuable learning is debateable, its valuable in the sense that if you don't do it you are out of business'*.

AE 13Y gained market knowledge from being part of a research consortium and was guided by a lead clinician on what the unmet critical need was and how it was currently misaligned in managing patients. This lead to the first piece of IP the AE filed. AE 13Y also gained market understanding from presenting to pharma companies and listening to feedback to inform the participant, '*we liaised with pharma companies under strategic research agreements, so we mention things to them we present to them and you can gauge their reactions. So it's always* *being open to listening to what people have to say and not necessarily directly asking them straight up questions'*. AE 27Y discussed how trying to understand the needs of industry partners helped in gaining that market knowledge '*I talked to people in industry, excessively over and over again, we got some people who were advisors to the company but we talked to potential clients trying to see what their needs were'*. AE 27Y had expertise in chemistry and worked with industry (manufacturing network) to gain knowledge around bulk production, an area they admitted knowing less about '*for example bulk production, I wouldn't be comfortable with that so I'm interacting with industry here, both large and small production operations'.*

AE 19 Y discussed the differences between academia and industry and how interacting with companies extended their knowledge base '*broadly, both before and after the formation of the company, working with industry has always been beneficial, as an academic it helps you understand the way industry thinks about things, how they think about problems, how they solve them, what their needs are, what the commercial world is looking for, in contrast to the way of thinking of an academic'*. AE19Y also gained market knowledge from the spin out team. The participant put together a team of three individuals (himself and two others) with different skillsets and expertise as founders of their venture. The founders of AE19Y spin out included an academic with a strong engineering technical background and the other, an external individual brought in to the company had a strong business background, was the CEO. They were connected through the state funding business partnership scheme. The business partner was brought onto the commercialisation fund as a consultant to start with and ended up in the CEO position. The CEO had a strong skillset in communicating with investors and raising funding. When it came to the point of forming the company and doing the legal work they also brought in a solicitor. AE 19Y described the venture as very much a team effort, where they used the skillsets of the other two members to complement their own knowledge base.

AE 16Y drew a lot on the expertise of the TTO to gain market knowledge, Moreover, in terms of marketing, the participant used the state funder's partnering scheme whereby they provided funding to bring in a specialist (initially an entrepreneur) to look at the product in a critical manner. AE 27Y stressed the importance of understanding market information on their first spin out which ultimately was wound up. AE 27Y stated '*we were very naïve about our market, such that there were only 20 companies worldwide that would of used the technology that we were proposing, it took a long time to understand that was wrong and that was one of the* *factors of the company failing, I learned that you need to have market pull, technology push is no good at all, there needs to be a market pull'.* AE 27Y also stressed the importance of conducting good quality market research when spinning out their subsequent venture. They outsourced the market research work to a consultancy firm. This time however the AE was cross checking what the market research consultant was telling them based on their prior work experience. '*I'd be seeing if there was logic with things that I already knew and I would know if something was wrong'* . Table 7.13 summarises theme four for Case Y.

Table 7.13 Case Y - Summary of theme four.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs.
Progressing the idea	Understanding Technical / scientific knowledge:	-Interact with colleagues. -Read the literature.	Development of scientific ACAP And the assimilation of technical knowledge.	RQ2. OBJ 2,3.
	Invention disclosure	-Develop a roadmap on how best to commercialise research. -IDF - invention details, prior art, funding and inventor details.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model)	RQ2, RQ4. OBJ 2,3.
	IP Landscaping	-TTM working with AE on patent searches by classification – more specified searches. -Combining patent searches with market reports. -Evidence of a lot of the work is done by the AE independently.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model).	RQ2, RQ4. OBJ 2,3.
	Patent process.	-Case manager plays support role, making sure the invention will be protected and budget is spent wisely.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model)	RQ2,RQ3,RQ4. OBJ 2,3.

Table 7.13 Case Y summary of theme four (continued).

Theme	**Sub theme**	**Sub elements**	**Conceptual model stage**	**Corresponding RQs and OBJs.**
Progressing the idea	Understanding market knowledge	-Working with clinicians refining their ideas to develop an end user focused design. -Gaining clinical data from clinicians. -Regulators – guiding innovation in terms of risk and safety. -Using consortiums to gain knowledge on clinical unmet need and work with clinicians and industry partners. -Using manufacturing network of industry contacts to gain market knowledge. -Using the skill sets of founding team members to complement technical domain expertise.	Transformation and exploitation stage of ACAP. Developing and refining the market proposition of the innovation. DCAP – taking the knowledge gained from working with the stakeholders to exploit the innovation.	RQ2, RQ3, RQ4. OBJ 2,3.

7.15 Theme 5: Learning

AEs at Case Y identified that past work experience was very beneficial. This work experience helped them to learn the importance of good lab standards and practices and they also gained the knowledge of what industry would be looking out for in projects. This knowledge is valuable to an AE. AEs with no industry experience or being nascent AEs would often face challenges in understanding the industry viewpoints and perspectives compared to an AE with industry experience.

The sources of knowledge for the AEs from Case Y are summarised in table 7.14.

Table 7.14 Source of knowledge from Case Y.

Scientific Knowledge Theme 4,7.	**Market knowledge Theme 4,7.**
Colleagues/ Read around the literature. Academic conferences.	Technology transfer managers. Clinicians / healthcare workers. CEO and founding members of USO. Investors. Market research consultants. Industry partner. Peers. Sales representatives of companies. Regulators. Participation in research consortiums. Commercialisation specialists at funding agencies.

7.15.1 Prior work experience

TTM 4Y noted a trend in AEs having had industry experience coming back into academia to take up academic roles within the institution. The TTM stated *'we are seeing an increasing number of researchers who haven't just come to academia through the traditional Ph.D./post doc route but have actually spent time in industry after their Ph.D. or post doc and are now coming back into the university having had that experience of working in industry and knowing* *the demands and constraints that industry has, so they are bringing in skill sets above and beyond the traditional academic ones and that's to be welcomed'*. It was found that AEs with past work experience had a good understanding of what industry were looking out for in projects. AE 26 Y stated '*because I worked in a company involved in drug delivery and vaccine delivery you learn how to develop GMP – good manufacturing practice, good understanding on what's important for a company to take on a project'*. In addition, AE 16 Y remarked on having a good understanding on the needs of industry from prior industry work experience.

7.15.2 On the job learning

In terms of USOs, similar to case X, AEs at case Y noted that a lot of it was learned on the job. AE 27Y stated '*all of the things we learned we didn't know anything when we went into it, writing a business plan, figuring out your market, how to deal with investors, how to get into a company, how to employ people and employment law, how to manage people in the lab'*. AE 19Y stated on the job learning was the main form of learning as they spun out their company *'It's on the job training and learning, I have no formal training really. I've attended seminars or workshops half a day kind of things, where you sit in and listen to an expert, for example I attend a workshop on setting a price point that was half a day workshop'*. AE 16Y described the constant learning process they undergo as they work in the commercialisation space, '*I would consider myself to have a lot of experience but you are constantly learning at the same time. The challenge of making that connection and breakthrough that people want is a constant learning process. Something I've learned from colleagues is to focus more on platform technologies or platform solutions where they can be widely used'*. In this example, the AE 16Y used his past industry work experience and on the job learning in new ways to conduct their research and inform them on new practices and processes.

7.15.3 Change of mindset

AE 27Y stated when asked how their innovative idea came about '*it came out of pure speculation that was thought of being impossible to do, might be possible by this other left field thinking'*. When the researcher asked how did you acquire the skills around this left field thinking the AE responded ' *I don't know what made me think of that, I was arguing in reverse, Why did I do that? I get ideas and I don't know where they come from. I don't think you can teach how to be innovative what you can teach is how not to kill it, it's very easily killed'*. AE 19Y remarked when asked how the idea around their technology came about *'I knew that or* *became aware that the research in the lab had commercial potential I honestly don't know how that came into my head except that it was always in my mindset, that any technology I'm working on or any research I'm working on, my motivation has always been around inventing things, so it kind of comes naturally to me to see if there is a commercial angle'.* These are two examples of how AEs were not fully aware of how they came up with an idea.

It could be argued that being entrepreneurial is an innate talent and some individuals can get that eureka moment from a natural talent. However, all the AEs in Case Y noted a change in mindset had occurred and they looked at things differently compared to other colleagues. AE 13Y recognised they think differently to colleagues '*I was trying to think where it all started really, but I have always been someone who is thinking outside the box but also very conscious that if all you do is think outside the box its wacky! I've always done things slightly differently. I see a lot of academic colleagues and their very inward looking, and they don't get out of the university very much apart from to go to an academic conference. So I guess I've always been outward looking and in that sense I don't have a typical academic mindset'*. Furthermore, all AEs saw their entrepreneurial role and academic role as being inherently complementary. AE 19Y stated *'I would say that company formation is just another form of dissemination. It performs the same function as publishing a paper in terms of disseminating your work so from a purely execution against the mission of the university I would say they are completely analogous'*. AE 19Y further remarked '*you have to take one hat off and put another on, when you are doing this type of work'.* Table 7.15 summarises theme five for Case Y.

Table 7.15 Case Y summary of theme five.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs
Learning	Past work experience	-Awareness of the importance of GMP and GLP. -Knowing what industry are looking for.	Exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.
	On the job learning	-Spin out activities mainly conducted as on the job learning. -No formal training -Constant learning process.	Exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.
	Change of mindset	-Left field thinking. -Thinking outside the box -Awareness to thinking differently to other colleagues. -Not knowing how ideas came to mind.	How AEs translate their PACAP into RACAP in the conceptual model and also how they develop their DCAP.	RQ2, RQ4. OBJ 2,3.

7.16 Theme 6 – Training

The training at Case Y was built on giving the AEs the knowledge and understanding around the commercial proposition of their innovation. The AEs learned valuable tools and insights on customer discovery and validation, appreciation of the end user and their needs, pitching their concepts to non - scientific audiences and scoping out market opportunities. Training around commercialisation relates to how AEs develop their market ACAP, they can subsequently take their learning to better exploit their innovation thus enhancing their DCAP.

7.16.1 Internal training

The findings identified the various training courses within the TTO that were available for AEs within case university Y. TTM 4,6Y both commented on the training efforts. Firstly, they provided a sprint session which is a one-day event where the TTO picks a topic and invites researchers in to pitch their ideas and if the case managers felt they found something worthwhile they would progress with it. The TTO also runs a bootcamp which is based on a lean business canvas model, where AEs are challenged to think around the commercial side of their work, focussing on their USP. From that model, the case managers asked questions around, Who are your competitors? and Why would people want your innovation over what's already out there? The bootcamp helped AEs develop a commercial plan (not a business plan) around their innovation. The commercial plan is typically incorporated into a grant application. The university also had a customer discovery program where the AE has secured a commercialisation fund a year or two into the project and the team is now focusing in on the market opportunities. The TTO asked the AE to reach out to various industry players to gauge feedback on their commercial offering. The university also has an accelerator program (specific to spin outs) which was built around the canvas model again and it challenges AEs to build a business plan. By this stage the academic projects were now thinking like a company and at the end of the program (8 weeks) the AEs pitched their business to an invited audience which includes potential investors and business partners.

AE 13 Y stated the training programme at the university allowed them the time and space to think around how they would go about commercialising their research. On the course the participant stated *'it was a morning a week for eight weeks or so and just carving out that little bit of time gave me the opportunity to think how I was going to commercialise things otherwise* *your diary just gets full and you don't get time and space to think about it'*. AE 26Y stated the work they did on pitching their concept and networking with colleagues were valuable learning activities from their time on a university course '*it was a morning a week/month , they would bring in speakers around the whole aspects of the commercialisation process which was really useful, we done a lot on the elevated pitch, There was a lot of PIs and post docs mixing so we all had a goal of trying to commercialise our biological innovations'.*

7.16.2 External training

With external training, the AE was exposed to expertise and training from specialised training providers within the academic entrepreneurship space. The TTMs at university Y recognised that they did not have all the resources and expertise in house and encouraged AEs to undertake specific courses within academic entrepreneurship. TTM4 Y commented on the need for external training '*we don't think we can do everything in house we recognise that certain external bodies have skillsets and a critical mass in certain areas that we can't replicate so we will send projects on a case by case basis to those specialised sites'.* AEs at Case Y underwent formal training to gain business skills for example, AE 9Y completed a post graduate diploma in business strategy which helped the participant gain the language skills in business and helped them to understand the interpretation that industry may have. AE 16Y described their mix of formal training and past work experience as enablers to help them understand market knowledge as they stated '*well my industry background, my involvement with a spin out and I did a masters in mechanical engineering management in X so I would have developed the business skills myself anyway. So I don't know if I'm really representative of an academic as such'.* AE 14Y travelled to the USA to take part in a commercialisation training program where they identified that the methodology is that before you build anything, you talk to the customer. Under the program, AEs talk to 100 customers before they build anything which allows the concept to build and evolve based on the 100 interviews. AE 14Y found the key take away from the course was around knowing their best solution may not be '*technologically driven but to listen to the customers rather than telling them what they think they want'.* Table 7.16 summarises theme six from Case Y.

Table 7.16 Case Y summary of theme six.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs
Training	Internal training	-Lean canvas model used as a tool for learning at the university Sprint days. -Commercialisation bootcamp. -Customer discovery program. -Accelerator program. -Assistance in writing business plans, commercial plans, identify the customer need, gaining market feedback and developing the market proposition.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4 OBJ 2,3.
	External training	-Formal education – diplomas in business education. -Talk to the customer before you build anything training methodology -Awareness to listen to the customer.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.

7.17 Theme 7 – Networks

This theme is broken down between formal and informal networks. Formal networks refer to networks within the home institution for the AE such as with a TTM or business development manager on site within the university. The informal network are the contacts the AE has outside of the university such as ex work colleagues, peers, consultants, and business advisors.

7.17 .1 Formal networks

The TTO at case Y stated that the interaction between case manager and AE is on a weekly or monthly basis. The ethos at TTO Y was to offer an open door policy and to get to know the researchers on campus. TTM 4Y stated '*our success is based on having good relationships with the researchers so the more we know each other, and even if we are supporting them that are non- core activities we are building up that relationship so when they do get that nice bit of funding leading to some interesting IP they know who to contact, and hopefully be one of the team and they can ask what are the next steps and that just starts the whole dialog and supports that we can offer'*. TTM 4Y noted the work of the TTO on arranging key agreements that need to be put in place to secure and protect the university invention '*we would have helped secure the comm fund, helped them protect IP done the negotiation of the license deal, we would of assisted in the setting up of the company and then assisted in the various investments that have gone into the company'*. TTM 6Y noted their assistance on a project '*the first thing with X was the research collaboration itself, we would of negotiated that and led that on behalf of the university, and obviously protecting the IP rights at the research stage, so we then led the negotiations around the license agreement – and around that we wanted to ensure that there was a fair return back to the university and the state in terms of royalties and so forth, so that was a deal that the TTO office negotiated'*.

TTM 4,6 Y stated that the AE is involved in the negotiation of contracts and gains an understating on the key agreements needed within UIC projects such as licensing agreements, shareholder agreements and investment agreements, NDAs or materials transfer agreements with third parties. Here the AE learns how IP is protected and the negotiations involved.

7.17.2 Informal networks

AEs at Case Y stated their informal network consisted of funders, or sources of funding, e.g. venture capitalists, or angel investors, TTO staff in external institutions, other academics who have been on the commercialisation journey, individuals who are in consultancy roles (market research) and people who work in the IP area (patent agents), ex -students and industry contacts e.g. CEOs of other companies, industry pharmaceutical specialists, and sales reps. AE 26Y commented on the benefits of using their informal network '*I had meetings with people in the past that I worked with previously who have gone into the venture capitalist area and they have given me information on how to de risk our vaccine in order to get it to the next stage and have been generous with their time I suppose as they know me they know where I am coming from, there's an understanding there'.* Furthermore, AE 27Y stated '*the only good knowledge is from the informal network ,the knowledge that comes from the university is not good, its designed to repulse, if a university goes to approach a company to see what they want, unless you are actually offering something and engage the company, all you are getting is the front of house person who hams you off with their glossy literature'.* AE 27Y stated that they built up their informal network by attending conferences or providing consultancy services to industry, the participant stated '*I pretty much know everybody in clinical production in Ireland, and a lot in England, you meet them at conferences or if they ask you about a process and you do some consultation'.*

AE 19Y compared their informal network to the university formal network ties. The AE stated '*it's different because its different questions you would be asking, I'm not saying it's better or worse, an individual at the TTO would probably come across dozens of examples of technology commercialisation and be able to synthesise a lot of learnings from that, but if you talk to a peer, someone like me who has commercialised something, they would very much be able to talk about their experiences and their company, you may not be able to get the same synthesises that you would get say from x type office or TTO who deals with dozens if not hundreds of spin outs'.* AE19Y here commented on the advice they received from an individual who has been through the commercialisation process before and was able to provide practical advice on the do's and don'ts from their perspective. AE 13Y stated their informal network grew from '*becoming an advisor to a couple of venture capitalists and doing some scientific due diligence for them'* where they learned very quickly about good and bad company practices. The participant also got to know the sales reps from manufacturing companies where they received valuable advice on commercialisation ventures. The AE provided the example of a sales rep putting the AE in touch with the vice president of the company that the AE sourced raw materials from. AEs use their informal network to gain knowledge from industry domain experts. This was built up over time from long relationships with companies or at conference participation or consultation work. Table 7.17 summarises theme seven from Case Y.

Table 7.17 Case Y summary of theme seven.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs.
Networks	Formal networks	-Weekly or monthly interaction between TTMs and AEs, not daily. -Open door policy at TTO. -Emphasis placed on building good relationships with the AEs. -Developing the contractual and IP agreements and including the AE in discussions.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.
	Informal networks	-Knowledge on how to de risk their technology from an informal network. -Developed through long standing relationships with companies, conference participation, due diligence work for companies, consulting, using ex colleague connections.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.

7.18 Theme 8 University level environment.

This theme addresses the contextual factors within the university which impacts the willingness of the AE to engage with commercialisation activities and the impact it has on them during the processes involved. For Case Y, the findings identified a number of sub-elements such as the low weighting of academic entrepreneurship on promotional rounds, resource shortages within the TTO, the level of bureaucracy and delays with IP contracts and agreements.

7.18.1 Low recognition within promotional criteria

It was identified that commercialisation activities were taken into account at case Y for promoting staff however, they have a lower weighting compared to traditional metrics such as teaching and publications. TTM 6Y stated '*it is taken into account but it is not very highly weighed, so what they look at is the research, they look at the teaching first and the quality and then the research citations and h index and down under that is commercialisation impact but it's not seen as the same level for the amount of work involved by the PIs'.* AE 11Y stated '*innovation could be built into the promotional system more'*. They further remarked that there is more of an emphasis on teaching and publications and that commercialisation activities lagged behind during promotional rounds.

7.18.2 Resource shortages

TTM 4Y discussed the resource shortages (time, money, understaffing) which impacted the service they can provide to the AE. The participant remarked '*we never have enough time and budget, if we had more people we could do more knocking on doors we need more resources. Ideally there would be a secondary team of junior tech transfer people and BD people who work with us to build the technologies and portfolios because often you get an academic who has a great idea and you want to work with them and you see the value but you're constraint on time and the universities don't have in house business development sales and marketing people to help develop it'.* It was suggested that if an AE feels the TTO is understaffed they may be reluctant to go to the office as a first point of contact. This did in some cases encourage the AE to reach out to industry directly and bypass the TTO. However, a problem with this was stated by the BDM where they witnessed AEs overpromising and under delivering on projects with industry, especially if the AE was nascent.

7.18.3 Contracts and agreements

Legally binding contracts and agreements were put in place to protect both parties (university and industry) within UICs. For example, if the university does not protect their IP efficiently and hold the rights to licences the IP, the threat of opportunism increases. Therefore, legally binding contacts are of utmost importance within the UIC space. The national IP protocol 2019 is the latest document which sets a framework around Ireland's research commercialisation efforts. TTM 6Y commented on this document stating '*now the national IP protocol is a useful document, it outlines terms that ideally should be in collaborative agreements with industry but many of those terms are not prescriptive there open for negotiation and we sometimes find that we get bogged down in contracted negotiations with industry on issues that really should have been prescribed by the funder in other words we shouldn't have to spend weeks or months negotiating contracts with industry. We should be able to say to the industry party, here is the contract as prescribed, It would be great to see some contracts that are not just being offered as templates suggestive for use but that they are templated agreements and their use is mandated by the parties'*. The ambiguity and open for discussion nature around some templated agreements took up a lot of time for TTM 4Y where the participant would '*rather that our time and efforts were spent negotiating licensing agreements when we are looking at the outputs of research projects, not trying to manage the inputs'*. Time delays can impact the AE starting the project on time. Table 7.18 summarises theme eight from Case Y.

Table 7.18 Case Y summary of theme eight.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs
University level environment	Promotional opportunities	-Low weighting in promotional criteria. -Teaching and traditional research metrics main metrics.	Acts as a moderator in the conceptual model, can inhibit or de motivate an individual to engage with commercialisation.	RQ5. OBJ4
	Resource shortages	-Lack of staff, time and money. -Desire to have a secondary team to build upon and develop the TTO and its services.	Acts as a moderator in the conceptual model, can frustrate or de motivate an individual to engage with commercialisation.	RQ5. OBJ4
	Contracts and agreements	-Delays in IP agreements and contractual agreements. -National IP protocol document is open to much discussion and debate, takes up a lot of time, recommendation for there to be mandated template agreements.	Acts as a moderator in the conceptual model, can frustrate or de motivate an individual to engage with commercialisation.	RQ5. OBJ4.

7.19 Case Z Findings.

Case Z is described in chapter 5, section 5.4.8. The findings for this case are now presented in sections 7.20 -7.26.3. Similar to the other two cases (X,Y) the themes identified were motivators, challenges, idea generation, progressing the idea, learning, training, networking and university level environment.

7.20 Motivators

AEs at Case Z were all engineers and were very much focused on the application of their research and engineering solutions to meet clinical problems. AE 25Z was motivated to engage with commercialisation work, where the participant stated that they didn't derive the same level of satisfaction from paper publications as gained from translational and applied research. This is demonstrated by AE 25Z commenting '*cynicism on the value of publications! Certainly engineering is very applied and should maintain an element of that so a key driver for me is to make a bigger impact'.* Although AEs at Case Z displayed a strong desire to help patient outcomes, they realised that the vehicle to get there is through commercialisation. AE 20Z commented on this stating *'the initial driver was the need to get funded, so X required it, when I worked in the U.S before coming back to Ireland, I never had any engagement, because there was no requirement to engage with industry, in Ireland that engagement exists as a state funding driver'*. In addition, AE 18Z commented on the importance of having a pathway to market from a funding perspective '*the average cost of getting medtech devices to market is about 9million euros, or 9 million USD in the states, so if you haven't thought about where you are going to get that 9 million it doesn't matter how good your research is, if you don't have the funding to do the clinical trial, build the company, and build the manufacturing, your research will never have impact'.* In summary AEs at Case Z were aware that it didn't matter how good their ideas or concepts were; without funding, they would never achieve impact.

7.20.1 Extrinsic motivators

No AE from Case Z mentioned financial benefits or how they themselves have benefited from their research; all participants strongly stated their social mission and responsibilities when using public funding. Table 7.19 summarises theme one from Case Z.

Table 7.19 Case Z - summary of theme one.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs.
Drivers	Intrinsic motivators	-To makes a bigger impact. -Less satisfaction from paper publications as an output. -The need to get funded. -Route to market.	Individual motivators, stage one of the model.	RQ1 OBJ 1.
	Extrinsic motivators	-No evidence of individual financial or rewards as a motivating factor from case Z.	Individual motivators, stage one of the model	RQ1 OBJ 1.

7.21 Theme two: Challenges facing the AE as they engage with commercialisation processes

The findings show the challenges faced by AEs at case Z were building the team around them, finding the funding and understanding end user needs.

7.21.1 Building the entrepreneurial team

AEs often needed other domain experts such as business and legal to provide advice and assistance on the running of a company. A key challenge stated by participants from Case Z was finding this talent. For example, AE25Y is the CEO of their company because they could not find the talent to lead the venture. They stated, '*so I tried to recruit a CEO to create a start-up company to go out and do this and I would of supported that person in doing that role, and I couldn't find one quite frankly'*. When asked the question what was the biggest challenged they faced in setting up their company, the participant stated '*People – I don't think technologies translate themselves, I think they can do but it's really about the personal relations and the contacts that the academic or the institution has'*. AE 20Y discussed for them the importance of a diverse set of skillsets coming from a team which has helped the participant understand the market side of their innovation, *If you look at me, as a half time clinician half time academic, I've never had formal training in commercialisation. So, it's also about the people you find yourself working with who make up for those deficits of not having a formal education or training background'.*

AE 18Z discussed the benefit of having people on their team with different backgrounds who can look at problems differently, '*one thing we often do is try to find people who sit between two domains, so we have people in the lab, for example, one guy who is a vet, an electric engineer and a pharmacist, so they can see the same problem and present three or four different solutions'*. It was suggested that when an AE was working with different people with different skillsets, it allowed the AE to take on the perspectives of others, to learn from other experts whose knowledge is from a different domain and therefore develop their ACAP. In turn, they took this learning and insight and used it to exploit their innovation thus developing their DCAP. However, if they cannot find the individuals with suitable skillsets this will impede the development of their ACAP and DCAP.

7.21.2 Seeking funding

Seeking funding was a challenge to AEs due to the highly competitive nature of public funding calls and also the requirements needed to access private funding. As outlined in the motivators theme, AEs were aware that without funding their ideas will never come to fruition and deliver on impact. In response to this challenge, AE 18Z identified that their strategy was to try secure the funding as early on as possible in the commercialisation process. The AE asked private investors early on if they are likely to invest or not in their research, the AE stated ‘ *In reality why projects fail is, it’s a funding problem, either you run out of funding within the university or you can’t get the private investment afterwards. So our strategy is to start thinking like an investor early on, and even before you start a project, to go out to an investor and ask them, if everything works right, will you invest in two years’ time and if they say no, well then you shouldn’t do the project because it is going to die anyway’.* AE 24Z commented on the competitive nature of securing funding and convincing others that your work is worth investing in as a challenge. The AE stated ‘*it’s a competitive process when you are applying for commercialisation funding so you may not be competing with others you are competing with reviewers its peer reviewed or expert reviewed it can be difficult to convince someone else that what you have is of commercial benefit’.*

Many AEs in Case Z were affiliated with the state run research centres which provides another source of funding. The BDM stated *‘we have got funded investigators and principle investigators and the PIs are those who can take advantage of platform funding, so this funding pays for their basic research and they can also avail of money for industry collaboration as well as co- funding for industry projects’.* AE 20Z identified that a lot of funding was provided by a state run research centre at university Z, therefore they had less of a reliance on the TTO for sources of funding. AE 20Z stated that a substantial amount of funding was provided for ‘*industry liaison, commercialisation management, technology transfer functions, if I was an individual PI working on my own within the university, then I would be much more dependent on the TTO’.* AE 11Z stated first point of contact on receiving funding was through the state run research centre as a funded PI ‘*since we are an X research centre we have access to funding, so I would typically use X first’.*

The competitive nature of seeking funding particularly, the challenge of securing private investment were identified to be challenges AEs faced within the commercialisation process.

AEs affiliated with research centres offered another avenue through which they can access funding for their research.

7.21.3 Understanding end user needs

In order for an AE to exploit their innovation and develop their DCAP, they must understand end user needs. It was identified that there is no point in an AE developing an innovation which nobody will want or does not satisfy an unmet clinical need. AE 24Z reflected on past projects and identified that their awareness around end user needs and what they were looking for was not as accurate or considered as carefully as it is now. The AE commented '*I think I'm in a slightly better place now knowing about markets but before then I wouldn't have known about customer development or needs or requirements. I think that is a common thing with researchers and scientists would have, they don't understand the needs of the customer they think of their own outputs and scientific outputs which may not necessarily match up to what the customer wants'.* AE 18Z underwent retraining to gain a better understanding of end user needs, the participant stated '*I retrained in clinical research to understand how to do clinical trials in devices and then I also started working with a program called the X program which is about med tech commercialisation, so basically I had to completely retrain to understand how you get something out of the lab and into the clinic'.* AE 25Z discussed how they would engage in clinical immersion, attend conferences and talk to the customer to gain an understanding on end user needs. AE 25Z stated '*well you go and you watch what they do currently, day to day, you watch how they solve problems, you go into the hospitals, you watch a surgical procedure in front of them, you go online you look at their case studies, you go to the conferences and you hear what other people are saying'.* Table 7.20 summarises theme two for Case Z.

Table 7.20 Case Z - summary of theme Two.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs.
Challenges	Managing the funding gap	-Gaining feedback from private investors as early on as possible. -Peer reviewed funding calls – the challenge to convince others your research has commercial potential.	Individual barriers – stage one of the conceptual model and as a moderator over the entire conceptual model.	RQ1, RQ5. OBJ 1.
	Understanding End user needs	-Knowing about customer development needs and wants. -Retraining to understand how to get an innovation from lab to clinic. -Talk to the customer, learn from them and how they perceive what are the unmet needs.	Individual barriers – stage one of the conceptual model development of market ACAP (stage two) and DCAP (stage three).	RQ1, RQ3, RQ4. Obj1.
	Finding the people to build a team	-Not being able to find a CEO. -Finding the people to join the AE on the commercialisation journey. -Employing staff with varying skillsets.	Individual barriers – stage one of the conceptual model development of market ACAP (stage two) and DCAP (stage three).	RQ1, RQ3, RQ4. OBJ1.

7.22 Theme 3: Idea generation

All AEs within Case Z identified that their ideas came from a needs-based solution to fulfil an existing problem. Curiosity wasn't mentioned as a component in their idea generation. This meant AEs were seeking out specific knowledge to answer a predefined problem.

7.22.1 Needs-based solutions

It was identified that AEs came up with ideas to problems when working with clinicians. AE 18Z stated that they gained a more complete picture or holistic analysis of a problem from clinical interactions *'it allows you to understand the patient pathway. If you are an academic and you're trying to place a device in the environment, I think it comes down to this idea of design thinking, you have a pre -set idea of how a patient is managed, and then when you talk to clinicians or health care workers you get a warts and all view of the problem, so it's a better understanding of the problem you get'.* This better understanding allowed the AE to start thinking from a more end user focus. The clinician was working with patients daily and had a deep understanding of what will and won't help their patients. Interestingly, AE 18Z found a '*slight disconnect'* between what the clinician and what the patient groups were telling their research group on what their needs were. The AE described their chronic pain project were the clinician stated '*the pain'* was the worst side effect of the condition. However, when the AE engaged with patients the response was '*the lack of sleep so I'm not sleeping because of chronic pain so if you can fix the sleep alone that's the biggest barrier for us for quality of life*. Table 7.21 summarises theme three for Case Z.

Table 7.21 Case Z - summary of theme Three.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs
Idea generation	**Curiosity Driven:**	-No evidence of curiosity driven ideas from case Z.	Acquisition phase of ACAP – stage two.	RQ2. OBJ 2,3.
	Needs based solutions:	-More holistic and better understanding of the problem from clinical interaction. -Slight disconnect between clinician and patient groups, ideas based on satisfying both groups.	Acquisition phase of ACAP – stage two. (Identifying the unmet need).	RQ2, OBJ 2,3.

7.22 Theme 4 Progressing the idea

Progressing the idea relates to how AEs convert their PACAP into RACAP and then subsequently how that is converted into the development of their DCAP. It involves the AE working with a range of stakeholders, where the AE is refining their commercial offering in order to achieve impact and meeting end user needs.

7.22 1 Understanding Technical / scientific knowledge

AEs sought out further technical knowledge from colleagues primarily. If it could not be found within the boundaries of the university, they had no hesitation in reaching out to other domain experts. The had a preference for experts who have industry experience. AE18Z remarked '*I wouldn't worry about the boundaries of academic institutions, so I would be looking for a domain expert but also a domain expert who has done some industry work before'*. AE 24Z would seek out technical knowledge from colleagues at Z, they stated '*I would look within the university, I would of worked with people in education , psychology or whatever for different projects, I've actually worked with all the colleges within the university, you can almost always find somebody who has some knowledge'*. AEs had no reluctance to go outside the home instruction to seek this information if needed.

7.22.2 Invention disclosure

The findings revealed the process of invention disclosure at Case Z. This took a number of steps. First, the AEs went to the TTO to disclose their innovation. They filled out the IDF template once they had developed an idea that they felt had market relevance. Then when they were confident that their innovation was something that they wanted to protect, they engaged with the TTO. The AEs found a lot of the work at disclosure stage was on their shoulders as AE 25Z stated ' *if you want the university to pay for the patent then you need to go through that IDF, they evaluate it per se, but really I think it's up to the investigator or the researcher to drive that process'*. The IDF at Case Z challenged the AE to answer questions such as: What is the problem or customer need for the invention? What stage of development is it at? What is the value proposition of the invention does it for example provide better performance, cost savings, quality? and What are the advantages of the invention over competitors?

7.22.3 IP landscaping

The IP landscaping work was done whilst the IDF is being prepared. One section asked the applicant to conduct searches on work already patented and competing technologies. The AE and TTM can work together on patent searches depending on the level of experience of the AE, TTM 5Z stated '*if it's a particular device that's out there, looking at the competing products what IP do they have, and then is there freedom to operate as in can you develop this technology further without infringing their patents, that depends on the expertise of the case manager in the TTO'.* The TTO would typically have a small budget to bring in a patent agent to review the application. TTM 5Z remarked '*we would ask the patent agent to look at four or five pieces of IP, and to give us their feedback on how easy it is to work around what is out there already, or is this something that they think we could pursue?'* AE 24Z commented on the benefits of working with a commercialisation specialist at the TTO '*we have a commercialisation executive who would be very good in terms of looking at something and trying to imagine not just the technical pitfalls but also what the funder may be looking for so they'd be trying to think say X what they will be expecting to see and that's usually good an external pair of eyes'.* Patent searches were a critical part in the commercialisation process where the AE needed to understand the competitive landscape. If there was freedom to operate or potential infringements issues with existing granted patents. This work was vital because if the AE could not protect their research properly it was open to threats of opportunism from others and a barrier to route of entry.

7.22.4 Patent process

The patenting process enabled the AE to focus in on the specifics of their innovation and asks what is unique about their innovation compared to competing products and patents already granted. As the AE focused on the originality of their work and their USP, they developed their market ACAP of how to meet a market demand within the confines of IP regulations. They were able to replicate this learning to subsequent innovations, thus developing their DCAP. AEs worked with the TTO in patenting their innovation, AE 18Z stated '*it's all through the TTO so we typically can't go directly to a patent attorney so that's all managed through the TTO'.* AE 25Z identified that they learned directly from the act of engaging in the patenting process. They stated *'how to protect patents, makes you drill down into your innovation and what is unique about it, you interact quite heavily when a patent examiner or a patent office sights other technologies in the public domain that are infringing on or where you might not* *be inventive because something like that may exist already, well then you end up drilling into your innovation and asking is that what we are doing? or are we doing it in a slightly different way that you could apply in the innovation so it's not from the patent lawyer it's from the process that you're learning from'.* This quote highlights the importance of conducting patent searches and exploring the competitive and IP landscapes to ensure the AE is not infringing on patents already granted. This process gets the AE to think what is unique about their offering. Some AEs had to pivot their offering slightly to make sure there were no infringement issues. AE 11Z discussed the importance of recognising any potential infringements to existing patents 'there *was a patent of a similar product already, so I had to modify my design slightly where I came up with the same mechanical performance, but I didn't infringe on the patent already granted. That's the beauty of mechanical design you have endless possibilities, but you have to do it within a window of regulations*'. The AEs noted that it is themselves that drives the conversation with the patent agent with the TTM taking an observer role. The AE needed to be able to communicate the research to the patent agent in a way that describes the novelty and non- obviousness of their research. It could be suggested that this could present a challenge as the AE mindset would be on the technical or scientific attributes of the innovation and not necessarily the potential of patentability.

7.22.5 Understanding market knowledge

The findings identified that by engaging with external stakeholders, AEs learned end user needs and market requirements and what will and won't work in an end user setting. Through these interactions they translated their scientific knowledge into market knowledge. As they learned from these groups and refined their offerings, they had the opportunity to exploit their innovation, thus developing their DCAP.

AEs at Case Z engaged with customers (end users), distributors (medical devices), regulators, industry partners and founding members to gain feedback and knowledge around market requirements. They had an understanding that scientific knowledge and market knowledge required a different approach to how they use and assimilate scientific vs market knowledge. AE18Z remarked *'market knowledge is a different type of knowledge where you just need enough knowledge to answer the question in comparison to scientific knowledge where you need to understand the underlying mechanisms or fundamental questions'.* AE 25Z stated when seeking out market knowledge '*I think the customer is always the best, so if you can get* *customers who are engaged with industry then you are getting a bit of both worlds'.* AE 25Z further described the individuals they would seek out '*you are looking for people who have knowledge and interact at the highest level so they are considered leaders in their segments and they are influencers and they have a particular view of the world'.* AE 18Z used their angel investor network to gauge market feedback. The AE stated, *'we have a really strong angel investor network, they tend to tell you no very quickly if there is no market, for a particular device so they are useful'.* AE 24Z identified how input from investors guided their direction in terms of what areas to focus on '*we had a meeting recently with some investors who said that the areas that are hot at the moment are devices for drug delivery and remote monitoring devices, and so by them telling us what areas they are interested in we can then look for opportunities in that space'.* AE 18Z noted their distributor network as an effective way to gain market knowledge *'another really useful group are distributors so end users tend to be biased as in if you ask a doctor if a particular surgical instrument works well they will almost always tell you yes because, they don't want to be seen as they are using poor tools so it's hard to get honest opinions. We all have our biases. Distributors though like salesmen in the hospital every day meeting doctors they kind of get a feel for what they like and don't like, so I think they are really useful'.*

It was found that the AEs at Case Z also gained market knowledge from regulators. AE 18Z discussed the importance of regulatory engagement for their research '*I would say X is absolutely pro innovation. So often they go above and beyond, so they will come down to us at an early stage of the product lifecycle and they will have a meeting on site and they will tell us what they want to see. So it's not like they are a barrier or to stop you they are actually guiding you to best practice and to getting approved, I would say they are a really good group'.* AE 25Z suggested that regulators helped them on how they perceived risk. AE 25Z remarked '*they don't necessarily care if the innovation is the best or most revolutionary piece of technology they have seen, their priority is to make sure no patient is at risk from letting a product through a clinical trial or into the marketplace as a result of poor efficacy, safety and efficiency considerations'.* AE 20Z used the skillsets of the founding and advisory team members of their spin out to understand and exploit market potential. AE 20Z in the study remarked that '*I'm not so sure I have acquired the skills as opposed to used other people's skills'.* AE 20 has a dual role as a clinician and an academic. AE20Z was identified to bring a lot of scientific knowledge and patient understanding to the team. They used their co -founder's knowledge on business and law to provide the business understanding. AE 20Z commented '*I think it's important to have someone involved who understands the disease, who deals with people, who can identify the problems, that person doesn't have to be the person who goes off and does the market research, but they are a key person to the process'.* Similarly, AE 18Z used their industry advisory board to gain market knowledge '*there is investors on that board that are senior people in large medtech companies, so they tell us trends that are happening'.* Table 7.22 summarises theme four from Case Z.

Table 7.22 Case Z - summary of theme four.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs
Progressing the idea	Understanding Technical / scientific knowledge:	-Seek out technical knowledge from colleagues. -Go beyond the boundaries of the university to seek out technical knowledge, with preference for industry experience also.	Development of scientific ACAP And the assimilation of technical knowledge.	RQ2. OBJ 2,3.
	Invention disclosure	IDF – four sections project contributor details, invention details, prior art and funding sources. -IP landscaping work done whilst completing the IDF.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model)	RQ2, RQ3, RQ4 OBJ 2,3.
	IP Landscaping	-Looking at competing products and what IP they have. -Is there freedom to operate, any infringement issues. -Patent agent brought in to review application.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model).	RQ2, RQ3, RQ4 OBJ 2,3.
	Patent Process	-Learning from the patent process not the patent agent. -Asks the AE to drill down into their innovation to seek out what is unique about their offering.	Development of market ACAP Transformation and exploitation (stage 2 of the conceptual model) and their DCAP (stage 3 of the conceptual model).	RQ2, RQ3, RQ4 OBJ 2,3.

Table 7.22 Case Z - Summary of theme four (continued).

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs.
Progressing the idea	Understanding market knowledge	-Engage with customers (end users). Talk to the customer. Customers who are engaged with industry offers both perspectives. -Distributor network - used to gain a more honest and blunt opinion, elimination of biases. -Angel investor network – to gain market feedback. -Regulators – seen as pro innovation, used to assess how they perceive risk. Guidance on best practice. -Founding team members – using the knowledge and skillsets of team members. Advisory boards to keep up with trends. -Awareness that market and scientific knowledge are different and possess different requirements.	Transformation and exploitation stage of ACAP. Developing and refining the market proposition of the innovation. DCAP – taking the knowledge gained from working with the stakeholders to exploit the innovation.	RQ2, RQ3, RQ4 OBJ 2,3.

7.23 Theme 5: Learning

The AEs at Case Z identified that past work experience was beneficial through their accumulation of commercialisation knowledge which they were able to use now in their academic commercialisation activities. Some AEs cited a lack of formal training and a learning by doing mentality.

The sources of knowledge for the AEs from Case Z are summarised in table 7.23.

Table 7.23 Source of knowledge from Case Z.

Scientific Knowledge	Market knowledge
Ask a colleague. Read around the literature. Academic conferences. No fear of going outside the boundaries of the university if needs be.	Technology transfer managers. Clinicians / healthcare workers. Investors. Market research consultants. Industry partner. Peers. Distributors. Regulators. Business development team at research centres. Commercialisation specialists at finding agencies. Founding team members at USO and advisory team.

7.23.1 Prior work experience

AE 18Z learned what worked and what didn't work on past projects and applied that learning into future projects to exploit that knowledge and engage in successful industry collaborations. Here, the AE was developing their DCAP, using the knowledge they gained from prior work experience. AE 18Z stated *'at the moment we are working with three medical ablation companies, and in a way, we learn from one project and then pass on that knowledge or that* *experience to another company and to another company.* The AE further remarked that '*if you build one type of medical device and you have learned the entire process, then you can replicate that with the next industry partner. So ablation is a massive area of innovation at the moment, we have done a few projects, so the next company that comes in for ablation, we've done it already with a few companies, so we know the process'.*

AE 24Z also commented on the learning from past projects as they stated *'I've learned from failures in start- ups where I would have been involved in companies where I was trying to develop three products instead of one and didn't focus on one thing and didn't think about doing one thing well and the want of customers'.* AE 18Z also used shadowing other companies to learn their patterns of behaviour. They had this opportunity as they are an advisor to budding entrepreneurs within Case Z, on a 24-month training program where the goal is for the nascent entrepreneurs to spin out a company. The participant stated '*when I've shadowed two or three companies getting built I saw patterns of behaviour and patterns of actions that added value and there's patterns that subtracted value. By watching two or three companies you can see a pattern of what works and so then when the fourth or fifth company comes in we show them here are the best bits of the last three or four companies that we have helped'.* Furthermore, AE18Z sat in on investor meetings and regulatory meetings where the AE '*could see what interested investors and what put them off and you learn that process'*. Case Z highlighted the importance of thinking like an investor and being able to pitch ideas that can attract further investment.

7.23.2 On the job learning

Some AEs at Case Z stated they engaged with little structured training around commercialisation and a lot of it was learned on the job through trial and error processes. AE 20Z stated that it was a combination of on the job learning and using past work experience in their role as an AE. AE 20Z noted '*It's a combination of both, but there's has never been anything structured or formal'.* The participant provided the example of regulatory engagement as an on the job learning activity where no training was provided. AE 11Z stated project management was learned on the job where the AE gained skills around risk mitigation strategies and scenario planning. AE 10Z remarked ' *I don't have the time to go to another training course, learning on the job is how I gain the skills'*.

7.23.3 Change of mindset

AE 25Z noted that their thinking has changed since getting involved with commercialisation activities. They now focused more on problem solving rather than understanding the underlying or fundamental aspects to a problem. AE 25Z stated '*well I think in a completely different way. I have a completely different perspective and yes that changes you from scientific technology focus to a problem solving focus, what's the problem you are trying solve, what's the best way to do that and how does that align with a business, so it's a complete mind shift'*. AE 18Z noted their thinking has become far more critical of projects and that they do not get involved in projects that '*don't have runway or don't have scope to have impact'*. AE 18Z discussed their moral obligation when receiving funding. They identified that if AEs are claiming impact on society and patients, it is the AE's responsibility to deliver on it. TTM 5Z at University Z commented on some of the supports around change in thinking and the skills required. The participant stated *'I think it comes natural to some academics but we are currently teaching a good bit of the frameworks and the methodologies to help progress their thinking, so we would look at design thinking to give them different tool sets to help them validate problems and look at customer discovery, so it does comes a lot easier to some than others'.*

AEs at Case Z found their entrepreneurial role and academic role as complementary. AE 24Z stated *'yes, they are very complementary, I was actually looking at some lecture notes before our interview for engineering and I brought in some entrepreneurship and asked if you were developing an electrical system how would you go about commercialising it? That's something most students never think about, they think how does it work they don't think about how do you make people want what you made work so they are complementary'*. No AE at Case Z perceived any conflict of interests between their academic role and entrepreneurial role. It could be suggested that this mindset of the two roles complementing each other is how the AEs streamlined their thinking into how their scientific knowledge applies in end user contexts. Table 7.24 summarises theme five from Case Z.

Table 7.24 Case Z - Summary of theme five.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs
Learning	Past work experience	-Learning what has and hasn't worked in past projects and applying that knowledge to future projects -Shadowing company behaviours.	Exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.
	On the job learning	-No structural training. -Learning as you go. -Regulatory engagement learned on the job.	Exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.
	Change of mindset	-Thinking changes to a focus on problem solving and how to achieve that. -More critical of projects. -Validation of problems. -Design thinking- problem based.	How AEs translate their PACAP into RACAP in the conceptual model and also how they develop their DCAP	RQ2, RQ4. OBJ 2,3.

7.24 Theme 6 – Training

This theme is broken down into training provided within the university (internal) and from external sources. AEs were trained on the commercialisation process at Case Z. The university supplemented this training with external training evaluated on a case by case basis.

7.24.1 Internal training

It was reported by TTM 3Z that Case Z provided courses across all communities within the university at least on a monthly basis. At the training the AEs learn the commercialisation life cycle and the appropriateness of non- disclosures agreements. In addition, the AEs learned how to consider research and look for identification of potential impact to their research, how and when to make decisions around protecting the research, and in devising commercialisation strategies. TTM 3Z identified that information on the funding pathways was provided as '*a lot of researchers are familiar with pathways to achieve funding for their research but not funding to put that research into a commercial avenue'*. It was also reported that the university has a mentoring program to help and assist nascent researchers with one to one mentorship on new ideas and how best to go about commercialising them. It was identified that University Z used the lean canvas model for training purposes. The rationale being on the left-hand side of the template, the AE is clearly asked to define the problem and to list the existing alternatives, where TTM 5Z found the lean canvas as more appropriate to university level innovations.

Unlike Case X and Y, the university also provided a fellowship program where multidisciplinary teams were put into hospital settings for three to four months. This was found to help them come up with a list of clinical unmet needs or inefficiencies in the hospital through shadowing doctors and nurses on site and taking notes through observation. The teams typically came back with a list of on average 800- 1,000 problems in a particular area e.g. cardiology. What they are next challenged to do is filter that list or to rank those needs in terms of

- What impact they would have on a patient?
- What would be the commercial opportunity associated with them?
- How technically feasible they are?
- How disruptive to the market would they be?

Over a three – four month period, the list is filtered down like a funnelling system to arrive at only 2 or 3 concepts. Then the fellows go out and get feedback from investors on their top 2/3 unmet needs and ask critically questions like 'If we developed a solution to this, would you invest in this concept?'. If the result is positive, brainstorming sessions start next, using a similar filtering process, to ultimately get the innovation to a stage where the fellows (budding entrepreneurs looking to spin out a company after the training program ends) can seek external funding for venture creation. AE 25Z (who is a director on the training program) stated '*the whole process from concept to spin out is 24 months, where the teams spend a year on the concept and don't build or buy anything for the first year, their emphasis in year one is on building a very strong value proposition*'. AE 18Z (an advisor on the programme) stated the key learning outcomes from participating in the fellowship program is an ability to evaluate problems and solutions to meet those problems and whether it's worthwhile for the team spending their time on that. Also, in conjunction with the validation of the critical need, the second key outcome was the establishment of the knowledge and networks needed for the fellows to be able to exploit their innovations.

7.24.2 External training

The external training from participants at Case Z focused in on helping them to know their customer and understanding their needs and wants. Furthermore, the training also focused on helping AEs learn market pull forces. These learnings help the AE develop their market ACAP and in turn their DCAP where they learn to identify a market need and how to meet that need efficiently. Similar to Case Y, AE 18Z travelled to the USA to take part in a commercialisation training program where the methodology is before you build anything you talk to the customer. AE 18Z take away from this course was to really understand the problem before any technical development is done. This was identified to have really influenced the way they look at problems now and has led to them doing a lot of research before development because of the training. AE 24Z completed an entrepreneurship development course where they learned about technology push versus market pull forces. Before the course, the participant was very much focused on technology push with not much consideration of market pull forces. After the training, AE 24Z '*appreciated the market side of innovation in far more detail*'. The course also provided learnings around customer discover and customer validation. AE 24Z described the training '*the process is around understanding who the customer is and what you can do for them, how you make money from them and how you can grow and scale a business*'. Table 7.25 summarises theme six from Case Z.

Table 7.25 Case Z - summary of theme six.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs
Training	Internal training	-Lean canvas model used as a tool for learning at the university. -Customer profiling. -The importance of IP, contracts and agreements. -Value proposition workshops. -Getting the pitch right workshops. Building the team. -Filtering ideas down to 2/3 concepts. -Clinical immersion program. -Brainstorming sessions and filtering of ideas methodology.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.
	External training	-Learning to understand the problem before any technical work is done. technology push versus market pull forces – before training overly focused on tech push, change in thinking as a result of training.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.

7.25 Theme 7 – Networks.

The AE holds a high degree of specialised knowledge from a technical background. However, the input and guidance from other domain experts are also an important source of knowledge which can help the AE commercialise their research. It was therefore important for AEs to access and maintain connectivity with other stakeholders within the UIC ecosystem who possess different knowledge and experiences. This theme looks at what types of information the AEs are getting from different networks.

7.25.1 Formal networks

This sub theme relates to the networking and connectivity between AEs and support functions within the university. TTM 3Z stated '*interaction with AEs happens on a weekly or monthly basis typically with informal discussion throughout the project also'.* AE 18Z stated '*we would probably talk to the TTO nearly weekly or every two weeks, as all of our projects are commercial'.* AE 10Z cited lack of staffing as an issue on how supportive the TTO can be. AE 11Z as a research centre director '*would liaise with TTO functions all the time, for example with NDAs, we are constantly engaging with them'.*

AE 25Z preferred to use their network of industrialists firstly rather than the university, they argued '*quite frankly universities are great sources of knowledge but really front ended on basic research when it becomes closer to anything that is applied I don't think universities have those skills'.* AE 20Z discussed less of a dependence on the TTO as they were affiliated with a research centre. The participant stated *'we had our own TT employees, so we were less dependent on the university's TTO. We had the expertise built into our programmes. We would go to our technology transfer officer; they would go to us as well every 3 months or so and sniff out if there were opportunities'.* AEs affiliated with research centres had additional connectivity with business development teams compared with a non-affiliated AE. The BDM can refer on an AE onto a client who is aligned with the partner's needs. The centres also hosted roadshows where the AEs get to interact with potential industry partners. There was also evidence of industry partners directly contacting AEs also who are affiliated with research centres.

7.25.2 Informal networks

Informal networks refer to the ties with stakeholders outside of the university. AEs at case Z referred to their informal network as comprising of ex colleagues, ex- students, industry contacts, investor networks, advisory boards, business partners, and market consultants. AE 18Z commented on using the investor contacts (angel investors) in their informal network allowed them get feedback that was direct and quite blunt as '*investors don't entertain bad ideas'*. The AE found this useful in guiding their innovation offerings. Comparing this relationship to the TTO, the AE found the TTO provide a softer interface, however the AE found often the more blunt advice is the most useful. AE 25Z used the informal networks of individuals (peers) who have been through the spin out process before. Here, the AE was not looking for someone to teach them the theory of venture creation but was looking for someone who had the experience of what goes on and how to approach problems and solutions. The AEs stated that this knowledge was lacking within the university.

AE 24Z stated the wide range of information they may seek from their informal network, '*this could be anything from looking for contacts to looking for information to be shared to asking questions looking for collaboration on projects it could be on lots of things'.* When probed when the participant would use their informal network, AE24Z remarked '*when there is an expert in a certain area that the TTO doesn't have you have to go to your informal network to find that expertise'.* AE25Z's informal network consists of both business and clinical contacts. The participant stated how their informal network developed their spin out in the early days '*I had a good connectivity with industry and high net worth individuals so I did get initial seed money from four individuals, and that allowed me to get off the ground, get an office, I already had incorporated the company and that allowed do a little bit of legal bills, license the IP from the university, and hire couple of experienced engineers'.* AEs used their informal network for practical advice from individuals who have been through the commercialisation process before. In addition, if the TTO did not have the contacts in a particular area, the AE goes to their informal network for the connectivity. Finally, the AE reached out to individuals from their informal network to bounce ideas off someone who they trust. They also gauged market feedback from investors asking if they are potentially interested in a concept.

As shown in Table 7.26, AEs used their informal network for practical advice from individuals who have been through the commercialisation process before. In addition, if the TTO don't have the contacts in a particular area, the AE went to their informal network for the connectivity.

Table 7.26 Case Z - summary of theme seven.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs And OBJs
Networks	Formal networks	-Interaction between TTO and AE happens on a weekly or monthly basis. -AEs affiliated at research centres would go to their tech transfer and business development people also, less dependence on TTO. -Frequent interaction between TTO and research centre on state of play with projects.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2, 3.
	Informal networks	-More honest and blunt advice. -Investors don't waste time on concepts they don't think have market attractiveness. -Looking for someone who has been through the experience and can guide them.	Transformation and exploitation phase of ACAP and the development of DCAP.	RQ2, RQ3, RQ4. OBJ 2,3.

7.26 Theme 8 University level environment

This theme addresses the contextual factors within the university which impacts the willingness of the AE to engage with commercialisation activities and the impact it has on them during the processes involved. For Case Z the factors are TTO constraints, strategic importance, mentoring and external experts.

7.26.1 TTO constraints

AE 18Z felt that they had to convince or prove that their technology had commercial appeal or there was a funding mechanism in place to realise the potential of their innovations. AE 18Z stated '*often the process is that we submit an IDF to the TTO, but they will essentially just file it and won't grant it until you have proven to them that there is either market interest in it from a licensing deal or there is sufficient interest in a spin out being formed. So that is often the challenge for us to convince the TTO that there is commercial interest in this'*. TTM 3Z stated that the TTO has a limited patenting budget and can't pursue every concept coming into the office. They use an evaluation form to assess each project's potential. TTM 5Z confirmed this when stating '*patent budgets are limited so your ability to speculate on patents that you are not sure will run or not, that's a budgetary issue for universities'*. If an AE feels the TTO is overly stretched, they may be reluctant to go to the office as a first point of call. AE11Z stated '*I found a lack of support from the TTO office in some aspects, and that's down to being understaffed'*. When probed what would be a consequence of this the participant stated, '*I would go to the industry people rather than the TTO'*. It can be argued, TTO constraints can act as a deterrent for AEs to work with the office.

7.26.2 Strategic importance

TTM 3Z stated that technology transfer and commercialisation within the university needed to be elevated to a strategic importance level. The participant remarked that teaching has much more priority in the university than technology transfer, and is a discipline very much understood. The participant argued more emphasis was needed to harness the commercialisation activities of the university. TTM3Z stated '*industry engagement is still somewhat unknown in comparison to teaching, so I think TT and impact is new and commercialisation to some researchers and PIs is a bad word. So elevating TT to a strategic purpose at universities across the board would be the one thing that I would suggest as most important'.*

7.26.3 Mentor model and external experts

It was identified by AE 11Z that there was a lack of mentors within the university, where a mentor model introduced in the university could aid AEs commercialisation efforts. They suggested the university could *'hire people who have an industry background, so they already have the language'.* Similarly, AE 25Z suggested '*I think you need to educate academics, academics know more and more about less and less! because people become so specialised and you need generalists who know less and less about more and more so they need to bring people in to talk about their experiences and about product innovation but you need to make that a realistic conversation, you need domain experts where there is a little bit of mutual respect'.* AE 18Z also called on outside expertise to leverage the work done at the university '*I think it's more realistic to allow the scientist to do the science and then bring in external dedicated people to look at the opportunities for IP to be leveraged'.* If the AEs and their students are not accessing the knowledge of industrialists, it becomes more challenging for them to understand their needs and what direction industry are going in terms of innovation. By universities adopting more open communication, guest speakers and open days this presents the opportunity for the AE to learn and understand their needs more deeply. Table 7.27 summarises theme eight from Case Z.

Table 7.27 Case Z - summary of theme eight.

Theme	Sub theme	Sub elements	Conceptual model stage	Corresponding RQs and OBJs.
University level environment	TTO constraints	-Convincing the TTO that there is commercial potential. -Limited budgets.	Acts as a moderator in the conceptual model, can inhibit or de motivate an individual to engage with commercialisation.	RQ5. OBJ 5.
	Strategic importance level	-Need to elevate technology transfer to a strategic importance level at the university to give it equal weighting as teaching and traditional research output metrics.	Acts as a moderator in the conceptual model, can frustrate or de motivate an individual to engage with commercialisation.	RQ5. OBJ 5.
	Mentor model and external experts**:**	-Importance of mentoring model to pass on knowledge to nascent entrepreneurs. -Bringing in more external experts and different domain experts of more a generalist background.	Acts as a moderator in the conceptual model, can frustrate or de motivate an individual to engage with commercialisation.	RQ5. OBJ5.

7.27 Cross case analysis and overall findings

The cross- case analysis was used to help in adding rigour to key findings in relation to the conceptual model and research questions, as part of the theory building process adopted within the thesis (Ragin and Schneider, 2011; Dooley 2002). Table (7.28) compares and contrasts the three case studies and it further extends the cross-case table from the methodology chapter section (5.4.9). Each of the core research themes will now be discussed from a cross case perspective leading to the overall key findings.

Table 7.28 Cross case analysis.

Theme	Case X	Case Y	Case Z
Motivators	-Overarching goal to problem solve and improve patient outcomes. - However, some AEs expressed having no choice but to engage with commercialisation.	-Overarching goal to problem solve and improve patient outcomes. -However, reference to extrinsic benefits such as retirement plans and route to funding blue sky research.	-Strong emphasis on the intrinsic benefits no reference to extrinsic benefits. -Strong desire to meet their moral obligation noted by participants.
Challenges	-Case X and Y noted similar challenges – seeking funding, building the team around them and meeting industry expectations.	-Case X and Y noted similar challenges – seeking funding, building the team around them and meeting industry expectations.	-Noted the additional challenge of meeting the end user needs.
Idea generation	-Idea generation took a curiosity driven approach and ideas to address predefined problems.	-Idea generation was derived from wanting to solve a pre-defined problem only.	-Idea generation was derived from wanting to solve a pre-defined problem only.

Table 7.28 Cross case analysis (continued).

Theme	Case X	Case Y	Case Z
Progressing the idea.	- Patent searches are an optional requirement when filling out the IDF. - Dedicated spin out and licensing manager along with TTMs who links in with the AE to offer guidance and assistance. - Investment fund initiative with Case Y to help avoid valley of death scenarios.	- Patent searches are a mandatory requirement when filling out the IDF. - Investment fund initiative with Case X to help avoid valley of death scenarios. - Specific enterprise manager who builds a database of potential investors/ management team executives along with TTMs.	- Patent searches are a mandatory requirement when filling out the IDF. - No dedicated TTO personnel, the four TTMs get a list of AEs they are assigned to work with.
Learning	- All but one AE had prior industry experience. - Two AEs had subsequent spin off experience. - Developed the ability to learn from past experiences and learning what it takes to build a company.	- Similar to Case X, all but one AE had prior industry experience. - One AE from Case Y had a subsequent spin off experience.	- Similar to Case X, Y, all but one AE had prior industry experience. Two AEs from Case Z had subsequent spin off experience. - AEs from Case Z had the opportunity to advise on companies being built and shadowing behaviours, sitting in on advisory board meetings.
Training	- Dedicated unit which conducts all the training which is completed at the business school. - AEs have the opportunity to take sabbaticals to attend training courses such as MBA.	- TTO provide the training where AEs can choose from short courses all the way through to accelerator programs. - Training is described as a funnelling system, starting with demo days, then when secure funding moving onto commercial plan and when further along the development, training around business plan.	-Specific training program based on a needs led innovation methodology. - Unlike Case X and Y, the AEs involved with the program offer assistance and guidance to fellows and learn the patterns with company development.

Table 7.28 Cross case analysis (continued).

Theme	Case X	Case Y	Case Z
Networks.	-Biweekly meeting with BDM at research centre and TTO. -Informal network developed through prior work experience primarily.	-Monthly meeting with BDM at research centre and TTO. -Informal network developed through prior work experience primarily. Also noted the benefits of consultancy work and scientific due diligence in gaining connectivity.	-Monthly meeting with BDM at research centre and TTO. -Located in a hot bed of SME activity in medical devices, strong informal networks developed by participants. -Noted the importance of links to local hospitals and staff.
University level environment.	Commercialisation not taken into account in promotion rounds. Culture of negativity stated by AEs and TTM at Case X where the feedback one TTM got was 'the '*work you do here is evil'* on a training course.	-Low level weighting of commercialisation activities in promotion rounds. -No evidence of scepticism or negative culture at Case Y from participants, some questioned the motives of TTMs at times.	-Commercialisation not taken into account in promotion rounds. -No culture of negativity stated by participants.

7.27.1 Theme 1 Motivators

Participants from all case studies were primarily motivated by the intrinsic desire to promote health and wellbeing in the community, to develop new technologies and discover breakthroughs in their field to fight disease and developed a needs-based approach to new ideas. Cases X and Y noted some of the extrinsic motivators to AEs; these were relating to pensions, funding their own work, conducting more blue sky fundamental research and personal financial gain.

Overall key finding: AEs are primarily motivated by their social responsibility and drive to make an impact that will benefit the end user, they are much less driven by financial rewards.

7.27.2 Theme 2 Challenges

All cases mentioned accessing funding (in particular funding when moving from pre-clinical data to human trials), managing the expectations of industry and finding the people to join them on the journey as key challenges. Case Z noted understanding the end user as a key challenge they encountered. Given that Case Z were all engineers, they were very much focused on application and translational research. The scientists from the other cases had more of a focus on the underlying science and fundamental aspects of their research. All cases noted the different mindsets and expectations venture capitalists had, where their predominant focus is to make money. The AEs stated investors did not share the same level of interest in the company or the product. They found it a challenge to think from an investor perspective where the focus was on financial and profitability metrics. The AEs primary motives were intrinsic in nature.

Overall key finding: AEs are primarily challenged with accessing funding and managing the funding gap, managing industry expectations, finding the entrepreneurial talent to accompany them and understanding end user needs.

7.27.3 Theme 3 Idea generation

Ideas came about from needs-based solutions to existing problems. Case X referred to some of the additional challenges with exploratory idea generation, such as how to measure success and what an impact on a new problem area looks like. Case X approach was to explore the technical uncertainties of an exploratory problem first and then to move onto market uncertainties. However, ideas mainly came about from interaction with a clinical lead who advised the AE on the unmet clinical need. Ideas also came from AEs believing they could add to the field and were able to spot an idea that had commercial potential, they cited past industry experience, thinking differently to peers and having a eureka moment where they often couldn't exactly pin point how they came up with the idea.

Overall key finding: AEs come up with ideas primarily to solve existing problems where they often work with a clinician who provides the input on how to come up with ideas that will have commercial impact.

7.27.4 Theme 4 Progressing the idea

AEs from all cases sought technical knowledge from colleagues and/or read up on the area.

Case X provided examples of how their research team would progress the innovation up to prototype stage where many AEs described this progression as a team effort. An IDF was used by all three cases to formally disclose an AEs invention however, an informal communication platform and open door policy was operational in all three cases. Case X asks for a patent search as an optional requirement giving nascent entrepreneurs hands on training experience with a dedicated TTM. Case Y and Z ask for patent searches to be conducted before filing the IDF however both cases stated their TTMs would work with AEs not comfortable with this task. All cases stated having a limited patent budget and AEs found it a challenge to convince the TTO that their invention deserved to be protected. Case Z noted an important skill is to think like an investor early on and to gain market feedback as early on as possible in the process. All cases funded their research through the state run commercialisation fund or state run research centres. There was little evidence of European level funding (H2020). The first point of contact for funding was from Irish funding sources. Case Y provided the example of how sales reps at manufacturing companies provided advice on who to talk to in order to progress their innovation. This finding also links with informal networking as the AE built up these relationships from years of dealing with the company. Market knowledge was gained from a variety of sources, these are presented in tables (7.5, 7.15 and 7.23).

Overall key finding: AEs seek further technical knowledge from colleagues and reading around the area to develop their scientific ACAP. There is no one group or stakeholder that an AE gains market knowledge from. It is from a variety of sources, where the AEs seek knowledge as close to the market as possible in order to de risk their innovation. De risking has three dimensions to it, the AE de-risks from a technical, commercial and IP standpoint.

7.27.5 Theme 5 Learning

The AEs in this study learned primarily from the combination of using past experience and learning on the job. All cases found their entrepreneurial role and academic role as complementary. Participants from Case Y stated that the wearing of different hats was needed to succeed in both job roles and analyse problems from different viewpoints. Case X provided examples of how industry brings contextualisation and relevancy to problems and the understanding of the need more closely. For an AE, this is a valuable learning experience as they do not work as close to end users as industry or clinical leads. Participants from Case Z identified that being part of the needs led training programme has allowed them to shadow companies from their inception and witness patterns in behaviours and actions. They took this learning into new company formations knowing the pitfalls to avoid. Also by being able to sit in on investor/regulator meetings, Case Z participants learned the process very quickly of what these stakeholders are looking for when making decisions.

Overall key finding: All participants stated learning on the job was the primary way they learned when spinning out their companies. Learning from past experience helped the AE with future projects and knowing how to apply best practice from past experience into future projects. The AEs also developed an awareness of what the industry partner would be looking out for in projects from past industry work experience. Finally, the AEs learned from failures in past projects and what not to do in future collaborative work.

7.27.5 Theme 6 Training

Case Z used the business school to conduct all training around commercialisation for AEs with the rationale being ‘it streamlines the whole process’ (TTM 1X). Case Y offers a bootcamp, pitch days, customer discovery program and an accelerator program to train budding AEs. Case Y also offered incubator facilities (spin in and spin outs) where the AEs got to work and sometimes co-locate with industry partners where the companies built the relationship with TTMs and AEs. Case Z offered a business innovation centre where industry can access lab facilities, shared workspaces and business supports through product validation, networking, sourcing funding and access to academic expertise. This in turn can help the AEs with understanding the needs of industry more. Case Z also has an accelerator program, demo days (pitching days) and a needs led training program. All cases used the lean canvas model and training was around value proposition, customer discovery and validation, competitor landscaping, IP landscaping, pathways to market, finding the executive talent and funding strategies. Case Y and Z had participants who travelled to the USA to partake in training where the methodology is before you build anything you conduct customer discovery field work. The AEs gauge market interest from 100 interviews with customers. Case Z had one reservation about this training that is you are left with just a yes/no answer. They compared this method to the filtering system they use and argued it is a better choice as with the filtering of ideas the AE should be left with a solid value proposition rather than 100 people saying yes or no.

Overall key finding: AEs are taught not just to de risk their technology from a technical standpoint. They must have market pull forces not just a technology push focus.

7.27.7 Theme 7 Networks

Case Z had less of a reliance on the TTO for formal networking. This was due to the large number of participants who were affiliated with research centres. The AEs at Case Z would use the research centre business development team as a main point of contact. All TTOs stated their success was built on good relationships with AEs. They operated an open door policy and interaction was on a weekly or monthly basis depending on the stage of the project. AEs informal networks for this study was found to consists of investors (VC and angel), industry contacts from prior engagements, market research consultants, business advisors, ex colleagues, friends/family, distributors, peers met at networking events/ conferences, former students and TTO staff from other institutions. Each case provided similar answers on who was in their informal network. AEs sought information from their informal network that was free from as much bias as possible. Case Y and Z referred to distributors of medical devices as a source of honest feedback. Case Y provided examples of doing due diligence work for companies and consultation work as a way to extend their informal network building up relationships with industry. Case Z provided the example of meeting investors at industry conferences as a way to gain feedback on what their interests are regarding innovations.

Overall key finding: The knowledge the AEs were seeking from informal networking was different to that of the formal network. Informal networks were found to be useful for AEs seeking more blunt, honest application based feedback on how they can progress their research.

AEs were looking for someone who had been through the experience before to guide them and found from their informal network they could access this information.

7.27.8 Theme 8 University level environment

University X and Z do not consider commercialisation activities as a criteria when an AE is going for promotion. Case Y does so but at a lower weighting to teaching and traditional research metrics. Case X participants would like to see quantifiable measures such as the number of patents granted used as a metric when evaluation promotional opportunities.

Case X participants voiced frustration at the length of time for contracts and agreements to be drafted and become binding. Case Y stated the national IP regulations should become more specific with mandated templates to be used to speed up the delay in contracts. Case Z stated that the importance of commercialisation needs to be elevated to incentivise and harness the full potential of the university, with an over emphasis on teaching presently. All cases stated the TTOs were understaffed and under financed, with resource constraints stated as a considerable limitation on what they could achieve.

Overall key finding: More dedicated resources at TTOs and templates used in UIC contracts and agreements to be less ambiguous and open for discussion to reduce time delays are two recommendations on how to improve UIC process from the cases. In addition, to increase the strategic importance of commercialisation at the university level and for commercialisation to be included as criteria used for promotional opportunities are additional recommendations on how UIC can be improved upon.

7.28 Conclusion

This chapter presented the findings from the main study. Eight themes have been identified as important when exploring the antecedents and challenges relating to the AE within academic entrepreneurship. Each case was discussed under the eight themes where summary tables for each them/case was outlined. Then, a cross case table was presented where the researcher highlights the similarities and differences across the cases. Within the summary tables reference is made to which RQ and objective it is addressing. The next chapter will discuss the findings in relation to the aim and research questions of the study.

Chapter Eight.

Discussion.

8.0 Discussion

This chapter discusses the findings in light of existing literature and theory and draws out the contributions of the thesis. To remind the reader, the objectives and research questions are presented first in section 8.1. Next, each research question is revisited in sections 8.2-8.6 and the key findings are discussed in light of existing literature and theory. Section 8.7 presents and discusses a revised conceptual model based on the empirical findings reflecting the inductive theory building process. Section 8.8 presents the key theoretical contributions of this thesis and identifies the implications of the findings for policy and practice. Finally, section 8.9 presents the limitations of the study and avenues for future research.

8.1 Aims and objectives

The overall aim of this research was to explore the micro level antecedents and challenges influencing university-industry open innovation collaboration.

The objectives of the study are:

Obj1 - To explore the micro level antecedents and challenges that influence academic engagement in university – industry open innovation collaboration.

Obj2 - To explore how the academic entrepreneur's highly tacit scientific knowledge is translated to market related knowledge and innovation outputs during UICs.

Obj3 - To develop an understanding of the capabilities of the academic entrepreneur and their influence within the UIC process.

Obj4- To make recommendations on how to enhance value creation and value capture during university – industry open innovation engagement.

The research questions underpinning the objectives are:

RQ 1- What are the micro level drivers and barriers which influences academic entrepreneurs' decision to engage in commercialisation activities?

RQ2 -How do academic entrepreneurs develop the capabilities to convert PACAP to RACAP?

RQ3 What approaches are taken for the AE to develop market ACAP?

RQ4 -What are the capabilities needed for the AE to develop DCAP?

RQ5 – What factors moderate the effectiveness of knowledge transfer between the AE and external stakeholders?

8.2 Research questions

The five research questions are now discussed in turn where for each research question, the key findings from this study will be presented and discussed through comparing and contrasting the findings to existing literature. At the end of each section, overall summary points and a proposition statement are made consistent with the propositional development approach suggested by Gioia et al. (2013).

8.2.1 RQ1 - What are the micro level motivators and barriers which influences the decision on whether the academic entrepreneur decides to engage with commercialisation activities?

From the findings, a number of micro level motivators and barriers were identified which were similar across all cases. These were presented in section 7.3 -7.4.3, 7.12 -7.13.3 and 7.20 - 7.21.3 and are summarised again below in table 8.1.

Table 8.1 Summary of motivators and barriers from the findings

Motivators.	Desire to problem solve. Intellectual curiosity. Improve patient outcomes. Route to funding sources. To conduct blue sky research. Social responsibility and moral obligation to derive impact from projects.
Challenges.	Finding the entrepreneurial talent to accompany the AE within the USO. Meeting industry expectations. Seeking funding. Understanding the end user's needs.

8.2.1.1 Motivators

Firstly, the motivations in relation to RQ1 will be discussed followed by the barriers. In addressing motivations, this research found that some AEs felt 'forced' into engaging with commercialisation. This was mainly due to the funding bodies mandating an emphasis on applied and translational research where the AE needed to work with external stakeholders to achieve their goals. Some AEs stated their preference would ideally be to work lower down on the Technology Readiness Levels (TRL) scale. D'este et al. (2012) suggests that academic entrepreneurship is a discretionary act. The findings identified that some AEs felt the pressure and need to engage with commercialisation to fund their work, their research labs and staffing of students. This could be considered to go against the idea of academic entrepreneurship being optional or conducted on a voluntary basis as identified by D'este et al. (2012). Balven et al. (2018) found the primary motive for AEs to engage with entrepreneurship was down to intrinsic rewards such as satisfaction. Davey et al. (2020) found the discretionary nature of academic entrepreneurship depends on the level of supports and the AE's perception of the institutional environment as important factors when assessing the motivators and barriers facing the AE. This research concurs with Balven et al. (2018) that intrinsic rewards such as intellectual curiosity, scientific passion and a desire to improve patient outcomes, were the dominant motivators for AEs.

In this research, the AEs had the overarching goal to problem solve, however their motivations transformed and evolved as they moved through the commercialisation process. This finding is consistent with Galati et al. (2020) who found that AE's motivations change over time, with the financial motive decreasing over time and other motivators such as a transition to social values becoming more dominant. However, this research further extends Galati et al's (2020) contribution by providing a more nuanced analysis of how the AE's motives evolve over time. This research found that within the early stages of the process, the AEs were interacting with clinical leads and clinical data. Their motive was strong on problem solving at this stage and to devise ideas that meets the end user's need. As the AE progresses and a working prototype is developed and the innovation is something they want to move forward and protect, their motivation changed onto developing a commercialisation pathway i.e. how will this be funded? What is the customer feedback? How best do I protect my innovation? How do I seek the external information that I need and from who? These are all questions that the AE faced as shown from the findings as the idea moves towards that of a tangible product. As the USO evolved further, the AE was motivated more on generating revenues, gaining a market presence, and demonstrating that the product works effectively i.e. competing in the marketplace.

For an SME like a USO, the AEs found it a challenge to compete with large organisations who have more resources and benefits such as economies of scale. Therefore, SMEs can opt to differentiate themselves through product innovation e.g. offering something new to the market. Hence, a key challenge for AEs in developing their USOs was understanding how to develop inexpensive, robust, new product development processes; which was consistent to research by Hossinger et al. (2020) who stated that high costs, lengthy developmental times, high risk and uncertainty are challenges for USOs. This research extends Hossinger et al's (2020) contribution by finding that through the AEs differentiating their product based on novel innovation and targeting unmet needs they are able to reduce some of the challenges of a start-up company competing with established competitors. Rahim et al. (2015) found the ability of the AE to leverage their technical skills in scaling up production processes with good quality control were important for the growth of the USO. This study's findings found that many AEs were using the skillset of the team around them to develop the knowledge around running a business or through trial and error learning. After company formation (near launching the product), the AEs referred to adding to their advisory team as the company grew with marketing and sales specialists. Therefore, the motivation and behaviours become more specific and defined as the AE moved through the commercialisation stages. This transition moved from wanting to problem solve to how they can derive impact and get the innovation to the marketplace. Galati et al. (2020) also found the motives of the AEs were affected by time and experience (where the AEs recognised, they did not have the required market knowledge to progress their USO). This research further extends Galati et al (2020) work by finding that AEs identified the need to hire external professionals (sales, marketing, legal expertise) through experiential learning where they learned by doing it wrong initially. The cited examples are the marketing and positioning of products.

In summary, the AE has the overarching goal to problem solve and improve patient outcomes in all cases. However, as they engage with the process, their motivations become more transformational, like a funnelling system where as they get closer to market the motivation becomes more defined and specific. The AEs drilled down into the detail of the USO and the offering the closer they got to market.

8.2.1.2 Challenges

In relation to RQ1, Table (8.1) summarises the challenges facing AEs as they engage in the commercialisation process from this study. Meeting industry expectations and understanding end user needs are connected. If the industry partner is the end user, the AE has the challenge of both understanding their needs and meeting their expectations. Each challenge will now be discussed. USOs typically start with high levels of human capital in scientific and technical knowledge and low levels of market knowledge with strong academic networks and smaller business orientated networks (Mathisen and Rasmussen, 2019). Seeking funding for example was a challenge for all AEs in the study. This research found that some AEs in this study (first time spinning out experience) were very dependent on the TTO to provide the networking access to potential investors. Other AEs who had developed their informal networks were reaching out to investors early on in the process to gauge feedback; they were also seeking advice on whether their innovation is potentially investable in X over a specific timescale. This research concurs with the findings from Mathisen and Rasmussen, (2019) who found the network of the AE towards venture capitalists was related to the success of the venture. Furthermore Vanacker et al. (2014) found AEs with limited networks often limit their search for potential investors to their close proximate surroundings citing lack of experience, institutional norms and bounded rationality as reasons.

The findings from this research, build on the contributions by Mathisen and Rasmussen, (2019) and Vanacker et al. (2014). In this study, the AEs assessed which private investment pathway to follow where they would interact with as many investors as possible. The AEs were aware of the expectations of private investors noting venture capitalists were more interested in the overall company composition with experienced management teams and low risk profiles of USOs. In comparison, the AEs noted angel investors were more interested in the human capital of the individual AE and their abilities. Some AEs learned through interaction with investors that due to the early stage of their USO, the angel investor was the correct route to follow as venture capitalists require a more finalised team and product offering. As identified by Nikiforou et al. (2018) large teams often signal quality and are therefore more appealing to investors. A key challenge faced by the AE and TTOs in this study was that of finding the executive talent to accompany them in their USO. Visintin and Pittino, (2014) found that the skill sets and composition of the founding team of a USO is a critical success factor in the long-term performance of these ventures. In overcoming this challenge, all TTOs implemented strategies to socialise the AE with potential CEOs early on in the process. The funding agency also provided access to potential CEOs for the AE and their team. Nikiforou et al. (2018) argue that at the early stages of a USO, the team is homogenous in nature and is dependent on the personal network ties of the founder. In this study, TTMs are highly aware of the challenge of finding talent and have developed databases of potential executives that may assist the AE. Therefore, the AE can avail of their personal network to attract talent but can also use the support of the TTO and funding agency to recruit the talent.

Another challenge faced by AEs was understanding the end user's needs. From this research, interaction with clinicians, nurses other healthcare workers and patient groups were all critically important sources of end user knowledge, which the AE can leverage to progress their innovation. Bazan, (2019) identified the skill of being able to define a market need as a key skill that AEs need in order to get their scientific innovations to the marketplace. In this study, such market need was in the main, identified by working with the clinician. This research found when the AE gained a clinical perspective, they develop a more holistic view of the problem and how it can be solved. The AEs were also using patient groups to gain critical feedback in tandem with clinical input and noting any discrepancies in feedback on the innovation and the disease state or clinical problem. These findings demonstrate the AEs are externally validating what the unmet need is and how the problem can be solved from multiple sources. This is in contrast to Thomas et al. (2020 p10) where no external validation of the end user need occurred, the AE was described as being 'gifted' at connecting technologies to true medical needs. In this research, all AEs recognised they cannot be sitting in their university lab coming up with ideas on their own, they require a multidisciplinary approach to understanding the end user's needs. The findings identified that the AEs were developing the skills of moving the innovation from idea to market through an iterative bidirectional flow of knowledge between clinical and academic partners in order to satisfy the unmet need. If the AE is working on a non- health problem, the study found the AEs used the knowledge of the industry partner to help contextualise the problem and its relevancy from a market focused perspective. However, AEs stated challenges with UICs exist relating to finding out the strategic interests of companies and delays from dealing with headquarters of MNCs in different jurisdictions and industrialists shortcutting processes. These findings provide a more fine grained analysis of UIC challenges from the AE perspective as extant literature has been at a high (macro) level of analysis citing trust and institutional differences as challenges; thus extending the work of De Wit de Vries et al., (2019) Steinmo and Rasmussen (2018), Bruneel et al. (2010).

Overall through RQ1, this research builds on the recent calls in the literature for more research aimed at the micro level of analysis within academic entrepreneurship (Cunningham and Menter, 2020; Gonzalez et al. 2020). For example, Cunningham and O'Reilly (2018 p552) identify the need for '*further micro level studies to examine more of the antecedent factors that shape individual perspectives and behavior prior to engaging with the technology transfer process'*. The research builds on Gonzalez et al.'s (2020) call for future research to investigate the potential relationship between the context in which scientists operate and their motivations. Furthermore, the research addresses Joan and Coates (2020 p736) conclusion that '*micro level academic entrepreneurship provides a good theme to further research case studies looking at the micro level of UIC's. It is important to compare commonalities in both barriers faced and methods to overcome them'* Consequently, this research contributes new insights into these gaps in the literature relating to RQ1. In summary, the challenges facing AEs are finding the executive talent to accompany them in the USO, seeking funding, understanding end user needs and managing industry expectations. As a result of the findings, a proposition has been developed relating to RQ1.

P1 – The development of intrinsic motivators grounded in contextual settings help address key challenges and positively enhance the success of the AE within academic entrepreneurship at a micro level of analysis.

8.3 RQ2 – How do academic entrepreneurs develop the capabilities to convert PACAP to RACAP?

This RQ addresses the question of how do AEs translate their highly tacit, idiosyncratic and technical knowledge into a more end user and market orientated focus. Whilst AEs often have an abundance of scientific knowledge, many lack the skills and capabilities to apply this in a market context and to sufficiently acquire and assimilate market knowledge (Rahim et al. 2015). To date, research has identified a number of key factors in converting an individual's ACAP which included network diversity, prior knowledge diversity and a bisociative cognitive style (Lowik et al. 2017), perspective taking (Distel, 2019), relational capital (Kale et al. 2000) exploitative learning processes (Cegarra et al. 2016) and knowledge sharing (Ebers and Maurer, 2014) (See section 3.6 for further elaboration on concepts).

Within UICs, Kobarg et al. (2018) found the gap between industry and university partners has reduced in terms of technical abilities, and the ACAP of industry has enhanced and are now better able to understand and assimilate technical knowledge coming from universities. Miller et al. (2016) found a number of factors (human centric, organisational, knowledge characteristics, power relationships and network characteristics) mediated the effectiveness of ACAP within university technology transfer. Their findings also identified moving from a triple helix to quadruple helix formation and including the end user was an important factor for the university in the conversion of ACAP. To build on these findings, this research provides a more fine grained micro level analysis of how AEs develop their ACAP. This is important due to Sjodin et al. (2019) stating further research within the ACAP literature needs to be focused at the individual level. In addition, within UICs under the open innovation philosophy predominately the literature has focused on the industry partner, not the university, therefore the study addresses this limitation (Striukova and Rayna, 2015; West et al. 2014). This research also builds on the importance of the end user in UICs, by analysing the information gained by end users and how it is used by AEs to develop their learning and processes. In particular, this research adds to the literature on how an AE translates their ACAP in a university context where the focus is on solving clinical unmet needs. The four components of ACAP are discussed in the next section.

8.3.1 Acquisition

Acquisition refers to the ability of the individual to identify and acquire externally generated knowledge (Zahra and George, 2002). The findings show that in the main, AEs seek the acquisition of external knowledge in order to solve a predefined problem. That problem can be of a health, environmental, societal or industrial nature. However, due to the nature of the type of AEs in this study, in the main it was a health problem which triggered search processes on the identification of the unmet need. The AEs achieved this through interaction with clinicians primarily; however, there is evidence of nurses, patients, and other health care workers providing valuable information. At this stage, the AEs learns the relevancy of the problem from a clinical viewpoint. Bazan, (2019) found translational research (the ability to turn basic scientific research into practical applications) requires a multidisciplinary approach where the AE is working with a range of stakeholders to develop their skills and knowledge. This research builds on the finding from Bazan, (2019) and found that the AE gains a better understanding of the problem from clinical input.

8.3.2 Assimilation

Assimilation refers to the comprehension and interpretation of external knowledge (Zahra and George, 2002). This current research found that the AE develops their scientific knowledge through working with colleagues at the university and utilising the skillsets and knowledge of their research team. Also, the AEs were keen to read around the latest academic literature and attended academic conferences to keep their scientific knowledge as up to date as possible. The stage at which the AE's own research group (post docs, Ph.D. students) helped most was at the prototype stage. This stage involved multiple iterations as the AE sought feedback from the clinician on the design and improvements that could be made. The clinician provides the information on what will and won't work in a clinical setting and why. Here the AE's design thinking was changed based on the feedback. The clinician was providing valuable information at the assimilation stage as well as acquisition. If the AE is not working on a health based product then the industry partner provides this feedback. Sousa-Ginel et al. (2021) found that AEs gaining the knowledge at prototype stage on optimal design is a challenge given that AEs do not typically employ individuals who are specialists in production activities or are immersed in a productive context. The findings of this study builds on the finding of Sousa-Ginel et al. (2021) by finding that external knowledge and assistance is needed at prototyping to match the technical ability of the AE and the market need.

It was found in this research that AEs reached out to angel investors at prototype stage to see if this is something, they would be willing to invest in currently or in the future. At this phase, the AE was trying to develop their understanding of the expectations of investors and what is needed in order to get funded. They were not only developing their technical knowledge but also their commercial and clinical knowledge at this stage. Baldassarre et al. (2020) found that the prototype stage can attract investment and convince external stakeholders to become part of the team and commit to introducing the innovation to the market. In further exploring this issue, this study's findings found that at prototype, the AE was building the skill of developing a commercialisation pathway for the project by reaching out to investors. It was also found that the assimilation of knowledge is not just from a technical viewpoint, the clinical and commercial knowledge of the AE are being developed. This is in contrast to Maine et al. (2104 p17) who found that technology market matching predominately occurred after USO inception where the work at the academic labs were focused on '*major technological advances, not radical innovations*'. It was only after USO formation, that the AEs with the CEO's guidance decided on the market application for its innovation. This research therefore highlights the market matching capabilities and skills the AEs were developing were prior to USO formation in contrast to Maine et al. (2014).

8.3.3 Transformation

During transformation processes, new knowledge is combined with existing knowledge to generate new ideas (Zahran and George, 2002). Here an AE integrates knowledge from a number of sources where a diverse network configuration is a key contributor (Lowik et al. 2017). The findings of this research, state that often when the AE was combining new knowledge with existing knowledge, they used their informal network of individuals they trust and have developed relationships with. Distel (2019) argues that perspective taking is a key antecedent in the translation of PACAP into RACAP and that by considering the perspectives of others it often stimulates people in the production of new ideas, where they are able to combine, build on, and experiment with different viewpoints. The interdisciplinary nature of translational research requires the AE to work with a range of individuals and groups in order to translate their tacit knowledge into a market orientation (Bazan, 2019). This research agrees with Distel, (2019) and Bazan, (2019) that a multidisciplinary approach is required at this stage and moreover that the AEs are taking the perspectives of key stakeholders (see table 7.5, 7.15 and 7.23) on the sources of knowledge for AEs. However, this research also extends Distel (2019) and Bazan (2019) findings to show that during transformation, the AEs tried to validate the feedback they had received from external sources. For example, from the market research, if the AE had the required experience and knowledge, they cross checked the feedback to ensure its relevancy. If the AE receives feedback from a clinician, there was evidence of the AE validating this with other experts in the field to reduce as much bias from the process as possible. The findings from this research also show that recognising patterns in past projects and applying them to new projects is a key way that the AE transforms their knowledge base. Zeng et al. (2019) found the ability of subsidiaries to recognise patterns in behaviour was a key antecedent in converting PACAP to RACAP. This research concurs with Zeng et al. (2019) and extends the finding to the individual level of analysis.

8.3.4 Exploitation

For this research, exploitation refers to how the external knowledge acquired, assimilated and transformed is ultimately used in the work routines of the AE, i.e. to internalise the external knowledge (Lowik et al. 2017). The findings found that mainly the AEs used prior work experience and/or on the job learning in their role. Many AEs in this study have come back to academia after industry work experience. This was a considerable trend in the study and the participants recognised this as a key skillset which differentiates themselves from other peers that do not have this experience. In this study, prior experience allowed the AE to develop the skills of pattern recognition, of understanding what industry are looking out for in projects, what data regulators will require and how market research should be used to progress the innovation. These were all learnings the AE developed through direct past experience. Cegarra–Navarro and Wensley (2009) found that past experience allows individuals to build up an ability to recognise patterns and appropriate responses. AEs in this study, have recognised that not focusing on one activity at a time, being naïve about the market and assuming what the customer wants, are all examples of learning directly from past experience.

When it came to spin out formation however, this was primarily achieved through experiential learning techniques. As even though many AEs had prior industry experience, few had spun out a company before. Sikimic et al. (2016, p656) found the process of '*doing, learning and doing some more'* allowed the creation, retention, retrieval and use of essential knowledge that enabled individuals to enhance their abilities in activities such as out licensing to be achieved in improved ways. This research builds on this finding in terms of USO formation, where the AEs reported that they went through a process of trial and error learning, often doing tasks wrong the first time around on the job and then learning from that experience. In some instances, the AEs recognised that external expertise was needed where they didn't have the knowledge to conduct the task, the marketing and positioning of products were cited examples of outsourced work.

Within the innovation ecosystem, universities have the potential to play a dominant role acting as an '*anchor organisation'* with open innovation ecosystems (Hayter, 2016 p5). Striukova and Rayna (2015) found entrepreneurial universities are becoming central actors within OI ecosystems and should position themselves as hubs through which collaboration can happen. However, the open innovation paradigm has been criticised as an abstract concept and being aspirational in focus (Jonsson et al. 2015). This study's findings identified that, in order for universities to achieve the potential of becoming central actors within the ecosystem and driving innovation forward, the university must have the underlying ACAP and DCAP capabilities in place. This finding concurs with Patton (2014) who found incubator facilities and the supports offered (mentoring, support agents and directors at incubators) converted the ACAP of AEs within UICs. This study's findings build on the contribution by Patton (2014) by identifying that the AE converts their PACAP into RACAP through interaction with a number of individuals/ groups who hold different domains of knowledge (the sources of knowledge for the AE are found in tables 7.5, 7.15, and 7.23), learning from past experience as well as trial and error experiential learning. Conversion of ACAP also comes from validating feedback from key stakeholders and using informal networks where AEs have developed trust and relational capital. Finally, when AEs recognise patterns with old and new information this was found to help translate PACAP into RACAP.

As a result, of these findings in relation to RQ2 a proposition has been developed.

P2 – AE's can effectively develop RACAP through multiple learning-based interactions in successive projects in an accumulated manner over time at a micro level.

8.4 RQ3 What approaches are taken for the AE to develop market ACAP?

To date, research on ACAP has over relied on using R&D or scientific and technological knowledge as the primary way in which ACAP has been examined (Scaringella et al. 2017; Lichenthaler, 2016). This over reliance or bias towards scientific knowledge has overlooked other important knowledge capacities in how individuals exploit technological innovations (Lichenthaler, 2016). A few key exceptions to this are from Murovec and Prodan (2009) who identified two streams of ACAP needed for improved innovation output as demand pull and science push and Lichenthaler (2016) who argued that both technological and market knowledge sets are needed to enhance innovation output. In addition, Neves and Franco (2018) found the academics in their study lacked the capabilities to align research with market needs, in addition, their research found the AEs struggled with finding the industry partner to assist them. Prior research has also identified, that AEs lack market knowledge and the ability to acquire, assimilate and ultimately use it (Jones and Coates, 2020; Woolley, 2017; Rahim et al. 2015). Scaringella et al. (2017) found customer involvement (end user involvement, feedback and satisfaction) was a key antecedent in converting PACAP into RACAP for technology spin off firms. Finally, Jones and Coates (2020) found bringing in external knowledge experts into the university was a key way to educate AEs on market knowledge and processes. This study's findings build on these prior contributions by finding that market ACAP is developed from training programs, diverse network configurations, using the knowledge and experience of the founding team, CEO and advisory board. Moreover, it also comes from reducing bias from the process, offering consultancy or due diligence work to industry and learning from others who hold different domains of knowledge. These points will now be discussed further.

The findings from this study found that AEs are trained using internal mechanisms from one day events such as pitching days or demo days right through to accelerator programs where the AEs learned skills regarding how to commercialise their research. All three cases supplemented this training with external training conducted off site where the AEs can avail of specialist training (pre commercialisation programs where the AEs validated their ideas with potential customers, structured the concept to get investment and learned how to pitch to investors). The TTOs (all cases) recognised that external centres had critical mass in certain areas that they could not replicate. In this study, the AEs commented on the internal training being at a too theoretical level with not enough practical advice given. This finding concurs with the finding by Jones and Coates (2020) where external experts provided real world examples and practical advice on starting a company. The AEs in this research, stated this was lacking at the training in all three cases and they sought this knowledge out from informal networks. In addition, many of the AEs in the study were at mid to late stages in their careers and recognised the importance of mentoring and wanted to see the mentoring model of training pursued further within the universities training efforts. In contrast, Kornelsen (2019) found the role of external mentors as a key enabler in USO formation and guidance in the process. This study set in Germany, found experienced internal academics prioritised research and teaching over commercialisation and mentoring. This finding implies universities and departments need to support and encourage more mentoring among academic peers and to stimulate relational learning to occur where more nascent AEs can learn from their more experienced counterparts.

One external training program which some of the AEs availed of followed a methodology where before they built anything, they had to conduct valuable customer discovery field work (100 interviews from potential customers). This validated assumptions about their business models. Duval-Couetil et al. (2020) found the AEs in their study who went on the same program developed three sets of competencies in terms of their learning 1) customer discovery skills 2) a change in mindset and 3) market-driven vs. technology-driven approaches to their work. This finding builds on the finding from Duval-Couetil et al. (2020) and found that a change in behaviour occurred from the training with AEs being more critical of projects, also a change in mindset of not assuming what AEs think the customer will want but to actually ask them and used the feedback to revise their thinking and behaviours. This methodology can help the AE develop their market ACAP as they are not assuming the customer need but are validating the assumption by learning what the customers actual needs are. Another approach through which the AEs developed market knowledge was through diverse network configurations. Hayter, (2016) argued that due to network homophily, AEs often lack the knowledge and skills needed to commercialise their research. This research found AE's informal networks were co-existing with the formal network. Based on the type of knowledge sought, the AE made a decision on who to go to for guidance; which is primarily based on the stage of development the AE is at with the venture. Gubbins et al. (2020) has called for further work on how social supports within academic entrepreneurship help the AE. In particular they refer to the need for research regarding how support is offered (mode of delivery) and the type of support sought. Furthermore, Mathisen and Rasmussen, (2019 p29) identified a key gap in the research stating '*because USOs typically rely on many different actors in their development, research that shed light on the relationship between USO teams and their support networks or ecosystem, would be of high practical relevance'.*

This research makes a contribution to addressing these gaps by finding that the AE seeks market knowledge from trusted sources where long standing relationships have been built.
From this study's findings, the advisory board provided the AE with the support on market trends and movements. The CEO brought a strong business acumen and focus on growing the business, with the co–founder(s) having a different set of skills and knowledge complementary to the AEs in the study. There is one AE from Case Z who is the CEO of their company, therefore an AE can be a CEO however the participant stated this was not their preferred choice, they had no other option as they could not find the talent. From this study co – founders can be other academics and/or come from industry positions into the USO. The USO advisory team provide the oversight in how to reach further funding rounds within the spin off. They comprised of individuals in senior management industry roles who provide the AE with the knowledge on current market trends or opportunities.

Nikiforou et al. (2018), Knockaert et al. (2011) and Columbo and Piva (2008), found that academic founders have a tendency to team up with other academics sharing similar experiences and mindsets, this homogeneous composition however restricts the access to market knowledge and access to networks. Most AEs in this study, noted the knowledge, skillsets and abilities of the other founding members (from different domains of knowledge) and the CEO were a strategic asset used in progressing their USO and a source of market knowledge. Sciarelli et al. (2020) found that a heterogenous composition of founding team members was an important determinant in the success of USOs. This research extends Sciarelli et al. (2020) contribution by empirically showing how different individuals help the AE during the spin out process. This is further discussed in the next section.

From this study's findings, often the AEs were looking for advice on how to de-risk their innovation from informal networks. Cited examples were angel networks, ex -colleagues and peers. Many AEs had built up strong relationships with investors, colleagues and peers which they reached out to for advice and support when needed. This finding is important as Gubbins et al. (2020) has called on further analysis on how support structures and social supports contribute to the AE developing their entrepreneurial knowledge. The results show the close built up relationships with social networks play a critical role in how AEs develop their market knowledge. Fini et al. (2018) found the pathway of informal interactions by the AE with industry is one channel in which AEs can bring their innovations to the marketplace. In this study, It was found that many AEs seek out market knowledge as early on in the commercialisation process as possible in order to change their thinking and behaviours and incorporate the feedback into their design. From the findings, this practical hands on information was lacking at the home institutions where the learning is very much theory driven therefore the AEs have to use knowledge sources outside the university. It was found that the AEs were seeking knowledge that is free from as much bias as possible, they achieve this by externally validating feedback from stakeholders. For example, if a clinician provides guidance on X or Y therapy, the AE validates the feedback with other clinicians to ensure it's as valid as possible. Another source of valuable information came from distributors of medical devices where the AE noticed the opinion was honest and direct and a very useful source of market feedback. Distributors of medical devices are interacting with hospitals and clinicians regularly where it was found the AE can gain a non-biased opinion on the effectiveness of devices. Hayter (2016) found non -academic individuals (investors, advisors) helped the AE develop their market orientated mindset and knowledge. This research builds on that finding by analysing the type of knowledge sought and how the AE used this knowledge gained from informal networks. In addition, it addresses the gap highlighted by Gubbins et al. (2020) on the type of knowledge sought from support networks.

In summary, in relation to RQ3, market ACAP is developed from training programs, diverse network configurations, using the knowledge and experience of the founding team, CEO and advisory board. Moreover, it also comes from reducing bias from the process, offering consultancy or due diligence work to industry and learning from others who hold different domains of knowledge. As a result of the findings relating to RQ3 a proposition has been developed. P3 – The effective development of structured training coupled with formal and informal networking with market facing stakeholders can enable the AE to increase the effectiveness of market ACAP at micro levels.

8.5 RQ4 – What are the capabilities needed for the AE to develop DCAP?

Desorptive capacity (DCAP) refers to how AEs identify what knowledge resources have economic value and how they transfer that knowledge to realise value (Lichenthaler and Lichenthaler, 2010). There is very little research to date which explores desorptive capacity (Behnam et al. 2018). Therefore, this research contributes to new insights into its importance and development within a university context. Table 8.2 outlines the capabilities the AE used in developing their DCAP from this research.

Table 8.2 DCAP capabilities of the AE.

Capabilities	Description
Environmental scanning.	Knowing the competitive and IP landscapes, to assess the potential of exploiting an innovation. Using broad patent strategies.
Market Assessment.	Being able to assess market potential by cross checking market feedback from the market research process. Also knowing how to use market research to further the innovation.
Pattern recognition.	Being able to learn from past projects and build the accumulation of knowledge, so it can be reapplied to new projects.
Ability to switch mindsets.	Ability to switch thinking from a purely scientific mindset to one which includes the end user. Ability for design thinking to change to incorporate the end user into the process. Ability to identify the unmet need. Ability to switch behaviours between exploration and exploitation i.e. ambidextrous behaviours.
Relational capital.	Ability to build strong personal relationships with key stakeholders, where the AE builds trust and mutual respect. Ability to listen to external stakeholders and not assume their needs.
Being able to pitch concepts to non- scientific audiences.	Being able to convince others from a different background that the innovation has potential from a commercial perspective.
Exploitative learning.	Ability to learn from the actions of others and to recognise the pitfalls from other people's experiences. Ability to learn quickly and respond accordingly. Ability to have foresight and build a commercialisation pathway for the innovation.

Table 8.2 based on the findings outlines how the AE develops their DCAP from this research. These concepts will now be discussed. First, the AEs develop their DCAP by recognising patterns from past projects and reapplying that knowledge into new projects of a similar nature. This accumulation of knowledge is a central way in which the AE can exploit innovations. Fuller et al. (2018) and Baron (2006) have identified that opportunity recognition often results from being able to connect the dots and identify patterns. This research agrees with this finding and extends it through showing that the AEs used the recognition of patterns in the exploitation of innovations as opposed to only that of opportunity recognition.

Second, all AEs in this research recognised identifying the unmet need as a key capability needed to exploit their innovation. Identifying market opportunities is the first stage of developing DCAP (Behnam et al. 2018, Lichenthaler and Lichenthaler, 2009). The AEs worked with clinicians primarily in guiding this process. This identification happened early on in the innovation process (idea generation and prototype stage). In contrast, Thomas et al. (2020) found that the star scientist in their study was able to formulate research projects targeting unmet needs without external validation. Woolf et al. (2008) found the interaction between clinical medicine and basic science brought about new innovations that can be brought to market. This research agrees that clinical interaction is of vital importance for AEs in the identification of the unmet need and how to solve it, but also extends the Woolf et al. (2008) contribution, by finding a more multidisciplinary approach is needed for an AE to develop their DCAP and improve patient outcomes. More specifically, the study found that the process of turning embryonic scientific innovations into market propositions requires clinical, academic and business expertise. In summary, the research concurs with Bazan (2019) that translational research is best served with a multidisciplinary approach, but also extends the contribution by showing how each stakeholder supports the AE as they develop their DCAP. (See table 8.3).

Third, in this research the TTO oversaw the patent pathway and ensured the direction the AE wanted to take the technology was protected. The broad patenting strategies pursued by TTMs allowed the AE some freedom in the direction they wanted to take the innovation and also have patent protection. Thomas et al. (2020) found claiming and protecting the innovation as a key competency the AE developed in their study. This research agrees with this finding; however, it's important to note the role of the TTO in providing oversight in this process also. Fourth, some AEs in this study mentioned the importance of developing platform technologies in order to exploit their innovations. A platform technology is devised for multiple uses and reduces the risk of having no end customer. This finding is similar to Thomas et al. (2020) where their research found using platform technologies reduced the risk of having no end user for the product.

Fifth, the findings show that AEs are not only thinking from a purely technical or scientific viewpoint, they are aware of meeting end user requirements and also the social responsibility of being publicly funded AEs. The AEs in this study were in constant flux between their ability to explore and exploit knowledge. The process was iterative, recursive and bidirectional in focus as the AE refined their innovation based on feedback and knowledge from key stakeholders. Within the processes, many tasks within IP landscaping, patent protection, and market feedback assessments required the AE to switch between exploring further into their innovation or innovation strategy to fully exploit or protect it. In order to help the AEs achieve this, a shift in mindset was found to occur. The second stage of DCAP development is in the ability to refine process, ways of thinking and behaviours in order to meet market demand and satisfy the unmet need (Behnam et al. 2018, Lichenthaler and Lichenthaler, 2009). In this study, the AEs accumulated knowledge through repetition of tasks and developed competencies in the processes involved. In addition, they developed the ability to not thinking or behaving from a technical standpoint only but recognised and assimilated market knowledge into their cognitive abilities and behaviours. Mom et al. (2009) argue that individuals achieve optimal innovation output by balancing exploration and exploitation activities through ambidexterity. (See section 3.11).

Schnellbacher et al. (2019) found individuals cannot simultaneously explore and exploit at the same time; rather they achieve ambidexterity through switching between the two opposing sets of behaviours. Baglieri and Lorenzoni (2014) found AEs who can adopt the roles of '*scientist*' and '*end user'* were more capable of accomplishing technology transfer tasks. Carl, (2020) found AEs have a more inclusive approach to entrepreneurship than only that of economic benefit or pure technological innovation. AEs now include social innovation as part of their thinking and design strategy to new innovations. This research agrees with Carl, (2020) and extends the contribution. From this research, in order for the AE to develop their DCAP, this required the AE to shift mindsets and incorporate end user needs and feedback into their design methodologies. The AEs learn to not just think from a purely technical viewpoint, this happens during the sense making processes the AE undergoes as they engage with external stakeholders.

Many AEs stated their project management skills were developed on the job. Here the AE through planning and foreseeing eventualities, developed the skill of thinking through permutations of how X is going to affect Y in their spin out activities. Calof et al. (2018) found that the ability of foresight was a key antecedent in successful open innovation ecosystems. This research adds to that finding at a micro level by finding that AEs are using anticipatory thinking, developing risk mitigation strategies and predicting when things will go wrong as skills in developing their project management abilities.

Matt and Schaffer (2016) found that relationships within UICs by AEs were developed over time and built on trust. Furthermore, Striukova and Rayna (2015) argued UICs are developed through contacts rather than only that of contracts, highlighting the importance of personal relationships. This research builds on these findings, where the AEs developed their DCAP by building strong personal relationships with key stakeholders. Strong personal relationships came from both their formal and informal networks. Examples used were relationships with distributors of medical devices, investors, market research consultants, the industry partner, TTO staff, ex-colleagues and co-founders of their spin out. They used these networks to validate assumptions, identify unmet needs, gain real world feedback and tacit knowledge. Many AEs noted the importance of building personal relationships, where many stated they would reach out to contacts to gauge feedback or opinion regularly.

Many AEs noted the informal network facilitated the introduction to other key opinion leaders which helped the AE to further develop their DCAP. Exploitative learning (please refer to section 3.10.2) for some AEs in this research included the shadowing of clinical leads and watching and observing spin off companies being built, where some AEs sat in on advisory board meetings and learned through others a greater understanding of the processes involved in academic entrepreneurship. Myers, (2018) found individuals learn vicariously in a more relational way based on the idiosyncrasies of the relationship and in a co-constructed way through co-active vicarious learning as identified in section (3.10.6). This type of learning involves mentoring, shadowing and seeking out tacit knowledge from past experiences (Myers, 2018; Zucker et al. 2001). This research finds as part of their learning processes, the AEs were learning in a co-active way, through the recursive, iterative and sense making processes they go through as they engage in the commercialisation of their research.

To complement table 8.2, table 8.3 outlines the skills and knowledge the AE developed from key stakeholders in the commercialisation process, and the stage of development where this knowledge or skill was gained. This table is a summary of the processes the AE underwent in this research. It adds to the processual view of academic entrepreneurship literature. This literature stream has called for further research due to the lack of research in the area (Skute, 2019; Garcia- Teran and Skoglund (2019). The table highlights contributions from the findings in this regard by showing the multidisciplinary approach to academic entrepreneurship with insights from academic, business and clinical expertise.

Table 8.3 How the AE develops their DCAP.

Stage	**Stakeholder participation**	**Skills/ knowledge gained by AE.**
Idea generation	Clinician/ patient groups.	Where the unmet need is. Clinical data provided. Patient samples. Thinking from an end user perspective.
Prototype	AEs own research team Post docs, Ph.D. students Working with the clinician until design freeze stage (concept is locked in).	Iterations based on user feedback. Design thinking not purely from a technical standpoint. Include feedback from idea generation stage.
Disclosure	Working with a TTM or business development team initially at a research centre in order to file the IDF complete patent landscaping tasks and work with a patent agent to file for patent protection.	During disclosure the AE assesses the potential of the innovation by conducting landscaping tasks on IP and competitors to ensure there is a valid opportunity to exploit. Patent database skills. Drilling down into the innovation to derive the non obvious and unique characteristics of the innovation.
Seeking funding	AEs work with a commercialisation specialist at the funding agency also try to seek private funding as early on as possible.	Gain the viewpoint of private investors. Ability to think like an investor and pitch concept to non-scientific audiences.
Market Research	Market research consultant, TTO staff and funding agency specialist.	Can decide to pivot the offering based on market research or continue on the same trajectory.
Initial Company formation	TTO help with company formation and the AE engages with a lawyer to set up the company. (spin out of university) Establishment of an advisory board. First round funding typically secured at this stage.	Gain knowledge and perspectives from other domain experts e.g. business, clinical, legal expertise (founding members/ advisory team). Ability to understand the technical, commercial and clinical data required to reach second funding round i.e. move to human trials. Advisory board providing oversight.
Company progression	CEO and founding members bring a wealth of experience and contacts that help attract funding and progress the company to grow.	Interaction with investors. Advisory team (USO) to help with trends and market movements Peer network on pragmatic advice. Clinical trials – clinical and regulatory support needed. Once human trials are completed can commence trading downsize R&D and increase sales and marketing efforts.

Overall, the findings identified that many of the AEs found the help the TTO provided in the patent pathway and IP protection strategies as helpful. However, they noted after initial company formation they were less reliant on the TTO. The findings show that the more experienced AEs, who had developed their angel investor, distributor, peer and industry partner contacts, used these networks more as the commercialisation process continued beyond invention disclosure. Padilla-Meléndez et al. (2020) found that AEs needed to take a proactive role in self -selecting between their formal and informal networks. In their research AEs encountered structural barriers at the university and used their informal network, in gaining the connectivity to the correct individuals to help progress their innovation. This research enriches Padilla-Meléndez et al. (2020) work, that in order for an AE to develop their DCAP their networking capabilities and access to different networks must transform within the different stages of commercialisation. The interaction with clinical expertise at the beginning, involving patients also is critical at the start of the process. In conjunction with the clinical expertise, the AE seeks feedback from investors at prototype stage to build the skill on developing the commercialisation pathway.

From the findings, strong networks with local hospitals are key contributors to the idea generation and prototyping stages of development. As identified in this section, The TTO played a critical role in the IP strategies and patenting protection. As the company is formed the AE extends their network to include business expertise as well as developing their peer networks. As identified in section 8.4, the AE used the advisory board of the spin out to provide guidance on market trends and movements.

Nikiforou et al. (2018) found bringing surrogate entrepreneurs (entrepreneurs from outside the home academic institution) into the USO enhanced the venture’s performance. In this study, as the USO gets closer to market, the AEs added resources to sales and marketing (appointing board members with this expertise) and reduced regulatory and clinical support after clinical trials. Therefore, the AEs networks transform as they move through the process. It is with this transformation and connectivity with key individuals at different stages the AE receives the support and learning in order to exploit their innovation i.e. develop their DCAP.

These findings make a contribution as they help answer recent calls for further research. For example, Carl (2020) called on further studies on how AEs can be supported in their role as transformational agents within entrepreneurial ecosystems. They further identify the need to understand how AEs contribute to social innovation should be determined empirically. Furthermore, Hayter et al. (2016) stated further work was needed on how AEs develop their skills and knowledge to reduce knowledge asymmetries within UICs; which is addressed in the current research.

In summary, DCAP is in its research infancy (Dell'Anno and Giudice, 2015; Meinlschmidt et al. 2016). This research has extended the desorptive capacity literature in a university context, by analysing how AEs identify market opportunities and then refine their processes to transfer that knowledge and realise value beyond the boundaries of the university (Meinlschmidt et al. 2016; Lichenthaler and Lichenthaler). Furthermore, this research also extends the DCAP literature by developing a table on the critical stage of development within academic entrepreneurship and the knowledge and skills gained by the AE as they move through the process. Although, prior research has identified, the 'critical junctures' within academic entrepreneurship, little research has explored these junctures in depth (Skute, 2019; Vohora et al. 2004). This research adds to this gap in the literature at a micro level of analysis. As a result of the findings in relation to RQ4 a proposition has been developed.

P4 –The ability of the AE and their networks to develop key desorptive capabilities (as detailed in Tables 8.2 and 8.3) can enable them to further transform their DCAP effectiveness.

8.6 RQ5 - What factors moderate the effectiveness of knowledge transfer between the AE and external stakeholders?

Contextual factors include both the moderating variables at the departmental and institutional levels at the university, and the wider national and international environments; which have an influence on the work of an AE (Davey et al. 2016; Kenny and Goe, 2004). This research concentrated on the university level environment and funding level environment as contextual factors. Table 8.4 summarises the university and funding level moderators from this research and also the impact they have on the AE and whether they should be maximised or minimised due to their effect.

It was found that AEs are actively responding to the environment around them. AEs felt a moral obligation and social responsibility when they engaged with academic entrepreneurship. This stems from the strong desire to improve patient outcomes and improve the health of the public. Moreover, the AEs felt that by taking state funding, they had a duty to achieve results and derive impact from their work. There were a number of moderators however that affected the AE in their pursuit to derive impact which will now be discussed. First, most AEs stated the universities did not fully recognise the amount of work and effort that goes into this type of work and it was a disincentive for them. Second, most AEs had grievances with the low (or none at all) level of importance that commercialisation had when it came to promotional opportunities at the university. Third, the AEs in this study (and the business development manager at the research centre) expressed frustration when it came to the delay in time it takes to get IP contracts and agreements drawn up and legally binding.

Fourth, this research found that the AEs have to convince TTOs that their innovation is worthy of patenting and must show a commercialisation pathway. This research found that, AEs derived less satisfaction from paper publications than spin off activity, but some AEs noted co -publications with industry had some benefits. These were of higher research impact, signalling of status and reputation in the area and future projects coming about from co-authorship. Fifth, in this research, the main reason AEs stated the reason why they done a lot of the work themselves was due to resource shortages at TTOs. The perceived resource shortages at the TTOs left most AEs with a 'jack of all trades' mentality, where they felt if they wanted to spin out a company it was going to be up to them to achieve this, especially at the start of the process. Bazan (2019), found that AEs success is often measured in terms of how much research funding they bring in, the number and quality of publications and how many students they supervise. Therefore, the incentive and promotional structures at universities were considered to not encourage AEs to engage with the commercialisation of their research. Barbieri et al. (2018) found that when AEs become founders of a USO, the amount of publications they write decreases. The AEs in their study found keeping up with traditional norms facing them which emphasises recognition and reputation status almost exclusively through the publication of research results was a challenge for founders of USOs. This research builds on these findings where some AEs in this study explicitly stated they were not following the traditional norms and metrics of the traditional academic system; which emphasised publication output. Their choice of impact was through translational research where they derive most satisfaction and benefit. Padilla-Meléndez et al. (2020) found that the high levels of bureaucracy within universities was a barrier in the efforts of the AE. This research also concurs with this finding, where it was found that some AEs just wanted to get on with the work and the collaboration and expressed frustration on lengthy wait times.

AEs in this study (all cases) recommended that more external experts and a mentoring model of training was to be encouraged within their universities. They critiqued the training at the university as being too theoretical with not enough practical advice on how to start a business or work with industry. This concurs with research by Guerrero and Urbano (2012) who found that factors such as role models and attitudes had a far higher influence on whether AEs engaged in entrepreneurship than formal factors such as education and training. This research finds that training, which is focussed on customer discovery and developing the skills to meet end user needs, was seen as beneficial to the AE. However, the majority of AEs identified the need for more practice driven examples and effective mentoring. There appears to be an overemphasis on providing the theory of entrepreneurship rather than the practical aspects.
From this study's findings, the implications here are that AEs will seek knowledge and advice outside of the university system and use contacts built up through industry collaboration more frequently to access pragmatic advice. Furthermore, Hayter, (2016) identified that nascent entrepreneurs typically lack industry contacts and market knowledge. From this study, the implication here is that less experienced AEs may fall into the pitfalls of what can go wrong when spinning out a company without the proper guidance and mentoring from individuals who have been through the process before.

Finally, high costs, lengthy developmental times, high risk and uncertainty, homogenous team compositions and the shortage of commercial knowledge have been identified as some challenges with USOs from prior research (Hossinger et al. 2020; Nikiforou et al. 2018; Columbo and Piva, 2008). This research adds to these challenges by finding that some AEs identified that the TTO wouldn't have the appropriate formal industry contacts in some circumstances and they had to use their informal networks for that connectivity. Some AEs, (Case Z) found the university to have a strong emphasis on knowledge around basic science but when it came to translational research, the university didn't have the skills to meet the challenges that translational research presents. Again, the AEs used their informal network to overcome any shortcomings in the university's knowledge base.

In summary, findings relating to this RQ adds contributions to the theory. For example, Roberson et al. (2019) has called for further research to examine what effect do contextual factors have on the AEs entrepreneurship endeavours. Furthermore, Hayter et al. (2018) proposed that future research should take a holistic ecosystem perspective looking at how the different actors and systems involved interact with each other. This research adds to these gaps by recognising that at the funding level, some AEs felt forced to engage with commercialisation to access funding. The AEs also felt the social responsibility of being publicly funded to derive impact from their projects. At the university level environment, the findings identified that long wait times in projects, lack of recognition for promotion, not following traditional norms and metrics, and perceived resource shortages and a feeling of 'having to do it all themselves' were key moderators which affected the ability of the AE to develop their skills and knowledge around commercialisation. As a result of the findings in in relation to RQ5, the following proposition has been developed.

P5: A number of key contextual moderators (as identified in Table 8.4 for the current study) should be identified and effectively managed by the AE at a micro level of analysis to increase the effectiveness of knowledge transfer between the AE and external stakeholders.

Table 8.4 University and funding level moderators

University Level Moderators	Effect on the AE. (Positively/Negatively).
Convincing TTOs that the innovation is worthy of patenting and must show a commercialisation pathway.	Has a negative effect on the AE. Should be minimised. AEs commented on convincing TTOs that the innovation had commercial potential as a considerate challenge.
Commercialisation not aligned with Promotional opportunities.	Has a negative effect on the AE. Should be minimised. AEs felt disincentivised and discouraged by the university system when it does not reflect the commercialisation of an AE's research as a criteria for promotional opportunities.
Bureaucracy – time delays with contracts and agreements to become legally binding.	Has a negative effect on the AE. Should be minimised. AEs expressed frustration at the lengthy times before a project can start.
Perceived resource shortages at the TTOs.	Has a negative effect on the AE. Should be minimised. AEs developed a 'do it all myself' mentality from the perceived lack of supports.
Mentoring model of training.	Has a positive effect on the AE. Should be maximised. AEs learned from each other and how to avoid common mistakes from one another. The recommendation is universities need to encourage communication among peers.
Knowledge from TTO on what funders are looking out for, the review of funding applications.	Has a positive effect on the AE. Should be maximised. AEs found the review from the TTO on funding applications as rewarding.
TTO can provide contacts that an AE may be missing especially at the early stage of career.	Has a positive effect on the AE. Should be maximised. In some cases, the AE gained a contact from the TTO which was very beneficial to the progress of their innovation.

Table 8.4 University and funding level moderators (continued).

Funding Level Moderators	**Effect on the AE. (Positively/Negatively).**
Moral obligation and social responsibility by being a publicly funded AE.	Has a positive effect on the AE. Should be maximised. AEs felt motivated and passionate about deriving impact from their research. Solving a medical unmet need, has the potential to bring a large impact to society.
Feeling of no choice.	Has a negative effect on the AE. Should be minimised. AEs needed to feel some freedom and choice in the work they do.

8.7 Revised conceptual model

The revised conceptual model is presented in figure 8.1. It builds on the original conceptual model by incorporating the implications of the empirical evidence of this study. The rationale for the changes are discussed and linked to prior research themes, RQs and objectives to further build theory, consistent with the approach adopted by Corley and Gioia (2004) and Eisenhardt (1989).

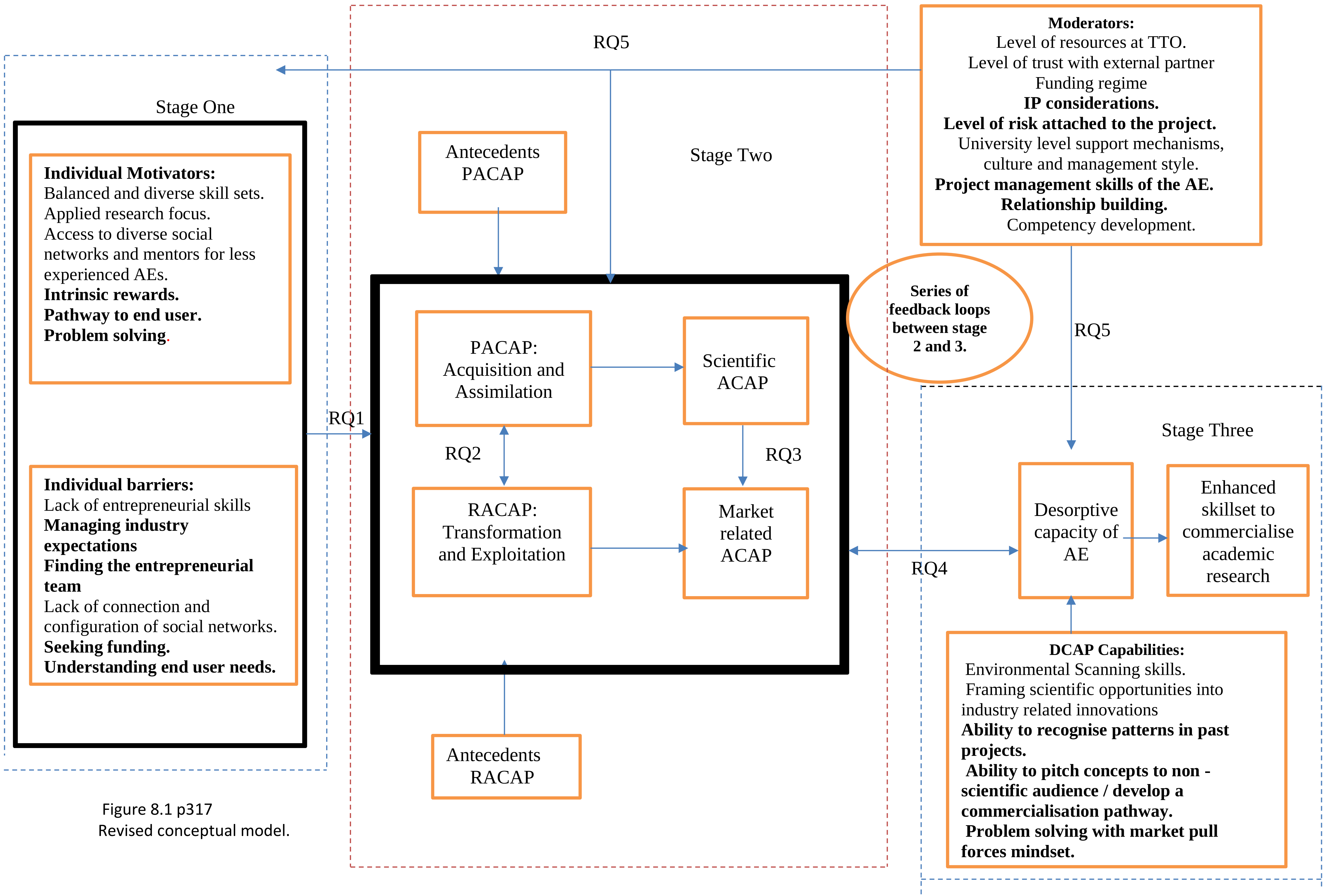

Figure 8.1 p317
Revised conceptual model.

8.7.1 Stage one of the revised conceptual model

Like the initial model, the revised conceptual model includes the individual motivators and individual challenges facing the AE as they engage with the commercialisation process. It refers to answering RQ1 and Objective 1.

The findings identified that intrinsic rewards, pathway to end user and problem solving as individual motivators for the AE. These are highlighted in bold on the revised model (Figure 8.1) to denote changes from the initial model. Ambidexterity has been taken out as a motivator as the findings showed the AEs were exploring and exploiting in many of the tasks they do. Therefore, ambidexterity has been included as an underlying mechanism between the ACAP and DCAP constructs. In building on prior literature (Hayter, 2016; Rahim et al., 2015; Baglieri and Lorenzoni, 2014) and the initial conceptual model, the findings identified that diverse skill sets, applied research focus and access to networks and mentors for nascent entrepreneurs were motivators for the AEs in this study. All participating AEs noted the diverse range of skills needed to be successful (see DCAP capabilities table 8.2 for a summary on these). In the individual barriers section, (highlighted in bold denoting different from the initial model) managing industry expectations, understanding end user needs, finding the team to accompany the AE and seeking funding have all been added as individual barriers due to the findings revealing their importance (see sections 7.3.1 -7.3.3, 7.13.1 -7.13.3, 7.21.1 -7.21.3). Conflicting role identity has been taken out as there was no evidence of this. All AEs saw using their commercialisation experience as complementary to their teaching role, where they would often bring in examples of how to go about commercialising an innovation. Furthermore, the findings did not illustrate ‘not sold here’ bias; however, the TTMs did mention that AEs can be reluctant to give over their companies to new business partners. To counteract this, all of the TTMs reported that they have strategies in place for this and recognise this as a potential problem. Therefore, they proactively facilitated and fostered early stage introductions and relationship building exercises.

8.7.2 Stage two of the revised conceptual model

Stage two of the revised conceptual model analyses the ACAP construct. It referred to answering RQ2 and RQ3 and objectives 2 and 3. The findings reflected an iterative, bidirectional flow of knowledge between the AE and external stakeholders at this stage of the model. The research found that the AEs were strongly responding to the environment around them and that they were actively engaged in trying to solve problems facing industry, the environment and society. Davey et al. (2016) found that AEs respond closely to the external environment around them. This environmental interaction and awareness activated search processes for external knowledge to help the AE generate ideas and problem solve. For health problems, the main interaction at this stage was the clinician who directly interacts with patients daily and has the knowledge of their needs. It was evident from the findings that although on the job learning is clearly present, the AEs in the study also learned by past experience from industry and UIC projects where they were recognising patterns in behaviours and thinking. There was also evidence of vicarious learning through shadowing clinical leads or other company behaviours.

8.7.3 Stage three of the revised conceptual model

Stage three of the revised conceptual model analyses the DCAP construct. It aimed to answer RQ4 and objectives 2 and 3. Ability to pitch ideas to non-scientific audiences, skills to develop a commercialisation pathway, problem solving with market pull forces mindset and recognise patterns in past projects have been included within the DCAP capabilities to reflect the findings from this study. These are highlighted in bold again to denote differences from the initial model. Environmental scanning and framing scientific opportunities into industry related opportunities remain from the initial model. Maintaining market intelligence has been removed from the revised model as this emerged as part of environmental scanning and landscaping work the AEs conduct. Strategic fit – ability to choose the industry partner has also been taken out. The findings show that relationship building and developing trust were more important considerations to both the AEs and industry partner, than the AE choosing which partner to work with. A detailed analysis on the DCAP capabilities of the AE can be found in section 8.5.

8.7.4 Moderators in the revised conceptual model

The revised moderators of the conceptual model include IP considerations, level of risk attached to the innovation, the project management skills of the AE and relationship building; these are highlighted in bold within the revised model. This section of the model aimed to address RQ 5 and objective 4 of this study. There are two arrows coming from the moderators section of the model. This is to represent that the moderators affect all three stages of the model. From the findings, the delivery and expectations around meeting timelines were important considerations that industry voiced when working with AEs and this was noted as a challenge for industry when working with academic partners. All AEs stated project management was primarily learned on the job where they developed a proactive approach to their work and meeting timelines. The IP considerations were also an area of contention for industry within this study. They stated the onerous and problematic nature around IP ownership within UICs was a deterrent for them to engage with IP intensive projects with academic partners. Also, the level of risk attached to the project, has been added to the revised model as the industry partners stated projects that are not sufficiently de-risked enough is a reason why industry would not engage with a UIC. Finally, relationship management and any previous rapport industry counterparts have built up with the AE was an important factor that industry partners took into consideration as they decided to engage (or not) with the UIC project. Level of trust, the university culture, resources at TTO, funding regime and competency development remain as there is evidence of all these acting as moderators within the findings.

8.7.5 Series of feedback loops

Within the revised conceptual model, a series of feedback loops have been introduced based on the findings. From the findings, the AEs stated that it was only after completing X course or talking to Y person within the commercialisation process, that they learned a greater understanding of the problem and solutions that would solve the problem. Their previously held assumptions and/or beliefs of how to problem solve were therefore challenged as they engaged with the processes. Thus, double loop learning challenges previously held assumptions as it often focuses on the root cause of problems (Henderson et al. 2013). As part of double loop learning, feedback loops were induced. Feedback loops refer to problem solving until an appropriate outcome has been reached (Horvat et al. 2019) where a cycle of learning occurs i.e. the output of knowledge becomes the input for the next iteration (Liu et al. 2020). In the conceptual model, the AE accumulates their knowledge base. They use their knowledge on how to exploit their innovations from past projects and apply this into their subsequent ones. Therefore, the output of knowledge becomes in part, the input for the next related project. As a result of this finding, a two-way arrow has been introduced between stage two and three of the revised model. This represents the recursive, bi-directional and iterative relationship between ACAP and DCAP. Both knowledge capacities have a reciprocal influence on each other. In order for the AE to build their DCAP, they must first have developed their ACAP. As the DCAP of the AE is developed, this accumulated knowledge is then used to enhance their

ACAP in future projects. Included in the theoretical contributions from the conceptual model are that feedback loops have only been identified in ACAP (Horvat et al. 2019). This model extends the learning cycle to include the DCAP of the individual. This model found that both ACAP and DCAP are reliant on each other, and that a cycle of double loop learning occurs. The model also finds that the accumulation of knowledge is dependent on the ability of the AE to develop their DCAP. The learning and absorption of market related knowledge must first be developed before the AE can develop their DCAP. Primarily, this is done through experience and learning the processes that are involved in academic entrepreneurship.

8.8 Conclusions and Contribution

The overall aim of this study was to explore the micro level antecedents and challenges influencing university-industry open innovation collaboration. In concluding remarks, this research highlighted the pivotal role of AEs within the entrepreneurial ecosystem. Their central role highlighted their importance and the need for these individuals to be supported fully by universities and government agencies for innovation to prosper from the bottom up. The practical recommendations from this research, provide the basis for policy reform and change on some of the key areas within the UIC ecosystem. As universities push forward with their mandate of translational research and an impact agenda on developing regional economic development (Etzkowitz, 2017; Cunningham et al. 2018) the recommendations from this research set out practical solutions to the problems identified by the participants in this study. The university and funding level moderators identified in table (8.4) highlight the institutional challenges within academic entrepreneurship and their impact on AEs as they engaged with the process.

The results identified a more targeted approach is needed within the internal training efforts at universities, with an emphasis needed on practical advice and learning from peers who have been through the process before. Also, high levels of bureaucracy at the university level, and frustrations on the length of time before a project can start and the perceived lack of resource shortages at TTOs are some of the reasons why the AEs in this research, had a 'jack of all trades' mentality where they noted if they were going to spin out a company, it was going to be up to them to achieve that goal. Other areas of concern, are the lack of promotional opportunities aligned with commercialisation activities and a perceived organisational inertia within one case (Case X) that struggled to promote an inclusive, transparent and open culture towards commercialisation. In summary, a roots up approach of developing the supports, skills and knowledge of budding AEs within universities will reduce any perceived conflicts of interest among AEs and promote the need for this type of model of innovation. Some universities risk being left behind if they do not embrace their emerging role in the knowledge economy. The theoretical contributions and implications for policy and practice are discussed next.

8.8.1 Theoretical contribution

The bodies of literature this research contributes to are university industry collaboration, absorptive capacity, desorptive capacity, knowledge management capacities, spin out formations, learning behaviours and academic entrepreneurship; with a focus on the micro level of analysis.

8.8.1.1 University industry collaboration (UIC) body of literature

This research provided a more fine grained analysis of UIC. Prior research has predominately taken a macro or top level approach when examining the phenomenon citing trust and institutional differences as challenges (De Wit de Vries et al. 2019; Steinmo and Rasmussen 2018; Bruneel et al. 2010). The findings identified challenges from the AEs perspective within UICs existed relating to finding out the strategic interests of companies, delays from dealing with headquarters of MNCs in different jurisdictions and industrialists shortcutting processes. From the industry perspective poor project management skills from AEs, technology not being sufficiently de-risked, the onerous and problematic nature around IP ownership and the rapport built up with the AE were all factors considered when they decided to engage in a UIC. The antecedents towards UIC participation identified by AEs were in the main, strong scientific passion, intellectual curiosity and a desire to make a ‘real world’ difference with their research. The contribution from these findings provide a micro level analysis of antecedents and challenges within UIC which addressed the gaps identified by Joan and Coates (2020), and Cunningham and O’Reilly (2018) as mentioned in section 8.2.3.

8.8.1.2 Absorptive capacity body of literature

This research adds to the micro level of analysis within the ACAP literature which has been called upon for further insights by Sjodin et al. (2019). In addition, the research added to the

ACAP literature in developing our understanding of market ACAP. As noted in the discussion on RQ3 section 8.4, few papers have identified a different source of knowledge (other than technological knowledge) that is needed to develop ACAP in individuals Scaringella et al. 2017; Lichenthaler, 2016). This research supports the concept that both scientific and market knowledge are needed for optimal research output. The research found training programs, diverse network configurations, using the knowledge and experience of the founding team, CEO and advisory board, reducing bias from the process, offering consultancy or due diligence work to industry and learning from others with different domains of expertise all developed the market ACAP of the AE. The research also identified AEs converted their ACAP through interaction with a number of individuals/ groups who hold different domains of knowledge, learning from past experience as well as trial and error experiential learning. In addition, validating feedback from key stakeholders and using their informal networks where they have developed trust and relational capital. Finally, when AEs recognise patterns with old and new information this was found to help translate PACAP into RACAP. These findings build on the work of Miller et al. (2016) who highlighted the importance of the end user in UICs, by identifying the type of knowledge gained by AEs from end users and how this knowledge is used within the commercialisation process.

8.8.1.3 Desorptive capacity literature

This study extends our knowledge on the DCAP construct; which has received little academic attention to date (Dell'Anno and Giudice, 2015; Meinlschmidt et al. 2016 Lichthenhaler, 2010). By this research adopting a dual lens approach, the research illustrated how the AE firstly learns the processes and knowledge needed to be successful at academic entrepreneurship and then how they exploit that knowledge. This research extends the literature on DCAP by developing a table (8.2) on the DCAP capabilities of the AE. These capabilities provided valuable insights into the skills needed in order for an AE to develop their DCAP. In addition, this research added to DCAP literature by providing an analysis on the key stages of development within academic entrepreneurship and the skills and knowledge gained by the AE and stakeholder participation at each key stage (see table 8.3).

8.8.1.4 Knowledge management capacities literature

From the conceptual model (Figure 8.1) the findings have shown a close interrelationship between ACAP and DCAP through a recursive, bi-directional and iterative relationship.

Both knowledge capacities have a reciprocal influence on each other. This finding extends the knowledge management literature within a UIC context. The conceptual model also identified double loop learning where a series of feedback loops occurred between ACAP and DCAP, previously only feedback loops within ACAP have been identified (Horvat et al. 2019). This finding extends the learning cycle to include DCAP within the processes. In summary, the findings illustrate that whilst academics often have scientific absorptive capacity, they can often lack market absorptive capacity. The research also illustrates that academic desorptive capacity is dependent upon market absorptive capacity.

8.8.1.5 University Spin out (USO) literature

The findings from the research add to the gaps highlighted by Gubbins et al. (2020) who called on has called for further on how social supports within USO help the AE and Mathisen and Rasmussen, (2019 p29) who stated '*because USOs typically rely on many different actors in their development, research that shed light on the relationship between USO teams and their support networks or ecosystem, would be of high practical relevance'.* From this study's findings, the advisory board provided the AE with the support on market trends and movements. The CEO brought a strong business acumen and focus on growing the business, with the co–founder(s) having a different set of skills and knowledge complementary to the AEs in the study. As the USO gets closer to market, the AEs added resources to sales and marketing (appointing board members with this expertise) and reduced regulatory and clinical support after clinical trials. Therefore, the AEs networks transform as they move through the process. It is with this transformation and connectivity with key individuals at different stages the AE receives the support and learning in order to progress their innovation and venture.

8.8.1.6 Learning behaviours literature

This research adds to the limited literature on the learning behaviours of AEs (O'Kane, 2015; Rasmussen et al., 2011). Prior research argued that AEs learn on the job primarily Cunningham et al. (2016) and O' Kane et al. (2017). This research whilst finding that there is clear evidence of on the job learning especially within spin out activities and project and regulatory management, AEs are also learning from past experiences. For example, returning back to academia after industry work experience or using the knowledge from past project success or failures and through vicarious ways such as shadowing behaviours, monitoring the behaviours of competitors and testing competitor products. Also, a key underlying mechanism in the conceptual model is how AEs switch between explorative and exploitative learning. This happened through ambidextrous behaviours where key tasks required the AE to further explore the innovation in order to fully exploit it. This research contributes to the individual ambidexterity literature which has received little scholarly attention (Mon et al. 2019). In summary, the development of learning behaviours and the skills underlying it are more multifaceted than just on the job learning.

8.8.1.7 Academic entrepreneurship literature

Gonzalez et al. (2020) suggested that future research should investigate the potential relationship between the context in which scientists operate and their motivations. This research adds to the motivation theory within academic entrepreneurship. The findings show that even though the AEs have the overarching motive to problem solve and improve patient outcomes, their motivations transform and evolve as they move through the stages of development when spinning out a company. This research also adds to the theory on the role of intermediaries within academic entrepreneurship. Case Z comprised of all engineers and who are all affiliated with research centres. They found that being part of the research centre offered additional funding opportunities, decision making was made at local levels first and the AE noting less dependence on the TTO. The business development manager noted the proactive stance the research centres take on solving industry problems rather than a more reactionary posture taken by TTOs. The AEs also noted the soft supports they received in terms of the business development team facilitating introductions with industry and developing their networks, were very beneficial. Hayter et al. (2018) proposed future research should take a holistic ecosystem perspective looking at how the different actors and systems involved interact with each other. By analysing the role of the TTO and research centres within academic entrepreneurship, this research extend the knowledge in this literature stream. This research also contributes to the entrepreneurial competencies literature for academic entrepreneurship. Hayter (2016) noted a gap in the literature on how skills and competencies are developed for AEs and how knowledge asymmetries can be reduced. This research adds to this gap, by finding there was no evidence of any role conflict or conflict of interests between the AEs academic role and entrepreneurial role. They were viewed both as inherently complementary. Skills developed by AEs in this study are described in RQ4 (section 8.5) within this chapter and are further outlined in table 8.2 on how the AE develops their DCAP.

The study finally, contributes to the advancement of knowledge on how contextual factors impact on the AE at a micro level. This contributes to the research gap on the influence of contextual factors in academic entrepreneurship highlighted by Robertson et al. (2019). Firstly, the AE is impacted by the social responsibility they feel and moral obligation when receiving funding to ensure their research has translational impact which will benefit patients or society. This is aligned with the concept of AEs moving away from pure technological innovation to include social innovation in their work (Carl, 2020). In this study, the AE develops a hierarchy of market needs and learned from clinical interaction which need is most important and why.

It is this most critically important need that they target first. The AE – clinician relationship in this study is a critical component to progress the idea generation and prototyping stages within academic entrepreneurship. The TTO provides a range of supports to the AE and are particularly strong with IP and patent strategies for protecting the AE's innovation. However, the AEs noted after initial company formation, the reliance and support of the TTO was not as clearly evident within the commercialisation process. Also, from the AEs perspective the resource shortages and bottlenecks within the process are points to note on where AEs stated that improvements could be made. The funding agency specialists and market research consultant advise on whether an AE should pivot their offering or not based on market research. The funding agency also can help attract follow up funding if needed within the commercialisation fund and help bring in potential investors and management team members when needed. However, the government led commercialisation fund is a 24-month programme, the AE needs to develop an exit strategy and how to secure additional funding and talent (if not already recruited) early on in the process. A key contribution is the conclusion that an integrated multidisciplinary approach is used within academic entrepreneurship where the contextual factors (TTO involvement, funding agency) help with the de -risking of the innovation.

8.8.2 Implications for policy and practice

This research has implications for TTOs, funding agency bodies, state run research centres, government policymakers influencing UIC and university managers. TTMs have called on mandated templates to be used when working on contracts and agreements with industry. The TTMs argued that the current templates are only suggested for use and are ambiguous and open for negotiation. If the templates were prescribed as per the national IP policy document (2019) this would reduce the time around the negotiation of contracts with industry. Next, the AEs noted the training at universities was pitched at too high a theoretical level and not enough practical advice given. The recommendation for university mangers and policy makers is that universities should include more external experts and industry counterparts as training designers and as guest speakers and that the mentoring model of training is incorporated more into the training programs at universities. The AEs also noted that forcing AEs to engage in academic entrepreneurship is the wrong approach. The recommendation for policy makers is to allow appropriate funding opportunities for basic research to continue and not to deplete it further. Therefore, the recommendation is for a more inclusive strategy when funding STEM research.

On the job learning, being a 'jack of all trades' and 'having to do all the work yourself' was a common theme AEs mentioned when spinning out their companies. In order to support AEs fully and develop their skills and competencies, policy makers and university managers should revise their approach to how the supports at the university are utilised. The recommendations is for dedicated resources on practical advice and mentoring early on in the process. If Ph.D. students express an interest in entrepreneurship, they should be offered support at this early stage. These nascent entrepreneurs won't have had the time to build strong networks around them and will rely on the university to support them at the early stage of their career. In order to incentivise AEs, the recommendation for policy makers and university managers is to formally announce that commercialisation activities are a part of the criteria taken into account in promotional rounds. If the university wants to promote its third mission mandate it must align this with incentives and rewards for the AE. Currently at the time of writing, the university system does not fully recognise the amount of work and effort that goes into commercialisation of academic research.

Next, the KPIs at research centres have doubled in recent years but staffing has remained the same. Policy makers investing more into the state research centres will help them meet the growing demands of the business. Also, the policy recommendation is that independence for research centres should be considered. At the moment these centres are linked with lead academic partners. However, from the research centre point of view this has reduced efficiencies and slowed down the process with bottlenecks along the way when dealing with the university infrastructure on how contracts are drawn up and implemented.

From the industry perspective, the right to IP ownership is quite onerous and problematic for industry partners. They cite this as a disincentive to engage in IP intensive projects. The recommendation for policy makers is to look at strategies that encourage the industry partner to want to engage with universities. Also, a recommendation for universities managers and policy makers is for a well- developed communications strategy on the benefits of what the university sector can offer to business is recommend. From the industry participants they questioned if most businesses in Ireland are aware of the capabilities available from the university sector. Finally, the Disruptive Technology Investment Fund (DTIF) has been praised by the SME participants in this study, as an influential and very successful mechanism in promoting UIC. The recommendation is that these companies can apply for more than one a year to promote UIC.

For implications on how to improve the DCAP of the AE, the recommendation would be for university managers and policymakers to look at more opportunities for AEs to work with industry. To allow a percentage of their work time to be dedicated to industry engagement as a way to network with industry counterparts is a recommendation. Both consultancy work and scientific due diligence work were examples provided of how the AE developed their networks and industry knowledge from this research. As AEs stated, their diaries fill up very quickly and they are under time pressures. Having a dedicated portion of time spent on industry engagement would allow the AE the time to develop their DCAP capabilities. Finally, as finding the executive talent in running a spin out has been found to be a key challenge in this study, the recommendation is that the funding agencies and TTO coordinate strategies and resources, to help socialise the potential CEO and AE as early on as possible in the process and that supports are provided on relationship management early on in the process.

8.9 Limitations and areas for future research

All research has limitations which will now be outlined, and areas of future research will be suggested. This research it is set in the Republic of Ireland and utilised qualitative methods, therefore without further research studies the findings cannot be generalised outside this region due to their unique funding and organisational structures within its innovation ecosystem. It is suggested that future research should explore this topic in other jurisdictions which will allow for any differences or commonalities to be explored. The study is not longitudinal, although repeat interviews and email exchanges were ongoing to ensure richness and to capture holistically the phenomena under study. It is suggested that a longitudinal study which explores how ACAP and DCAP are developed would enrich the insights gained from this study and allow us to understand how ACAP and DCAP are developed over time. This research is case study based. It would have been beneficial for the research to include longitudinal observational empirical research. Due to the pandemic, planned observational research was not possible. The final limitation is that all three case studies are research intensive universities. Future research should include the mix of entrepreneurial and research-intensive universities to analyse the phenomenon allowing for any differences or commonalities to be examined.

This research has unravelled many important factors, some of which demand future research. For example, this research highlighted the importance of the cognitive capabilities of the AE in driving their ability to translate their scientific thinking and mindset into a market orientated one. However, it was beyond the scope of this study to delve deeply into AEs cognitive structures and the factors which impact on it, future research should focus on the role of antecedents and determinants in the cognitive capabilities of the AE. Future research could extend the DCAP perspective from other stakeholders within the UIC ecosystem, in particular how TTMs and research centres develop their DCAP. As DCAP is in its research infancy, future research could extend our understanding on the theory, by examining the antecedents and determinants of DCAP in entrepreneurial ecosystems. Future research is needed on training initiatives at universities to develop the skills of nascent AEs, this research found the mentorship model as the main recommendation from participants. However future research could delve into the role of mentoring more specifically and further the literature. Another avenue for future research is on developing the five propositions into testable hypotheses to be evaluated quantitatively. Finally, future research could include AE personality dimensions to extend the contribution on the AE motivation.

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Appendices.

Appendix 1: Initial codes generated from the data analysis process.

The below are the codes generated from the data collection process which the researcher used as the starting point in the data analysis process as outlined in section 5.8.

Identify market opportunity, very clear market demand, identify the gap which has commercial interests, discontinuities in the process, keep it funded to a point where it is commercial, patented the technology, working prototype, TTO supported us in writing the patent, informed by end user, different perspective from industry, market application, what you can deliver, scale up the process, commercially appealing, gain the language skills in business, different mindset than scientists, timing issue, ability to react, different timelines, deliverables, the application of the technology, PIs can't write patents, interaction with patent attorneys, willingness and an open mind to commercialisation, mentoring - assist newer academics to get involved with industry. Funders don't get involved in a high risk area, de risk technology, personal effort, learning by experience, making mistakes, key contributors to commercialisation success. legal elements and regulatory requirements,. venture capital space, the market analysis, different terminologies, personal interest, company interest, unmet need, talking to clinicians. act fast and be responsive, TTO interaction. trust, repeat interactions, preliminary discussions. learning by doing, intrinsic motivation, in house - expertise to bring to prototype, post docs, building a team, external collaborators (academics) prototype stage. managing expectations, meeting deliverables, project management, time management, resource management, different paces, industry may not be interested in the next generation innovation – market saturation, translation from the lab to the bedside, is it going to make a difference? change in mindset, prior work experience, predict when things will not work, risk mitigation strategies, back up plans, not hiring the right people to do the job, very good business acumen, venture success, industry trying to shortcut the process, scientists are incremental in their advances, learned how to build a good rapport with people, technology showcase, came up to me after my presentation. thinking outside the box, thinking left field, independent thinking, reliance on oneself, start -up founder vs start- up advisor, provided guidance, scientific due diligence work, going out to conferences and meeting people, , no scientific paper will ever improve a patient outcome, a real desire to actually do something, funder doesn't want to fund research that is aligned with a specific company, finding good people to work with. feasibility grant ,market readiness, TRLs, business canvas model, lean canvas model, value proposition, unmet clinical needs, guidance of a clinician, cross checking, Serendipity – fortunate we work well together, listening to what people have to say, wide network of people. outward looking, don't have a typical academic mindset, being prepared to do things slightly different. being aware of the needs of others, driven by clinical needs, validate those clinical needs, a commercial opportunity, ideas are needs driven, fundamental curiosity driven, listen to the customers, market reports – high level, generic not niche enough. gateway for us, engage with other key opinion leaders, highly regulated environment, take a step back, clinical immersion, people's honest opinions, informal network, gut instinct about something. having sabbaticals, time structures, build up a database. Solving real problems, pace, continental drift, get it done type approach, negotiate a price and a contract for that IP, infringing IP, mentoring programs, market research -very niche market, distilled from the patient groups what we needed, customer scoping exercise, would people use this, funder – where is your data to prove what you are saying, as a university project and not an entity, no one really takes you seriously, you have to be a jack of all trades, product design is a very hands on discipline, business advisor - build the relationships, strategic interest to companies, collaborating with MNCs HQs, not in their remit, valley of death – funding gap, lack of prospects of promotion, helper attitude rather than a guardian attitude, working relationships are really key, you learn a lot yourself, personal differences, predefined problem. retraining, , filter that list, ranking in terms of impact, seeking investor opinion, iterative process, brainstorming solutions, filtering process, talk to the customer, market interest, research impact, patient impact, vehicle to get there is commercialisation. convince the TTO, market analysis, closer to acquisition, specific data required, advisory board, proper oversight, seeking domain experts , angel investor network, patient pathway, design thinking, shadowing patterns of behaviour, very critical of projects, on site visit from regulators, it kind of comes naturally to me to see if there is a commercial angle, got a post doc to work on a proof of concept, drafting the patent – skill as an academic you need advice on, GMP (Good Manufacturing Practice) , the IP landscape, working with a consortium, gap in the funding ecosystem, forced to work with commercialisation activities, Post doc, drivers, competitor analysis, funding agency, commercialisation specialists, taxpayers money, pivot into something similar, market research consultant, mentor, procurement rules, panel meetings, lab based demo, initial proof, commercial step change POC, commercialisation roadmap, IP pipeline, experimental data, conflict of interest, non- disclosure agreement, invention disclosure form, infrastructural initiatives, market opportunity assessment, viable market opportunity, we try and match them up accordingly, ask the right probing question, business partners programme, market validation, customer discovery, most credible feedback from the market, gap in terms of the commercial case, independent unbiased consultant, budget business consultancy support, economic impact in Ireland, commercial case, strong market validation, very strong team to undertake the project, it's not just purely technical proof of concepts, technology risk level of the project, credible market opportunity, we support animal studies, an idea versus lab scale demo, the lead commercial role, the technical side, European Commission funding under FP7 and H2020, co-author, spin out , licensing, collaborative research, publications, background IP, foreground IP, IP considerations before the project starts, two week meetings, disconnected from your partners, work packages, co -location, physically working together, regular communication, evidence based company, facilitate blue sky research, you miss the unknown unknowns, allow IP out into the commercial environment, fitted in with our portfolio, pre -clinical testing, patent had already been granted, reduced to practice, was workable, producible and robust, what is the researcher like to work with, proximity to the researcher, are they still working on that project, troubleshooting, where the technology sits in that landscape, what that landscape is doing, other competitors in the market, cutting edge, fast follower or me-too product, less IP intensive, members of a consortium, H2020 project, long project lists, help us to find talent, a lot of visibility, wider research areas, we want results a lot sooner, strategic partner, not as focused on what the actual unmet need, keep that inhouse, information you are sharing, worldwide scan, fund exclusively, the statement of work, long standing relationships, key challenges, deep dives, all the hard work is done upfront, tripping points, KPIs, tiered approach, product roadmap, patenting route, case manager, a hub and bespoke model, showcases, business planning, putting a convincing team together, PCT (Patent Cooperation Treaty), keep it secret, most of them want to work at much lower TRL levels, mediation role, intermediary role, middle man, trade shows, trade fairs, industry conferences, academic conferences, biggest stakeholder is the government, PIs will always go to the lowest hanging fruit of funding, the most important thing is the team, who is the CEO , who is in it for the short term? getting the executive talent to add to that team, to act as a filter early on, project planning tools, lack savvy with engagement with industry, series of bottlenecks, regular email that goes out, newsletters, commercialisation life cycle, encourage our researchers to engage with industry, TTSI's, patent centric, we don't really deal with ideas, incubators accelerator programs, bootcamp, external bodies to assist training, insular opinion, some academics would say we don't need your help, the commercial piece and the IP piece, list of consultants, is there freedom to operate? patent office, drill down into your technology, competing technologies, TRL Zero, facilitating the initial introduction, making sure expectations on both sides were aligned, negotiating with industry and agreements with industry, centre it has to be 2/3 years away for market, quick turnaround times, Patent budgets are limited, USP, benchmarking, patent search, search by classification, get the investors and the CEO engaged at an early stage, metrics, preplanning, enterprise manager, if you leave it too late the project will die, entrepreneurial mindset, cynicism at the value of publications, I don't think technologies translate themselves, personal relations, bandwidth, right place at the right time, everybody in a big company is busy, design iterations, its somebody else's knowledge and somebody else's interpretation, starts with the customer, getting over that mental obstacle, really front ended on basic research, how they perceive risk, regulators are there to assess risk, become less curiosity driven, research money, getting the open door, links with companies, I would go anywhere, you can go off in tangents, ex-colleague, prior student networks, it had to be done all by yourself.

Appendix 2: Participant information sheet.

The below text was provided to all participants before engaging with the researcher and the study sent via email.

Invitation

You are being invited to take part in research being conducted by Barry Gilsenan, who is a PhD researcher at Ulster University (UU). Before you decide whether to participate, please read the following information and do not hesitate to ask any questions about anything that is unclear to you.

Background

This research concerns how academic entrepreneurs (AEs) develop the skills and capabilities necessary to successful engage in entrepreneurship activities. Given the heightened expectation and need for universities to make an impact with their research and contribute to economic development and develop linkages with key external stakeholders. This research sets out to examine the effect this has had on the individual academic scientist/ engineer and the challenges and obstacles they face as they commercialise their research.

What is the purpose of the research?

The overall aim of this research is to explore the micro level factors influencing university-industry open innovation collaboration.

The objectives of the study are:

- To explore the micro level antecedents and challenges that influence academic engagement in university – industry open innovation collaboration.
- To explore how the academic entrepreneur's highly tacit scientific knowledge is translated to market related knowledge and innovation outputs during UICs.
- To develop an understanding of the capabilities of the academic entrepreneur and their influence within the UIC process.
- To make recommendations on how to enhance value creation and value capture during university – industry open innovation engagement.

Why have I been chosen?

Participants in this research will be primarily PIs or Co PIs from universities who have experience in working with industry (transfer of IP in the form of licence agreement) or who have experience in establishing a spin out company. TTO staff, funding bodies, and industry scientists will also be interviewed to gain a holistic view of university – industry technology transfer.

Do I have to take part?

Participation in this study is entirely voluntary.

If you decide to participate, you will be given this information sheet to keep and you will be asked to provide contact details and sign a consent form. You have the right to withdraw from the study at any time without giving a reason. You can do so by contacting any of the research team using the email addresses provided.

You will be asked if you agree to be contacted for follow-up questions in relation to the data discussed during the interview. This will be at the participants discretion and it will have no influence on your involvement in this research study

What do I have to do?

Upon agreeing to participate in this study, you will be asked to provide contact details prior to participation, and these details will be stored in accordance with Ulster University's GDPR policy (which can be found online here: https://www.ulster.ac.uk/about/governance/compliance/gdpr/gdpr-policy.

All participants will be asked to:

- **Give written consent to participate in this study**
- **Give verbal consent to be recorded**
- **Take part in one or more interview to identify how AEs develop the knowledge, skills and competencies needed to successfully engage in UICs.**
- **Participate in follow-up research (to be conducted in a manner of their choosing, to further discuss issues relating to the study)**

Data

All data will be anonymised and will be held at Ulster University, accessible only by the investigators and the data auditors.

The chief investigator will act as the data controller for this study and therefore will be responsible for looking after your information and using it properly. **To safeguard your rights, this study will collect the minimum personally identifiable information possible. You can find out more about how we use your information at:**
https://www.ulster.ac.uk/about/governance/compliance/gdpr/gdpr-policy

Your name and contact details (telephone number and address/email address) will be used to contact you about the research study. The only people who will have access to information that identifies you will be the research investigators, and auditors of the data collection process. Ulster University will keep identifiable information about you from this study for 10 years after the study has finished, for auditing purposes.

Risks and/or disadvantages of taking part?

There is minimal risk associated with taking part in this study. The participant is under no obligation to answer any question asked by the interviewer.

Are there any possible benefits in taking part?

On approval, the final report will be made available to government bodies to help guide and direct future policy changes with the aim to improve collaboration between university and industry. Also management at the university level, can benefit from any training and development shortfalls and implement any changes accordingly.

What happens when the study ends?

Participants may be contacted to consider participating in Phase 2 of the study. Follow up research may be conducted on issues identified during this research.

Will my taking part in this study be kept confidential?

All information collected for the study will be kept strictly confidential, in accordance with Ulster University guidelines and will be kept for a minimum of 10 years. The data will be archived securely in a restricted access room. All identifiable information collected from you will be stored in a locked filing cabinet. All computerised data will be coded so that you cannot be identified, and the data will be held on password protected and encrypted computers. Information will be safely destroyed once it is no longer required.

What will happen to the results of the research study?
The findings from this research will be used as the basis for the chief investigators PhD thesis. It is also intended that the findings from this study will be published in scientific journals and / or presented at conferences. You will **not** be identified in any report or publication.

Is there an independent contact that can give me advice?
Should you have any concerns about the ethical procedures surrounding the research or if you have any complaints please contact Nick Curry, Head of Research Governance, n.curry@ulster.ac.uk. Full details of the UU research complaints procedure can be found here: http://research.ulster.ac.uk/rg/02078ResearchVolunteerComplaintsProcedure.pdf.

Copies are available upon request. If you have any queries or complaints relating to GDPR regulations please contact The University's Data Protection Officer, Mr Eamon Mullan, University Secretary and Data Protection Officer, University of Ulster, Room J313, Coleraine, BT52 1SA. e.mullan@ulster.ac.uk

Thank you for taking the time to read this information.

If you have any questions or would like more information, please contact:

- Barry Gilsenan; Chief Investigator: gilsenan-b1@ulster.ac.uk
- Professor Rodney Mc Adam: r.mcadam@ulster.ac.uk
- Dr Kristel Miller k.miller@ulster.ac.uk

Appendix 3: Interview schedules.

This appendix includes all interview questions for each stakeholder – AEs with licensing experience, AEs with spin out experience, TTMs, funding agency specialists and industry partners and pilot and repeat interview questions.

Pilot interview schedule:

Q1 Could you tell me a little about yourself and the work you do here?

Q2. What are the key motivating factors which have led to your engagement with academic entrepreneurship activities?
Can you tell me a bit about these activities? What type of actors do you work with?

Q3. What factors have enabled you to successfully engage with entrepreneurial activities? i.e. networking, university supports, previous contacts, learning from industry partner, prior work experience, mentors, role models etc

Q4 In general, what are the barriers facing academic engagement in entrepreneurial activities? i.e. acquiring market knowledge, networking, balancing academic remit, applying your research to practice, delayed publications, seeking funding.

Q5. Do you feel an increased pressure to collaborate with industry?
Why? Who from? Has this led to you changing your research/behaviours etc?

Q6. What skills have you experienced which have been most helpful or do you see as important when trying to commercialise your research?

Q7. What supports are available to you to help you achieve your goals as you commercialise at the university level?

Q8 If we look at the stages of commercialisation, for example , idea generation, proof of concept, initial publication, market research, to prototype , at those stage which one (s) are the most challenging to you as you try progress your innovations and why?

Q9 How do you overcome these challenges?

Q10 Have you worked collaboratively with a partner from outside the university previously? What type of partner? How did you connect with them? Did you know them before ? If so how long? What was your experience of this….

Q11 Could you tell me a little about a project where you worked collaboratively – what were the key milestones or deliverables? Idea generation , proof of concept, disclosure, seeking funding market research etc
Q11B During this project when did you feel the need to acquire external expertise or additional knowledge ? how did you go about this?

Q12 Have you ever felt you were lacking any knowledge around the application of your scientific knowledge into a more market orientated output in any project you worked on?

Q13 How did you acquire this market related knowledge?

Q14.Did you learn anything new or were you able to refine your methods/processes from working with a collaborative partner?

Q15. How do you keep up to date with current market trends and emerging technologies?

Q16. Do you find your academic role and your entrepreneurial interests as complementing each other ?
Can you explain how or give me examples?
How are you able to balance the demands of both?

Q17. Have you ever felt a need to develop your business skills or business acumen? How did you do this?

Q18. Do you feel that your innovations are meeting consumer needs or industry needs? Explain how/why….

Q19. Have you ever experienced challenges when working external partner? Can you tell me what they were? mistrust, opportunism etc….

Q20 Do you see any recommendations on how UIC can be improved at a macro level? looking at funding bodies, government involvement and policy decisions?

Q21. Finally in your opinion, should all academics engage in applied research?

Q22. Is there anyone else you could recommend I speak to?

Interview questions for AEs involved in licencing (main interview stage).

Q1. Could you tell me a little about the work that you do here, for example, how long you have worked here, and what your main role/responsibilities are?

Have you worked in any other academic institutions?
If so – what type of role

Q2. Prior to working in your current role, have you always worked in academia or have you worked in industry also?
- If yes – do you think academia is very different from business?

I now want to take about your technology commercialisation experience:

Q1 How many years have you been involved in technology commercialisation activities?
Q2 What are the different types of technology commercialisation activities you have been involved in?

Q3: What has been the key motivational factors or drivers that has led you to engage with Technology commercialisation?

Q4What have you found to be the key challenges or barriers you have had to overcome to engage with academic entrepreneurship?

Ok, great. I want to take some of your technology transfer experiences and discuss them in some detail.

Thinking of X (licencing deal) can you take me through the stages of how this emerged? For example,

Q5a How did you recognise the opportunity for this technology?
Q5b What types of knowledge helped you to identify this opportunity?
Q5c How did you acquire that knowledge?

Q6a Have you worked on this alone or with other academics/external individuals?
Q6b What knowledge, help/ assistance did they provide?

Q7a Did you interact with the TT office? What role did they play?
Q7b Did you follow formal stages for technology commercialisation disclosure?
Q7C Did you interact with the company(s) who licenced your technology? What type of engagement did you have? Are you still interacting with them now?

Q8 At different stages of the project, what type of knowledge did you often find yourself seeking?
for example, what knowledge was needed for idea generation , proof of concept, invention disclosure, seeking funding, market research.

Q9 Specific to the project, were there any obstacles or challenges you had to overcome? what were they? how did you achieve this?

Q10 Did you gain new insights or perspectives from working with other stakeholders within the project? if yes, from who and what did you learn?

Q11 During the project, what skills helped you to understand market orientated knowledge? could you provide an example? (in general if not context specific).
Do you consider the skills needed to obtain your subject specific knowledge and market knowledge to be different?
- Have you had to switch skillsets and mindsets on different tasks that you have worked on within the project? Could you provide an example?
How important was it for you to understand the market/industry needs in order for this licencing deal to be a success?
- Do you feel that you have a good grasp of market industry needs?
- How do you keep on top of market/industry needs?
Do you believe that academics have these skills and capacities to understand and meet the needs of industry? If not, how could they achieve them?

Q12 Do you find your academic role and your entrepreneurial interests as complementing each other ?
o Why complementary or competing?
o It could be suggested that to be entrepreneurial requires a different mindset to being an academic, do you agree with this? Why?
o Have you always been interested in entrepreneurial activities? If not, what do you think changed your mindset to be interested in them?
o Have you noticed your behaviour changing since you have been involved in technology commercialisation activities, for example in regards to how you approach research topics or the types of knowledge sources you engage in?

Q13 Looking at learning now, did your past work experience help with your technology commercialisation activities? Or was there any key individuals who have aided your technology commercialisation activities. (and how)?

Q14 Have you used informal contacts such as ex colleagues or VC contacts to gain assistance or guidance from? Does the knowledge you gain from informal contacts differ from the formal contacts at the university?

Q15 Do you feel that you have learned from the TT process – how? What key takeaways will you use for future engagement in TT activities?

Q16 How much of your learning has been on the job? what types of activities have been learned through on the job training/learning?

Q16B During your entrepreneurial projects, could you think of a time when something went really well or when there was time of a failure and what made it such a success or failure? what skills did you use in this scenario?

Q17 What could universities/ departments do to help academics to develop the skill sets to engage in more applied research? Incentives – reward structures, training initiatives etc.
Do you think that universities should engage more with industry? How can they do this better?

Is there anyone else who you know that could be useful for me to speak to who has engaged in technology commercialisation?

Interview questions for AEs involved in spinouts (main interview stage).

Introductory Questions
Q1. Could you tell me a little about the work that you do here, for example, how long you have worked here, and what your main role/responsibilities are?

Q1B. Have you worked in any other academic institutions?
If so – what type of role

Q2. Prior to working in your current role, have you always worked in academia or have you worked in industry also?
- If yes – do you think academia is very different from business?

I now want to take about your technology commercialisation experience:

Q1 How many years have you been involved in technology commercialisation activities?
Q2 What are the different types of technology commercialisation activities you have been involved in?

Q3 What has been the key motivational factors or drivers that has led you to engage with Technology commercialisation?

Q4 What have you found to be the key challenges or barriers you have had to overcome to engage with academic entrepreneurship?
Use prompts to help them – networks, time, market knowledge etc….

Ok, great. I want to take some of your technology transfer experiences and discuss them in some detail.

Q1.Thinking of X (spin out company) can you take me through the stages of how this emerged? For example,

Q2 How did you recognise the opportunity for this technology?
Q3What types of knowledge helped you to identify this opportunity?
Q4How did you acquire that knowledge?

Q5Have you worked on this alone or with other academics/external individuals?
Q6What knowledge, help/ assistance did they provide?

Q7Did you interact with the TT office? What role did they play?
Q7Did you follow formal stages for technology commercialisation disclosure? Can you talk through the stages you followed?

Q8 I want to take each different stages of the spin out, and try to understand the types of knowledge and individuals who helped you. Can you discuss the different stages and try to reflect upon these stages to identify who was involved and how the technology developed at each stage?

Q9 Specific to the spin out, were there any obstacles or challenges you had to overcome? what were they? how did you achieve this?
Prompts was the marketing or positioning of your innovation difficult? Money, time, Did you interact with individuals in the university/TTO, surrogate entrepreneurs, colleagues

Q10 Did you gain new insights or perspectives from working with other stakeholders within the project? If yes, from who and what did you learn?

Q11 Have you used informal contacts such as ex colleagues , family and friends or venture capital contacts to gain assistance or guidance from? Does the knowledge you gain from these informal contacts differ from the formal contacts at the university?

Q12 During the spin out process, could you think of a time when something went really well? Can you tell me about it – what made things go well? Were there particular individuals, knowledge, support etc.

Q13 Now can you think of a time when there was a failure. What happened? How did you overcome it? What skills did you use in this scenario?

Q14 During the spin out formation, what skills helped you to understand market orientated knowledge? Could you provide an example?

Do you consider the skills needed to obtain your subject specific knowledge and market knowledge to be different?

- How important was it for you to understand the market/industry needs in order for the spin out to be a success?
- Have you had to switch skillsets and mindsets on different tasks that you have worked on within the spin out? Could you provide an example?
- Do you feel that you have a good grasp of market industry needs?
- How do you keep on top of market/industry needs? (use prompts such as events, research, industry exchanges)
- Do you believe that academics have these skills and capacities to understand and meet the needs of industry? If not, how could they achieve them?

Q15 I want to understand a bit more about the learning process that happened during technology transfer activities. Did your past work experience help with your technology commercialisation activities? Or was there any key individuals who have aided your technology commercialisation activities. (and how)?

Q16 How much of your learning has been on the job? What types of activities have been learned through on the job training/learning?

Q17 Do you feel that you have learned from the TT process – how? What are the key takeaways will you use for future engagement in TT activities?

Q18 What could universities/ departments do to help academics to develop the skill sets to engage in more applied research? Incentives – reward structures, training initiatives etc. Do you think that universities should engage more with industry? How can they do this better?
Q19 Is there anyone else who you know that could be useful for me to speak to who has engaged in technology commercialisation?

Interview questions for TTMs (Technology Transfer Managers).

1. Could you tell me a little about the work that you do here, for example, how long you have worked here, and what your main role/responsibilities are?

2. Prior to working in your current role, have you always worked within a tech transfer university role or have you had other work experience for example within industry?

3. What is the highest qualification you hold and in what area?

4. Would you say your prior work experience has helped you in your current role, if yes, how?

5. What motivated you to get into this line of work?

6. How many technology disclosure, licensing deals and spin outs have you had over recent years?

7. Do you feel that the TTO has a good relationship with academics within the university?

Could I now ask you about the process of technology commercialisation within the university.

1. Firstly, what are the main stages involved?

2. How do you go about identifying potentially commercialisable ideas within the university?

3. Do you run events, information seminars, promote it at a micro level to staff, have informative webpages, send out emails or is it based on an academics self- awareness and initiative to identify that they have a potentially commercialisable idea?

4. On the courses that you provide, How often do they run. What do these courses entail and what would a PI typically learn? Do you think these courses are effective? If not – why and what else could help?

5. When an academic has an idea, what is the process that is followed to help them progress this?

If I could now get you to reflect on a commercialisation project (licensing deal or spin out) you are aware of/ was working on, where you provided a high level of support and guidance to a PI within the university:

1. Firstly how did this project come about? At what stage did you get involved? who was it initiated by?

2. What role did you play in the project? – what were your objectives? what support mechanisms did you help the academic with?

3. How did you usually communicate with the PI and how often?

4. Were there any obstacles or challenges during the project? How were these overcome? Did you need to step in to provide assistance/guidance to the PI? please explain? Prompt them – market research/market knowledge, networks, money, networks, time

5. What in your opinion made this project a success/ failure? could you give an specific example of how you contributed to this?

6. There is a real focus now on applied research. Do you think PIs have the skills, knowledge and capabilities to conduct applied research?
If not how could they gain it?

7. How important do you think it is that PIs engage with industry? Why?

8. What do you feel are the challenges of PI and industry engagement? How can these be overcome? For example it is often thought that academics and industry operate differently and speak different languages.

9. Are there any mechanisms/initiatives that the TTO offer to help PIs engage with industry? Are these working well? Can you give an example of successes?

10. It is widely acknowledge in literature and practice that PIs often lack market knowledge and awareness, where scientific and market knowledge is very different and requires different skills and capabilities to acquire it and understand this. Have you found this to be the case with the TT activities you have been engaged in?
How do you think this could be improved?

11. To be entrepreneurial requires a different set of skills and ways of thinking about knowledge and markets, do you think this comes naturally to the academic or should it be taught?

12. Do you find it a challenge to support a range of academics who have varying degrees of skill and knowledge and come from different areas? How do you overcome this?

13. Can you make any recommendations on how the TT process at the university can be improved?

14. Is there anyone else you could recommend I speak to?

Interview Questions for industry partners.

1. Could you tell me a bit about yourself? (Past experience with business etc.)

2. What is your highest area of academic qualification and in what area?

3. What form of engagement have you had with academic scientists, for example have you co-authored papers, or worked on licensing deals?

4. What motivated you to become a scientist?

5. In general, how have you found your interaction with universities on projects you have collaborated with them on?

If I can ask you now to discuss a project that your worked specifically with a university scientist(s) on:

6. How did you become involved with working with the university/ specific AE? At what stage did you get involved, and what was your role in the project?

How did you communicate and interact with the AE? how frequent was it and what was the main form: face to face, formal/ informal meeting, telephone/ email etc.

6b. What has the benefits been (for you/the university/academic).

7. What has been the main challenges to date with your interactions with the university/particular AE/ a particular project?
    a. Were these overcome? How?

8. What success factors have helped your relationships/ business activities with the university/AE?

9. What benefits do you/your organisation get out of working with academics?

10. Have you worked with the university/academics in the past? Could you tell me a bit about these activities?

11. It is often said that academics lack market knowledge and talk 'in a different language', have you found this with your interactions?
    a. Could you give an example?
    b. How do you think this could be improved?

12. It is important now more so than ever for academics to conduct applied research, can you identify mechanisms which might help academics and industry collaborate better together?

13. Is there any particular mechanisms universities/ government could implement?

14. What have you experienced to be the biggest impediment or barrier in university and industry scientist working together?

15. Do you feel the gap between industry and academic scientists is converging or diverging in terms of mindsets and skillsets in order to develop new innovations? For example how is the challenge of the opposing logics of open science and proprietary science overcome between academia and industry?

16. Is there anyone else you could recommend I speak to?

Interview questions for funding agency specialists.

1. Could you tell me a little about the work that you do here, for example, how long you have worked here, and what your main role/responsibilities are?

2. Prior to working in your current role, have you always worked within a university – industry knowledge transfer support role? or have you had other work experience?

3. What is the highest qualification you hold and in what area?

4. Would you say your prior work experience has helped you in your current role, if yes, how?

5. What motivated you to follow your career path?

If I could now ask you some specific questions on a particular project which you have worked on where you had a high degree of interaction with a PI and/ or TTO office at a university:

1. Firstly, how did this project come about? At what stage did you get involved? who was it initiated by?

2. What role did you play in the project? – what were your objectives?

3. Within the university, did you usually communicate with a PI or TTO staff member or both? How did this communication happen, was it typically face to face meeting, telephone , email etc.

4. Were there any obstacles or challenges during the project, were you needed to step in to provide assistance/guidance to the PI or TTO staff ? please explain?

5. How did the PI learn from your expertise to help move the project forward? Could you provide an example?

6. Were there any barriers in communication or conflicts of opinion on this project ?
   if yes, how were these resolved?
   if no, in general, how have you resolved such issues?

In general:

7. What skillsets are important contributing factors when an AE is making a funding proposal? (in general).

8. What type of feedback do you provide to the AE if he /she is not successful?

9. How important is this feedback as a tool where the AE can learn? Can you provide an example of how you provided assistance or aided learning to the AE?

10. What support services do you offer AEs when they are commercialising their research? For example do you run courses or provide informal advice?

11 Are there any knowledge or skill gaps which limit your opportunity to work with academics or TTO staff? what are the main challenges with working with these individuals?

12 What factors in your opinion build a strong relationship between you and the PI/ university?

13 Could you provide an example of how your body has developed the skills and knowledge around the market orientated processes for AEs? Were there any other stakeholders who helped in this initiative? who?

14 Do you feel there is an adequate amount of resources for both basic and applied scientists?

15 Finally, what improvement(s) do you see that can make UICs more effective?

16 Is there anyone else you could recommend I speak to?

Repeat interview questions.

For strategic level TTMs (all three cases).

1. Does X have any incubator facilities on campus? If yes, what are they?

2. Does X offer an accelerator program for PIs or budding entrepreneurs ? if yes, what is the learning outcome?

3. Would you know what the funding level was from the Irish funding agencies in 2019 and or 2020 for STEM research?

4. Also, would you know how much E.U. level funding was received approx. for 2019 and or 2020 again for STEM research?

5. How many research centres are on site at the campus relating to STEM research? What areas are they in? are they headquartered on campus?

6. How many IDFs licensing deals and spin outs are attributed to the centres that are based on campus e.g. the X centre?