Knowledge, Technology Transfer and the Third Mission of Universities

A mixed method approach investigating innovation ecosystems, collaboration projects and technology transfer offices

Randi Elisabeth Taxt

Thesis for the degree of Philosophiae Doctor (PhD)
University of Bergen, Norway
2023

UNIVERSITY OF BERGEN

Knowledge, Technology Transfer and the Third Mission of Universities

A mixed method approach investigating innovation ecosystems, collaboration projects and technology transfer offices

Randi Elisabeth Taxt

Thesis for the degree of Philosophiae Doctor (PhD)

at the University of Bergen

Date of defense: 27.06.2023

Year: 2023

Title: Knowledge, Technology Transfer and the Third Mission of Universities

Name: Randi Elisabeth Taxt

Print: Skipnes Kommunikasjon / University of Bergen

I shall be telling this with a sigh
Somewhere ages and ages hence:
Two roads diverged in a wood, and I—
I took the one less traveled by,
And that has made all the difference.

Robert Frost (1874–1963)

Scientific environment

This research is carried out as a Public Sector PhD Project (OFFPHD) scheme funded by the Research Council of Norway (RCN) and Vestlandets Innovasjonsselskap AS (VIS) was the project owner. I have been part of the PhD programme at the Faculty of Social Sciences, University of Bergen at the Department of Geography. University of Bergen was a partner in the OFFPHD project together with the Mohn Centre for Innovation and Regional Development at Western Norway University for Applied Sciences. I spent three months as a visiting guest researcher at École Supérieure d'Ingénieurs en Électrotechnique et Électronique (ESIEE) in Paris, France.

Acknowledgements

This PhD project has been a strenuous journey and balancing my ordinary work at both VIS and for the Centre for Digital Life Norway with the PhD project and life in general has been especially challenging for me. However, despite some frustrating days, this PhD project has been a source of joy and satisfaction due to new learning, as well as constantly giving me knowledge and insights that have proved useful for my ordinary work. However, this thesis would never have been completed without all the good people and institutions who have helped and supported me along the way, and the list of these is long.

Words cannot express my gratitude to the former CEO of VIS and the first internal supervisor of my doctoral research, Anders Haugland (PhD). Without his enthusiasm, constant push, and encouragement I would never have embarked on the project. I would also like to express my deepest gratitude to my supervisor Professor Knut Hidle for his presence, patience, and invaluable support, and to my co-supervisor Professor Arnt Fløysand, whose contribution has been crucial at critical points throughout this journey. I am also very grateful to the Department of Geography at the University of Bergen (UiB), which has included me as a PhD student and given me constant support along the way. My appreciation is also directed towards the Mohn Centre for Innovation and Regional Development (HVL), for its general support and for letting me into its PhD community. Additionally, this endeavour would not have been possible without support from the Research Council of Norway and Horizon 2020. I also wish to express my deepest appreciation of VIS, my employer, which has allocated internal resources to fund this OFFPHD project. In this respect, special thanks are owed to my internal supervisor, CFO Halvor Aas, OFFPHD project leader Mona Leirgulen, and CEO Stine Fiksdal. My stay as a visiting guest researcher at École Supérieure d'Ingénieurs en Électrotechnique et Électronique (ESIEE) was very important for my research and therefore I would also like to extend my gratitude to this institution. Many thanks go also to the NORSI research school, where I have been an affiliation as member. Additionally, I am deeply indebted to all my informants and respondents who took their time to participate and sharing their experiences in my research. Thanks, are also given to NIFU, for providing data on marine-related PhDs in Paper 1 in my thesis.

Many thanks are owed to Professor Douglas Robinson and Antoine Schoen, not only for excellent scientific collaboration, but also for the help and assistance in enabling my research stay at ESIEE. I also owe thanks to all my other colleagues in the EMBRIC project and especially Professor Anders Goksøyr, project leader of the EMBRIC project in Bergen, and both Professor Pierre Colas and Professor Ibon Cancio who helped me to make contact with cases and respondents in Roscoff and Bilbao respectively. I would also like to extend my warmest thanks to Professor Inger Beate Pettersen, for her constant support and mentoring. Associate Professor Øystein Stavø Høvig is thanked for good discussions and Professor Grete Rusten and professor Roger Strand for their advice along the way. Many thanks are further owed to Jorun Pedersen and Lasse Olsen for their inspiring collaboration in the Norwegian technology transfer community, which also resulted in one of the papers in this thesis. Special thanks are owed to Catriona Turner, whose language contribution has been far beyond what could have been expected and was undoubtedly necessary.

Furthermore, I am deeply thankful for all the feedback sessions with my dear friends, Åshild Lunde, Jarl Giske and Kristin Bakken over the years. Their contributions have indeed inspired and impacted my work. I also want to thank my other friends, Anne Fjellbirkeland, Dag L. Aksnes, Jan Petter Hansen, and Torny Aarbakke, for their critical questions, proofreading, encouragement, and moral support, as well as for all the fun along the way. I would also like to mention all my colleagues at VIS, who have been understanding and supportive as well as given me critical feedback. I would further like to recognise my other colleagues at UiB and HVL and at the Centre for Digital Life Norway, as their encouragement and perceptiveness has been important to me.

Finally, my deepest thanks are given to my family and friends, who have been so utterly compassionate and supportive during the years I have spent on my research. My dearest Amund means everything to me, and, without any complaints, part of his own life has been put on hold because of my PhD-related work. He has also been one of my most eager proofreaders. My warmest thanks are also given to my beloved children, Synve and Sindre, who are always there for me and never complain when I am often behind my computer. I am also extremely grateful to my parents, who have constantly backed. I would also be remiss in not mentioning all of my other dearest family members and friends for their encouragement and for understanding when I am being distant, non-responsive, or not showing up on family or social occasions. I am looking forward to enjoying your company again more fully. I also hear the nature and mountains calling.

Abstract

The overall research objective of this thesis is to provide insights into the field of knowledge and technology transfer in relation to public research organisations in innovation ecosystems Public funding and investments in research impact have become highly politicised, and universities are increasingly expected to provide value from their research activities to society through a third mission in addition to research and education. Universities worldwide have set up or have access to a knowledge transfer office (KTO) or to a more specialised technology transfer office (TTO) to help them to execute their third mission activities. These offices can be organised either internally or externally. Traditionally, innovation and commercialisation based on research has been viewed as a linear process that is driven by economic growth in society, as well as by the monetary-related motivations of individual researchers. This is also reflected in governmental funding instruments and university supportive structures for third mission activities. However, recent, the literature has revealed that the third mission of universities is now in transition from a monetary-driven policy structure towards a more socially engaged and sustainability-driven mission. This transition is partly driven by the many global challenges we are facing today, such as climate change, an aging population, and diseases and environmental threats.

In this thesis the relationship between knowledge and technology transfer from universities, industry-funded research projects, the establishment of innovation and commercialisation projects, and the involvement of TTO actors have been at the core of the research. The research has been interdisciplinary, spanning the fields of innovation studies and economic geography. One section is devoted to describing the authors position as a professional within the field of knowledge and technology transfer including reflections upon how this might have influenced the research. The main findings from the research for this thesis can be briefly summarised as follows:

Universities, TTOs, and external collaborative partners are embedded in different types of ecosystems with different logics of actions, like innovation, knowledge, and business ecosystems. When collaborating through third mission activities, the actors span the boundaries of these ecosystems. This crossing creates both conflict and learning. Through the focus on third mission links, this thesis gives valuable insights into the mechanisms for

collaboration, knowledge and technology transfer as well as dynamics among the various ecosystems in both time and space.

The nature of and motivations for third mission activities seem to reflect social engagement more than economic rewards. This is the case not only for researchers but also for other involved actors, such as department leaders and TTO executives, as well as external collaborative partners. It is argued that these findings in many ways reflect the transition of third mission activities from more monetary-driven and commercial-oriented *second-generation innovation policy* actions towards more diverse and mission-oriented *third-generation innovation policy actions.*

When supporting innovation and commercialisation activities based on research, universities seem, along with other research organisations and government funding institutions, still left behind in the second generation of innovation policy and possibly even in the first generation. In other words, they are still considering innovation and commercialisation as linear processes and are favouring economic rewards. They are also considering the role of TTOs as taking part of commercial activities alone. The third mission of universities are, however, in a transition towards the third generation of innovation policy. The question remains as to whether this should correspondingly be reflected in a change in the roles and missions of TTOs.

The thesis ends with some offers of advice to policymakers and practitioners within the field of knowledge and technology transfer. Some advice towards Norwegian policymakers is given to push the process of transitioning research-based knowledge and technology transfer processes to reflect the third innovation generation policy in a better way. Following this, knowledge and technology transfer should be considered more as a social mission than as an economic activity and consequently, the mission should be reflected in the funding schemes of TTOs. Finally, consideration should be given to initiating a shift in the perception of the roles and tasks for the TTOs in Norway towards the more broadly defined KTOs. The special competencies TTOs have on intellectual property rights and business model development for innovative research ideas, must however be maintained and further developed. Finally, a hope is expressed that (Norwegian) TTOs can embrace and exploit the coming opportunities and will not stick to 'business as usual'.

Sammendrag

Målet med med denne avhandlingen er å kunne gi mer og bedre innsikt i den kunnskap- og teknologioverføring som skjer i universiteter og andre offentlige forskningsinstitusjoner innenfor innovasjonsøkosystemer. Bakgrunnen for dette er at offentlig finansiering i forskning i stor grad er politisert, og at universitetene forventes i økende grad å tilbakeføre verdi fra forskning til samfunnet. Dette blir omtalt som det tredje samfunnsoppdraget i tillegg til de to andre, forskning og undervisning. Universiteter over hele verden har tilgang til et kunnskapsoverføringskontor (KTO) eller til et mer spesialisert teknologioverføringskontor (TTO) for å hjelpe dem med å utføre det tredje samfunnsoppdraget. Disse kontorene kan organiseres enten internt eller eksternt. Tradisjonelt har innovasjon og kommersialisering basert på forskning blitt sett på som en lineær prosess drevet av økonomisk vekst i samfunnet eller av økonomiske motivasjoner hos de enkelte forskere. Disse lineære prosessene gjenspeiles også i statlige finansieringsordninger samt i universitetenes strategier og støttefunksjoner. I det siste er det imidlertid påpekt i forskningslitteraturen at universitetenes tredje samfunnsoppdrag synes å være i en overgang fra en mer økonomisk begrunnet aktivitet til en aktivitet nærmere fundert i bærekraft og generelle forbedringer i samfunnet. Denne overgangen er delvis begrunnet med de mange globale utfordringene vi opplever i dag, som klimaendringer, en aldrende befolkning, epidemier og miljøtrusler.

I avhandlingen er forholdet mellom kunnskap og teknologioverføring fra universiteter, industrifinansierte forskningsprosjekter, etablering av innovasjons- og kommersialiseringsprosjekter og involvering av TTO-aktører undersøkt. Videre er dette forholdet sett i lys av aktørenes rolle i innovasjonsøkosystemet. Forskningen har vært tverrfaglig og spenner over fagområdene innovasjonsstudier og økonomisk geografi. PhD kandidaten arbeider selv i en TTO og med oppgaver innenfor kunnskap og teknologioverføring. Et underkapittel i avhandlingen er derfor viet refleksjoner over hvordan dette kan påvirke forskningen i både positiv og kanskje også i mer negativ retning.

Hovedfunnene i avhandlingen kan kort oppsummeres som følger:

Universiteter, TTOer og eksterne samarbeidspartnere tilhører naturlig ulike typer økosystemer, henholdsvis innenfor innovasjon, kunnskap og ulike næringer eller verdikjeder.

Disse økoystemene har ulike sett av verdier og logikker. Når aktører fra flere økosystemer samarbeider i prosjekter, må de krysse grensene til andre økosystemer enn sitt eget. Dette skaper både konflikt og læring. Med et søkelys på prosjekter innenfor det tredje samfunnsoppdraget til universiteter gir denne avhandlingen derfor en innsikt i både mekanismer for samarbeid, om hvordan kunnskap og teknologioverføring faktisk foregår mellom aktørene, samt at dynamikk mellom de ulike økosystemene utforskes i både tid og rom.

Motivasjonen for å gå i gang med et innovasjons og kommersialisering prosjekt ser ut til å være mer basert på et sosialt engasjement enn økonomiske motiver. Dette gjelder ikke bare for forskere, men er også uttrykt fra andre involverte aktører, som instituttledere, TTO ansatte samt eksterne samarbeidspartnere i prosjektene. Det er antatt at disse funnene på mange måter gjenspeiler den endringen man i dag generelt ser for det tredje samfunnsoppdraget, mot mer sosiale og bærekraftig aktiviteter, og dermed også en del av en tredje generasjons innovasjonspolitikk.

Universiteter, sammen med andre forskningsorganisasjoner og statlige finansieringsinstitusjoner, synes imidlertid fortsatt å agere etter prinsippene i andre generasjons innovasjonspolitikk og muligens til og med fra første generasjon. Med andre ord, de vurderer fortsatt innovasjon og kommersialisering som lineære prosesser (første generasjons innovasjonspolitikk) og favoriserer økonomiske belønninger (andre generasjons innovasjonspolitikk). Dette medfører også at TTOene sine oppgaver ofte begrenses til det kommersielle med et motiv om mest mulig økonomisk gevinst. Spørsmålet reises om universitetets overgang mot en tredje generasjons innovasjonspolitikk ikke også bør gjenspeiles i en endring i roller og oppgaver til de tilhørende TTOene

Oppgaven avsluttes med noen råd til beslutningstakere og de som arbeider innenfor feltet kunnskap og teknologioverføring. Råd gis først til dem som arbeider med policy om å påse at den prosessen som i dag pågår rundt organiseringen av kunnskaps- og teknologioverføringsprosesser i Norge, bedre reflekterer den tredje generasjonspolitikken. Som en følge av dette bør kunnskaps- og teknologioverføring betraktes mer som et samfunnsoppdrag enn som en ren økonomisk aktivitet og dermed også reflekteres i finansieringsordningene til TTOene. Det må også da vurderes å utrede om ikke rollen og oppgavene til TTOene bør være mer i tråd med de bredere definerte KTOene. Den spesielle kompetansen TTOer har på immaterielle rettigheter og forretningsmodellering for innovative forskningsideer, må imidlertid opprettholdes og videreutvikles. Til slutt i avhandlingen uttrykkes et håp om at (norske) TTOer både kan omfavne og utnytte de endringer og muligheter som nå synes å komme og ikke holde seg til "business as usual".

List of Papers

Paper 1:

Randi Elisabeth Taxt, Douglas K.R. Robinson, Antoine Schoen and Arnt Fløysand (2022). The embedding of universities in innovation ecosystems: The case of marine research at the University of Bergen. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* 76(1), 42–60.

Paper 2:

Randi Elisabeth Taxt. Collaboration in university third mission activities: A case study of academic engagement and commercialisation in three European universities. *Industry and Higher Education* (resubmitted March 2023).

Paper 3:

Randi Elisabeth Taxt, Øystein Stavø Høvig and Inger Beate Pettersen (2022). The relational dynamics in the extended teams of academic spin-offs: A Norwegian case-study. *International Journal of Research, Innovation and Commercialisation* 4(1), 31–51.

Randi Elisabeth Taxt, Anne Christine Fiksdal, Lasse Olsen and Jorun Pedersen (2022). The Development of Technology Transfer in Norway – A System in Flux. *les Nouvelles* LVII(4), 285–292.

Table of Contents

1 Introduction

The whole is greater than the sum of its parts
(Aristoteles, 384–322 BC)

This thesis examines how universities collaborate with other actors in innovation ecosystems to create impact in society through knowledge and technology transfer from research, also termed third mission activities.

Public funding and investments in research impact have become highly politicised, and universities and other public research organisations are increasingly expected to provide value from their research activities to society. For higher education institutions this means that in addition to the missions of *research* and *education*, they are expected to contribute through a third mission in terms of *knowledge and technology transfer* to address societal and economic challenges (Etzkowitz & Leydesdorff 2000; Laredo 2007; Compagnucci & Spigarelli 2020). However, despite considerable efforts from governments, industry, and university leadership, the economic and societal impacts of research have not been as high as expected (OECD 2013; 2019; Reillon 2017).

Historically, new knowledge and technologies were expected to drizzle or diffuse almost passively from basic academic research into new products or processes in industry or the public sector, a view highly influenced by the concept of a linear model of innovation. This linear model is designated as the basis for the *first generation of innovation policy* and was highly influenced by the work of Vannevar Bush in the mid-1940s (Bush 1945). Following the linear model, the third mission activities of universities have traditionally been measured by their ability to attract external research funding or to commercialise research (Siegel & Wright 2015; Breznitz & Feldman 2012). Commercialisation and the development of technologies are also the core fundament of the *second generation of innovation policy* that started to emerge in the 1970s and became established in 1980s, as described in Chapter 2 of this thesis. However, the recent and extensive reviews by Perkman et al. (2021) and Compagnucci & Spigarelli (2020) show that the third mission of universities is now in transition from a monetary-driven policy structure towards a more socially engaged and sustainability-driven university mission. This transition is partly driven by the many global challenges we are facing today, such as climate change, an aging population, and diseases and environmental threats, and is often termed the *third generation of innovation policy*. In this thesis I argue that this transition should be better reflected in how universities and other research organisations align their strategies and support structures for their third mission activities. Additionally, I investigate how and to what extent universities have managed to implement the third mission in their activities and daily operations.

Universities have established various internal and external organisational structures to support their third mission activites, such as internal rules and procedures, management, and administrative support offices including knowledge transfer offices (KTOs) and spin-off incubators (Clarysse et al. 2005; Link et al. 2015). Furthermore, universities worldwide have set up or have access to a technology transfer office (TTO), a more specialised type of KTO, to support their commercialisation activities (Etzkowitz et al. 2000; Link et al. 2015). The performance of these university TTOs has in many ways been coupled to how universities are perceived to execute their third mission, channelled through formal commercialisation outputs such as patents, licensing agreements, and spin-offs (Link et al. 2015). However, in the last two decades, consensus has emerged among scholars within innovation studies that informal and relationship-based knowledge and technology transfer mechanisms are in many ways of greater importance for innovation and commercialisation processes than the more formal and traditional channels mentioned above (Fagerberg et al. 2005; Perkman & Walsh 2007). In my research for this thesis, I have investigated both formal and informal channels for knowledge and technology transfer but paid most attention to the relational-based collaboration channels, including collaborative research projects, contract research, licencing agreements, and spin-offs. Based on the theoretical framework constructed for this thesis I argue that both within academia and within support structures, governmental bodies, and funding instruments, the linear model for innovation is still current in perceptions, practices, and organisational structures related to third mission activities.

Third mission activities cannot be studied in isolation. This can be explained partly due to the embeddedness of both universities and their TTOs in *innovation systems*, which include all forms of interactions among the involved actors (Freeman 1987 Lundvall 1985). For some innovation systems the biological metaphor *ecosystem* is used (Moore 1993). Within the last decade, ecosystem concepts have been increasingly used by scholars, as well as by practitioners and policymakers, to describe the dynamic and competitive nature of innovation systems. More specifically, the concept of *innovation ecosystem* (Adner 2006) belongs to a variety of ecosystem concepts, including *business ecosystems*, *knowledge ecosystems*, *digital ecosystems*, and *entrepreneurial ecosystems.* Various types of ecosystems have a high degree of interconnectivity and actors can be involved and play different roles in each system (Valkokari 2015). To add to the complexity, several definitions exist for each concept (Granstrand & Holgersson 2020) and the concepts are used ambiguously. This has resulted in limited consensus and understanding among researchers and practitioners on how and when to use the concepts (Valkokari 2015; Granstrand & Holgersson 2020).

Further research on the interaction between the different types of ecosystems has been called for (Valkokari 2015), as well as for how ecosystem actors perceive their concurrent roles in different ecosystems (Heaton et al. 2019). In response to this call, I explore third mission activities through the lens of innovation ecosystems. By this approach, I draw attention to *how* actors such as universities and TTOs are positioned and act within these systems. In the philosophy of ecology, holisms (also known as wholisms) include both the principle that the whole has priority over its parts and the assumption that properties of the whole cannot be explained only by the properties of its parts (Keller & Golley 2000). Highly inspired by the methodology of *activity profiling* (Laredo & Mustar 2000), as described in detail in Section 4.2, I undertake a holistic approach to innovation and commercialisation by providing and analysing an empirical dataset and the most important research-based knowledge and technology transfer channels within innovation ecosystems. This contrasts with most studies within the field of innovation and commercialisation, which traditionally has concentrated more on one or a few output measures, such as patents, academic spin-offs, and licensing deals. Hence, most previous studies have taken an approach more in line with reductionism.

In recent decades, in line with the *second generation of innovation policy*, the commercialisation of research has been considered the most important example of how academic impact is generated for the society (Gulbrandsen & Slipersæter 2007; Breznitz & Feldman 2012). However, it has been demonstrated that joint research projects involving public and private partners, contract research, consulting, membership of committees, training, and personal contacts are much more common channels for knowledge transfer than traditional commercialisation activities (Salter & Martin 2001; Grimpe & Hussinger 2013). This type of external collaboration is designated *academic engagement* (Perkman et al. 2013). In this thesis, I explore, by means of a qualitative approach, how researchers, university managers, support structures such as TTOs, and external partners in private and public organisations collaborate in third mission projects. I also investigate how the collaborations are influenced by factors such as individual motivations, personal background and relations, university strategies and support, and geographical contexts. The Norwegian context has been especially important for my research (see Section 2.5). However, my research also includes third mission activities at other European universities, namely Sorbonne University in France and the University of the Basque Country in Spain. This gives an international context for my findings well as a certain degree of saturation and then generalisation from my data.

This thesis is the result of a Public Sector PhD Project (OFFPHD) funded by the Research Council of Norway (RCN). The OFFPHD programme was established 'to expand research activities in public sector bodies' and the doctoral projects are 'to help to generate knowledge that is relevant and applicable to public actors and their users'.[1] My employer Vestlandets Innovasjonsselskap AS (VIS) is the project owner. VIS is a public company with TTO functions for most of the research organisations in the Bergen area in Norway. In the following I will briefly explain how my educational and professional background motivated me to engage in research and resulted in an OFFPHD project.

I was awarded a cand.scient (equivalent to a master's degree) in cell biology by the University of Bergen (UiB) in 1990, and I worked at UiB for many years in various positions within research, research coordination, and management. In 2008 I was awarded a Master of Technology Management (MTM) degree jointly by the Norwegian University of Science and Technology (NTNU) and Norwegian School of Economics (NHH). During this master program, I spent six months in full-time study at the then Sloan Business School, Massachusetts Institute of Technology (MIT). This period raised my awareness of the importance of research-based innovation and my final master's thesis was on research collaboration and knowledge transfer in university-industry links (Taxt 2008). I was appointed a Vice President of VIS in 2012 and I have now been a technology transfer professional for more than ten years.[2] Throughout my career, I have witnessed and been part of decision-making processes within universities, governmental institutions, and TTOs. As I

---

[1] https://www.forskningsradet.no/en/call-for-proposals/2019/public-sector-ph.d.-project--doctoral-project-in-the-public-sector/?tab=1#FORVALTN
[2] Since September 2020 I have been working as a senior advisor at VIS and, since 2021, I have been working part time at the Centre for Digital Life Norway, University of Oslo.

have seen, many of the processes have not been sufficiently based on research-based knowledge. Furthermore, the literature within innovation and innovation management studies consists of many thematic streams and is mostly empirical (Dogdson et al. 2014). The lack of theory and sometimes conflicting empirical results makes it difficult for practitioners to draw generic knowledge from the research on strategies, practical applications, and actions. Due to this knowledge gap, VIS applied for and was granted a public PhD project with me as the PhD candidate in 2017. The research presented in this thesis is therefore closely related to my work as a technology transfer professional. The years I have been working on my PhD project, I have also been an active part in the ongoing processes and public debate relating to innovation, entrepreneurship, and commercialisation of research regarding the role and performance of Norwegian TTOs.

An important motivation for me to engage in research has been to contribute knowledge generated from practice to the scientific fields of innovation studies and economic geography. From my position as a TTO professional and practitioner, I consider that my most valuable contribution has been by adding empirical data to existing analytical frameworks. Accordingly, the purpose of my research has been to test and clarify the various concepts and to fill some of the above-mentioned knowledge gaps. In my research design and approach, I have been inspired by the philosophical tradition of pragmatism that originated in the US and claims that all philosophical concepts should be tested though scientific experimentation to verify its usefulness and truth. However, I have done this without excluding the possibility of adding new theory. My hope is that this thesis also contributes to practitioners working with knowledge and technology transfer at universities and in other PROs, in TTOs, and in governmental and funding bodies, and as a valuable contribution to the ongoing discussions about the role and organisation of TTOs in Norway.

1.1 Research objective and research questions

The overall research objective of this thesis is to provide insights into the field of knowledge and technology transfer in relation to public research organisations in innovation ecosystems – insights that I have generated through both research and professional practice. In particular, the relationship between knowledge and technology transfer from universities, industry-funded research projects, the establishment of innovation and commercialisation projects, and the involvement of TTO actors have been at the core of my research. My approach has been to examine third mission activities in innovation ecosystems, including knowledge and technology transfer in some selected universities in Europe. To operationalise this PhD project, three research questions (RQs) were formulated:

> RQ1: How are knowledge and technology transfer activities involved as part of the third mission activities of universities in innovation ecosystems?
>
> RQ2: How are university third mission activities impacted by the embeddedness of the actors and by the different scales and scopes in the innovation ecosystems?
>
> RQ3: How are actors in innovation ecosystems motivated to take part in third mission activities and what do they experience as challenging during those activities?

The research questions are addressed in four papers and the research has been interdisciplinary, spanning the fields of innovation studies and economic geography. The research findings are based on mixed methods as a combination of qualitative and quantitative apporaches and can be considered both descriptive and analytical. Collectively, the four papers relate to the three research questions, as elaborated in the next section.

1.2 Research papers

Paper 1, *The embedding of universities in innovation ecosystems: The case of marine research at the University of Bergen,* is a rich case study which demonstrates and discusses how universities are embedded within their innovation ecosystems. Moreover, the paper demonstrates how a university performs its third mission activities through diverse types of links and collaboration with other actors in its ecosystem in time and space. The paper mainly addresses RQ1 and RQ2.

Paper 2, *Motivations for academic engagement and commercialisation: A case study of actors' collaboration in third mission activities from three European universities,* includes an in-depth qualitative multiple case study and analysis of third mission channels. The paper explores how three European universities have performed their third mission activities, including contract research and commercialisation projects in collaboration with public and private actors. In addition, the paper covers how the researchers are motivated and supported, and how TTOs are involved. The paper primarily addresses RQ3, but also RQ1 and RQ2.

Paper 3, *The relational dynamics in the extended teams of academic spin-offs: a Norwegian case study,* probes deeper into a specific type of a third mission activity, namely the academic spin-off. Through a qualitative multiple case study, the paper examines in depth how TTO executives and academic entrepreneurs, together with investors and university departments, collaborate in their efforts to prepare the academic spin-offs for entry into a market. The paper mainly addresses RQ2 and RQ3.

Paper 4, *The Development of Technology Transfer in Norway – A System in Flux,* was written as an invited contribution to a special issue of *les Nouvelles* (Journal of the Licensing Executives Society International) on the role and contribution of multi-institutional technology transfer offices (MiTTOs). This paper is specifically dedicated to the theme of the development of MiTTOs in Norway. The paper elaborates on the establishment and development of the Norwegian TTO system and reflects the context of my thesis and is included as a part of this thesis because of the importance to the context of my theoretical framework, the Norwegian TTO context (Section 2.5).

An overview of the four papers is provided in Table 1, and the relations between these papers, the thesis and the research questions are shown in Figure 1.

The rest of the thesis is structured as follows. In Chapter 2, I present some important theories and the context that are relevant for my research and how it is positioned within the field of innovation studies. In Chapter 3, I elaborate on the theoretical framework, including the positioning for my research within the field of economic geography. The methodological approach, including research design and data collection, is presented in Chapter 4. Finally, Chapter 5 highlights the main findings, and includes a presentation of the four papers and a general discussion of the most important findings and implications.

Table 1. Presentation of the papers in the thesis including author contributions

Paper	Reference, status, and authors' contributions	Relation to RQ
Paper 1	Randi Elisabeth Taxt, Douglas KR Robinson, Antoine Schoen and Arnt Fløysand (2022) The embedding of universities in innovation ecosystems: The case of marine research at the University of Bergen. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* 76(1):42–60. Author contribution: Taxt 80%, other three authors 20%	Addresses RQ1 and RQ2
Paper 2	Randi Elisabeth Taxt (2023) Motivations for academic engagement and commercialisation: A case study of actors' collaboration in third mission activities from three European universities. *Industry and Higher Education* (resubmitted March 2023)	Addresses mainly RQ3, but also contributes to RQ2 and RQ1
Paper 3	Randi Elisabeth Taxt, Øystein Stavø Høvig and Inger Beate Pettersen (2022). The relational dynamics in the extended teams of academic spin-offs: a Norwegian case-study. *International Journal of Research, Innovation and Commercialisation* 4(1):31–51. Author contribution: Taxt 70%, other two authors 30%	Addresses RQ2 and RQ3
Paper 4	Randi Elisabeth Taxt, Anne Christine Fiksdal, Lasse Olsen and Jorun Pedersen (2022) The Development of Technology Transfer in Norway – A System in Flux. *les Nouvelles* LVII(4):285–292. Author contribution: Taxt 80%, other three authors 20%	Elaborates on the history and background for an important context for my research

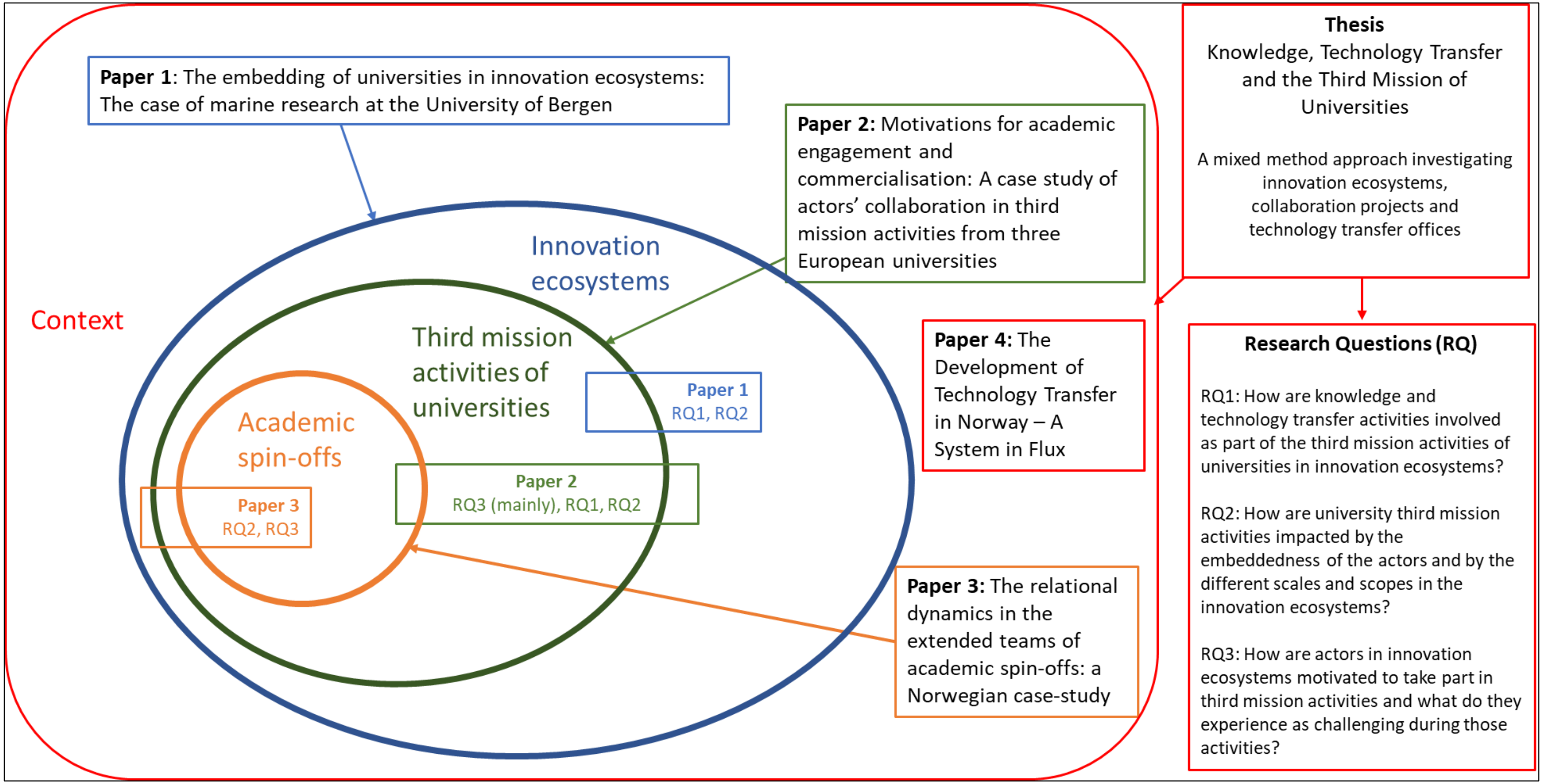

Figure 1. The context and relations between the thesis, the four individual research papers and the three research questions (RQ). The context is knowledge and technology transfer with a special emphasis on the role of TTOs. The coloured circles are indicating the thematic scopes covered by the papers.

2 Theory and context

Innovations are changes which cannot be
decomposed into infinitesimal steps.
(Joseph A. Schumpeter, 1883–1950)

In this chapter I highlight some theories that I have found useful when studying innovation, knowledge, and technology transfer in relation to the third mission of universities. In addition, there is a section on the Norwegian technology transfer office (TTO) context. The theories and context presented here must be considered as closely associated and as preparing the ground for the more specific theoretical framework presented in Chapter 3. In this way, I demonstrate how my research belongs to the field of innovation studies and how the Norwegian TTO context is linked to this academic field. However, my positioning within the field of economic geography is better clarified in Section 3.2, in relation to innovation (eco)systems. While the theoretical framework in Chapter 3 is more important for the analytical part of this thesis, both Chapters 2 and 3 provide a background for the presentation and discussion of my main findings in Chapter 5.

2.1 The field of innovation studies

In modern society, innovation as become associated with finding solutions to many problems and the field of *innovation studies* is a relatively young discipline. It started as a fundamentally quantitative discipline concerned with technological inventions and change in the 1930s, and most of the contributors were from the US (Godin 2008). Many consider Joseph Schumpeter, an Austrian-American social scientist, as the father of the more modern innovation studies, including innovation work processes, and relations (Godin 2012). Schumpeter was the first to separate invention – technology or process – from innovation, which is defined by successful implementation of a technology or process. Furthermore, in the English translation of his book, *The Theory of Economic Development* (Schumpeter 1934), both the idea of *the entrepreneur* and the idea that entrepreneurial innovation is central to economic change and development are introduced. According to Schumpeter, the process of technological change in a free market consisted of three parts: (1) invention (conceiving a new idea or process), (2) innovation (arranging the economic requirements for developing and implementing an invention), and (3) diffusion (whereby people observing the new discovery adopt or imitate it). These stages can be observed in the history of several major innovations, ranging from the lightbulb developed by Edison to Google's disruptive search engine and Apple's iPhone (Berkun 2010). In many ways, these three steps constitute the foundation of most innovative work processes used in business development today, including many TTOs.

In the 1970s a second tradition of innovation studies emerged, mainly in Europe. Christopher Freeman played a leading role in the development of the tradition, which is also termed the *neo-Schumpeterian tradition*. This tradition was about innovation in economic development and the role of scientific and technological activities in ensuring better processes and services in society. Over time innovation gradually and increasingly became established as the commercialisation of technological innovations (Godin 2012).

As pointed out by Godin (2012, p. 399), the development of the second tradition of innovation studies finally resulted in a closer definition of the term 'innovation':

> For over 2500 years, innovation has been understood as 'introduction of change' in individual behaviours, social practices and groups of 'organizations' activities. However, from the 1970s it came to be restricted to technology and commercialization [...] a representation which became hegemonic in the following decades.

The first edition of Freeman's book *The Economics of Industrial Innovation* (Freeman 1974) is perhaps one of the first studies of the system behind the phenomenon of innovation, namely the professionalised industrial research and development system (R&D system). The book describes the rise of a research-intensive economy. Later, both Freeman and Lundvall developed the concept of *national innovation system* (NIS) (Freeman 1987, Lundvall 1985). The NIS concept is discussed in more detail in Chapter 3 of this thesis, as a part of my theoretical framework.

According to Fagerberg and Verspagen (2009, p. 218), 'the development of innovation studies as a scientific field is part of a broader trend towards increased diversification and specialisation of knowledge that blurs traditional boundaries and challenges existing patterns of organization within science (including social science)'.

Today, studies of innovation and of knowledge and technology transfer from research, including literature on KTOs and TTO, is well established within the field of innovation and innovation management studies. To explain the importance of research in innovation and commercialisation processes, various conceptual frameworks have been developed in recent decades, both in research and for policy action, as described in Section 2.3. Before discussing some of these frameworks in more detail, I first dedicate some space to a presentation of the three generations of innovation policies, which are strongly connected to the traditions of innovation studies. These three generations of innovation policies collectively form an important background for this thesis in terms of understanding the development of a variety of innovation policy frameworks and instruments over time, including the role and function of TTOs.

2.2 The emergence of a third-generation innovation policy

The term innovation policy is relatively new, and according to Edler & Fagerberg (2017) the term started to appear more frequently in the innovation literature in the late 1990s. Edler et al. (2016, p. 3) define innovation policy as 'public intervention to support the generation and diffusion of innovation'. In recent decades, many conceptual frameworks have been used to explain the role and importance of innovation in terms of knowledge transfer in society. As mentioned in Chapter 1, the *linear model of innovation*, which was inspired by the work of Vannevar Bush (Bush 1945), has had a great impact on the development of research policies in many countries. In his report *Science the Endless Frontier*, Bush argues that large investments in basic research would, as a direct consequence, inevitably filter down into industrial applications and finally to sales (Bush 1945). He considered that other policy actions or instruments to achieve innovation were unnecessary. This *first generation of innovation policy* was dominant for many years but was eventually questioned in the 1980s, when scholars started to argue that innovation was a more non-linear and interactive process (for an example, see Kline & Rosenberg 1986) and *a second generation of innovation policy* emerged. This development gradually emphasised the complexity of innovation and the interdependency of various actors in the innovation processes. In this second generation of innovation policy, innovation and commercialisation became increasingly contextualised through various forms of innovation systems (see Section 3.2 for an overview). All the above-mentioned systems acknowledge that the processes of innovation and knowledge transfer are moving towards increasingly complex patterns of knowledge co-creation from many types of actors and through value chains or geographical co-location. This complexity also affects universities, and how they collaborate with their external partners in third mission activities. The way that universities and their TTOs are embedded within these systems is described in more detail in Chapter 3. In contrast to the first generation, the second-generation innovation policy instruments were often designed to support the linkages between knowledge creation and commercialisation in systemic networks, and those concepts quickly became popular among policymakers. In particular, they were fronted by the OECD (Wyckoff 2013; Technopolis Group 2019), as well as the European Commission (2003).

The triple helix approach (Etzkowitz & Leydesdorff 1997) can be considered as a framework rooted in the second generation of innovation policy. Etzkowitz & Leydesdorff (1997; 2000) introduced the *triple helix model* as a systemic concept, which has since been frequently used by policymakers. They describe a dynamic interplay between academia, industry, and government, using a metaphor alluding to the double helix structure of DNA[3]. Furthermore, Etzkowitz & Leydesdorff (1997; 2000) described how universities could play an enhanced role in innovation within knowledge-based societies. This was built on the idea that universities through academic entrepreneurial activities could take on roles traditionally held by industry in economic development. Cooke (2001) described the *triple helix model* as especially applicable to Europe, where small and medium enterprises (SMEs) are supposed to be the major players in the provision of networks for collective learning and innovation within their regions. The triple helix concept was further developed into the concept of the quadruple helix (Carayannis & Campbell 2009) and subsequently the concept of the quintuple helix (Galvao et al. 2019). This development was driven by the recognition that several other drivers or groups of actors, such as stakeholder groups, are necessary to achieve innovation in society (Galvao et al. 2019).

While the main goal of the first generation of innovation policy was to solve the problem of market failure through increased research and development (R&D), the second generation of innovation policy attempted to solve a system failure in the commercialisation of research. Thus, in this context, the establishment of university TTOs can be viewed as a second-

[3] According to MedlinPlus, 'DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms' (MedlinePlus 2021).

generation innovation policy instrument for generating income from research back to the universities. The *third generation of innovation policy*, which emerged in the early 2000s and is still evolving, is aimed at finding solutions to major global challenges we are facing, including climate change, environmental threats, diseases, and ageing populations. Tackling these challenges can involve overturning existing technologies and structures, as well as involving wider and more complex form of governance, stakeholder involvement, and collective actions (Technopolis Group 2019). The governance principle of *responsible research and innovation* (RRI) is often associated with third-generation policy actions or instruments (Section 3.3). Several scholars have been important for the emergence of the third generation of innovation policy. For instance, Schot & Steinmueller (2018) introduced the term *transformative change*, which implies to do things differently in terms of radical change in social, institutional, and legal norms. Furthermore, Borrás & Edler (2014) have written about how socio-technical systems are addressing the fact that individual technical artifacts or innovations are not operating in isolation. On the contrary, the function of innovations is highly dependent on the specific and complex ensembles in which they are embedded. Borrás & Edler (2014, p. 7) stress how policymaking sometimes takes place in a rather isolated manner 'without taking into account various forms of state action, or the complexity of governing change in socio-technical systems'. Geels (2004, p. 19) has introduced the term *system innovation*, defined as 'large-scale transformations in the way societal functions such as transportation, communication, housing, feeding, are fulfilled'. Finally, the Technopolis Group (2019) highlights in its report to the Research Council of Norway that we are facing a transition failure, and it claims that governments are gradually starting to implement third-generation policy instruments to overcome this failure (e.g. European Commission 2017). In the next section (2.3), I present how the different innovation policies and policy instruments have affected universities and their third mission.

2.3 The evolving third mission of universities

The core mission of teaching and education is believed to have been assigned to universities during the later Middle Ages, first at universities in Bologna and Paris (Ridder-Symoens 1992). Research first emerged as a regular mission in German states in the early 19th century

(Scott 2006), starting at Friedrich Wilhhelm University[4]. Several other missions of the universities have been identified, and Scott (2006) mentions, as some prime examples, *nationalisation* – with reference to how they served governments (from c.1500 onwards), *democratisation* – with reference to the provision of individual and societal needs (in the US in the 1800s), and *public service* (in the US in the late 1800s). It is now common to acknowledge that universities having a third mission of providing benefits to society, beyond the two core missions of teaching and research. The third mission was first described by the OECD's Centre for Educational Research and Innovation (CERI) think tank in 1982 (Zomer & Benneworth 2011). Montesinos et al. (2008) describe three dimensions of activities that universities carry out alongside their teaching and research activities: a non-for-profit social approach, an entrepreneur focus, and an innovative approximation. A common feature of all these three dimensions is that they contribute additional benefits for society, but they do so on different terms and for different groups.

Zomer & Benneworth (2011) argue that the rise of the third mission can be seen as a response to three distinct historical drivers: a funding crisis, neoliberalism and increased complexity of knowledge production. The first driver must be viewed as the funding crisis in the higher education sector in the first half of the 20th century. This driver had its basis in the recognition of universities as important for industry and society, and in many ways, it led to the linear model of innovation, as described in Section 2.2. The driver created in stakeholders in society an expectation of endless expansion of scientific research, which in practice resulted in a funding crisis for universities, since they were not able to meet those expectations due to limited resources. Universities then sought to fill their funding gaps with external sources of income, including increased commercialisation activities, such as filing of patents, spin-offs, contract research and consultancy (OECD 2004). According to Zomer & Benneworth (2011), the second driver was the rise of neoliberalism in the 1980s. Neoliberalism can be defined as an ideology and policy model that emphasises the value of international competition in the free markets.[5] It resulted in the evolution of national steering and financing of teaching and research, and governmental expectations of universities to supplement their budgets with income from external sources, including paying customers. In addition, both national governments and the European Commission emphasised the

[4] Humbolt University of Berlin was established in 1809 with the name University of Berlin. From 1928 to 1945 it was named Friedrich Wilhhelm University. The university's current name was formalised in 1949.
[5] https://www.britannica.com/topic/capitalism/Criticisms-of-capitalism

importance of knowledge and technology transfer, and of industry-academia partnerships. As a result, a second generation of innovation policy instruments was implemented to stimulate activities such as public funding schemes and TTOs (Laredo & Mustar 2000; Smits et al. 2010). The third driver emerged with the increasingly complex nature of knowledge production during late 1990s and early 2000s, which required input from experts representing a diverse range of backgrounds, which were not necessarily academic. National research council's worldwide and the European Commission highlighted this complexity with a gradual shift in their funding for programmes for disciplinary research to programmes addressing complex multidisciplinary issues. In line with this, the universities experienced an increased demand for societal impacts from their research, as well as a demand for interdisciplinary and transdisciplinary collaboration. Zomer & Benneworth (2011) conclude that commercialisation and academic engagement should no longer be considered as peripheral add-ons to the other two core missions, but on the contrary, it should be regarded as an additional core mission of universities.

In line with the view of Zomer & Benneworth (2011) on the rationale for the emergence of the third mission, universities have traditionally been evaluated based on their ability to attract external funding for research and innovation activities, patents, license technology, and the creation of academic spin-offs (Gulbrandsen & Slipersæter 2007; Breznitz & Feldman 2012). During the past two decades, there has been a global increase in university support for entrepreneurship, innovation, and commercialisation activities, not only for researchers but also for students. This illustrates the transformation towards a concept labelled the *entrepreneurial university* (Guerrero & Urbano 2012; Etzkowitz 2017; Sánchez-Barrioluengo & Benneworth 2019) (see also Section 3.2.2). However, within the last decade, an additional dimension – possibly even a fourth driver – has been added to the concept of the third mission, since universities have experienced being viewed as societal actors, due to their education of skilled workforces, their participation in policymaking, culture, architecture, research, and innovation infrastructures, and last, but not least, through their creation and dissemination of new knowledge (Breznitz & Feldman 2012; Sánchez-Barrioluengo & Benneworth 2019). According to this broader definition of the third mission, universities are expected to engage in social and societal deliberations, and in decision-making processes in their respective regions, and thereby provide a window to the world for their local region (Chatterton & Goddard 2000; Laredo 2007; Breznitz & Feldman 2012). Recently, a stronger focus on the transition of universities' strategies to sustainability and to green and social innovation has emerged (Montesinos et al. 2008; Benneworth et al. 2016; Reichert 2019), alongside the emerging third generation of innovation policy (described in Section 2.2). The third mission concept is therefore described as being in its infancy as a nebulous and complex phenomenon (Giuri et al. 2019; Compagnucci & Spigarelli 2020; Çinar 2022). This inevitably affects the TTO functions of universities and in the next section (2.4), I elaborate on the Norwegian TTO context and on how it has developed over time due to international trends and national innovation policies. This background is then built into the theoretical framework presented in Chapter 3. However, before moving to the Norwegian TTO context, I first clarify how I define and use the terms 'knowledge transfer' and 'technology transfer' in this thesis.

2.4 Definitions of knowledge and technology transfer

In this thesis, I rely mostly on the term *knowledge transfer* as defined by Argote & Ingram (2000, p. 151): 'The process through which one unit or organisation is affected by the experience of another'. However, I also acknowledge that knowledge transfer is described as involving social conventions and legal rights, economic interests, and including *all activities* that enable the transfer of implicit knowledge, codified or non-codified know-how, and technology into use (Bercovitz & Feldmann 2006). Knowledge transfer is further described as being embedded and 'sticky', implying that it is difficult for the transfer to take place directly without involving personal contact in some way (Polanyi 1956; Nonaka &d Takeuchi 1995). This contrasts with the more passive communication activities which are disseminated from researchers, universities, and other organisations.

According to Bozeman (2000), *technology transfer* can be defined in many ways, depending on the discipline and purpose of the research. However, in the literature, technology transfer is very often considered a subcategory of knowledge transfer (Campbell et al., 2020). In this thesis, I rely on a definition provided by the European Commission (2020):

> Technology transfer (TT) refers to the process of conveying results stemming from scientific and technological research to the market place and to wider society, along with associated skills and procedures, and is as such an intrinsic part of the technological innovation process.

I have chosen to use this definition because it states that technology transfer is an integrated part of the whole innovation process. Although I consider the definition is still based on a linear perception of technology transfer, it does include the wider society and not just the marketplace. Moreover, it acknowledges that associated skills, competence, and procedures need to be in place for successful technology transfer.

2.5 The Norwegian TTO context

In Norway, this third mission of universities was at that time mostly understood as a general dissemination of knowledge to the public (Fagerberg, 2017), which contrasted to how the US, and most countries in Europe interpretated the third mission. In those countries, innovation and commercialisation activities were more explicitly included in line with the simultaneously emergence of the second generation of innovation policy. In 2003, a new law on institutional ownership was passed in Norway (NOU 2003: 25) and to a large extent based on the principles of the US Bay-Dole Act, a federal law from 1980 that enables universities, non-profit research institutions, and small businesses to own, patent, and commercialise inventions developed under federally funded research programmes in the US (U.S. Government Publishing Office 2011). National legislation relating to higher education institutions in Norway included more explicit expectations of collaboration with public and private actors from 2005 (Ministry of Education and Research 2005), and since then the expectations of the Norwegian government and society in general have gradually increased in line with the emerging third mission of universities.

The Norwegian TTO landscape is currently dominated by TTOs organised outside the research organisations, and most of the TTOs have been set up as public companies with multiple owners. This has been the result of a development over the last 40 years, during which a variety of TTO structures has emerged in Norway through an organic growth of old and new organisations (for an overview of this development, see Paper 4). Universities and university hospitals are often the main owners of the TTOs, but ownership frequently includes university colleges and research institutes (Borlaug et al., 2022; Spilling et al., 2015). The rationale for this type of external organisation of TTOs has partly been to achieve a critical mass in capabilities and competence. Furthermore, it has partly been motivated by an intention to achieve a more flexible and less bureaucratic handling of the commercialisation processes than internal departments or offices within large organisations, such as universities can handle.

Although organisational questions were not directly included as part of my research questions, establishment and organisations of Norwegian TTOs became a relevant background and context for my research and it is covered as a theme in Paper 4. To a large extent, I have leaned on the work of Brescia et al. (2016), who have identified the most common organisational KTO structures developed by universities. Brescia et al. (2016) distinguish between three different types of KTO organisations:

- External, where the KTOs are independent companies outside the university (20%)
- Internal, where the KTO activities and processes are managed by dedicated internal offices (65%)
- Mixed, where the KTO activities are divided between internal and external structures (15%).

Among the universities in US, internal offices are the most frequent type of KTO organisation. No such clear trend can be drawn from the data for Europe and Asia, where the distribution of the three types of organisations is much more even (Brescia et al. 2016). Furthermore, Brescia et al. (2016) describe various subcategories of their three main KTO organisational types, including the E-JOINT. In E_JOINT the KTO activities are conducted by an external 'shared' company that are owned and/orworks for more than one university or other research organisations. Other scholars have recently named this subcategory multi-institutional TTOs (MiTTOs) (Fraser et al. 2022), and it is the major organisational model for the TTOs in some countries, including Norway and France (Stevens et al. 2022). Brescia et al. (2016) point out that the E-JOINT, introduced after 1998, was the newest form of KTO organisation. Its introduction was mainly explained by digital opportunities, which lowered the collaboration and coordination costs across geographical and organisational boundaries. The E-JOINT KTO, (MiTTO) types of organisations are considered particularly useful for smaller universities and research organisations, which can benefit from pooling resources into a shared KTO (TTO). Fraser et al. (2022, p. 355) mention several other benefits of MiTTOs: they can establish a pro-commercialisation culture immediately, they provide a critical mass of personnel, skills, and resources, they allow for aggregation of complementary technologies from different sources, and they provide a focal point for lobbying for the importance of tech transfer to government at an early stage. However, Fraser et al. (2022) also point to some important challenges faced by the MiTTOs, such as financial challenges, lack of commitment, and change in the priorities of their owners and member institutions. In addition, the MiTTOs are also facing several operational and cultural challenges (Fraser et al. 2022, p. 356).

Knowledge transfer activities to and from universities have been widely studied by scholars in terms of intellectual property (IP), licencing and management activities, various patent studies, or spin-off creation and support (for reviews see, for example, Link et al. 2015; Cunningham et al. 2020). In addition, the competence and effectiveness of TTO organisations and TTO executives have in general been the subject of many studies worldwide (for a review see, for example, Kirchenberger & Pohl 2016). Although TTOs are considered an important intermediate type of organisation and support structure (Hossinger et al. 2020; Cunningham et al. 2020), a stream of literature reports a negative attitude towards the function and role of TTOs. In this literature the TTOs are described as transaction-oriented and bureaucratic structures that sometimes even slow down the commercialisation processes (Clarysse et al. 2011; Link et al. 2015; Hayter 2016). Historically, the US has been at the frontier of successful technology transfer when measured in terms of licencing fees, and the difference in university licensing fees between the US and Europe is quite substantial (Stevens & Kato 2013). However, Stevens et al. (2022) claim that only the most successful US universities can rely on significant earnings from the licensing budget, whereas the majority of smaller TTOs struggle with earning sufficient sums to cover their expenses. The same has been observed for Europe (ASTP 2020). Several scholars therefore stress that 'one size does not fit all' when it comes to business models for university TTOs (Baglieri et al. 2018) and that the way the TTOs align their support is dependent on the nature and maturity of their innovation and entrepreneurial ecosystems (Roberts & Malonet 1996; Wright et al. 2008) It is also documented that TTOs with strong support from their owner organisations are the most successful in terms of commercial success (Debackere & Veugelers 2005; O'Shea et al. 2005).

The above-mentioned international trends and challenges are also recognised in Norway, where the system for commercialisation of research, including the TTO system, has been subject of evaluations and changes in funding and framework conditions for several years (Spilling et al. 2015; Borlaug et al. 2022). Critical voices have questioned the innovation culture in universities, including the role, tasks, and benefits of the TTOs (Hvide & Jones 2018; Lekve 2019). It has also been debated whether Norway really should have adopted the US system to the extent that it has done. Many have argued that the Norwegian MiTTO system has prevented the universities from including innovation and commercialisation activities in their own strategies and operations. Others claim that researchers are not sufficiently incentivised to take on commercialisation of research (Grünfeld et al. 2018). Also there has been a criticism of the sizes and effectiveness of the various Norwegian TTOs (Lekve 2019). Varnai et al. (2020) stress in a Centre for Digital Life Norway report, labelled the 'AS IS' report, that running TTOs as commercial companies with complex ownership structures complicated their operations and made them support more mature commercial ideas with a higher potential of economic gain. The report labelled the 'TO BE' report, also produced by Centre for Digital Life (Arnold & Patriksson 2021), suggests that TTO functions should be better integrated into a holistic set of knowledge exchange practices. This to prevent a narrow focus on patents and licensing which in turn is reducing the overall effectiveness of university knowledge exchange and the dynamics of the innovation ecosystem. The 'TO BE' report also suggested that TTOs in Norway need more thematic specialisation to succeed.

In 2015, the Ministry of Education and Research conducted an evaluation of the instruments for innovation and commercialisation of research (Spilling et al. 2015). The Ministry of Trade, Industry and Fisheries followed up with a study of incentives for commercialisation of research (Grünfeld et al. 2018). Through the FORNY programme (Norges forskningsråd, 2017) for commercialisation, the Research Council of Norway has supported several projects with the intention to increase competence and professionalisation of the Norwegian TTOs. Many of the Norwegian universities have in addition conducted their own evaluations of their innovation and commercialisation activities and supportive structures, including evaluations of their TTOs (for examples, see Normann et al. 2018: BDO 2019; Kaloudis et al. 2019). Based on evaluations, some universities have already implemented organisational changes in their support systems, with a trend towards establishment of internal support structures for innovation can be detected (for examples, see Tidemann 2022; NTNU n.d.; UiA n.d.). Some of these universities want to include the existing TTOs later in the commercialisation process, making them narrower in scope and more specialised towards generating economic value from research. This trend reflects advice given in several of the reports published during the evaluation process (Grünfeld et al. 2018; Lekve 2019). In 2021, the Ministry of Education and Research launched a tender process for a study of different models for the organisation of TTOs, based on the Norwegian system for technology transfer[6]. As a result of the tender, a recent study by the Nordic Institute for Studies in Innovation, Research and Education (NIFU) has, in a report by Borlaug et al. (2022), identified four possible models for the organisation and financing of TTOs. This report has been used for further discussions among stakeholders, including the universities and the Research Council of Norway. During these discussions, the Norwegian government has signalised that publicly funded research organisations in Norway will be given assignments and incentives to take on more responsibility for their innovation and commercialisation activities, including the TTO functions. The process is ongoing and is expected to conclude during 2024. However, as a response to this ongoing process, an early-stage commercialisation instrument named *lokale prosjektmidler*, which is administered by the Research Council of Norway's FORNY programme (Norges forskningsråd, 2017), has already been changed. This instrument, which until now has been directed through the Norwegian TTOs,[7] will from 2023 instead be directed through the research organisations (Tidligfase Teknologioverføring)[8]. Although, to a large extent TTOs are expected to be partners in the applications from the research organisations to the Research Council of Norway and continue to receive (some) funding, 'The longest duration of *direct* government support [to MiTTOs] documented in this special issue is in Norway, where the Norwegian Government has funded the official Norwegian TTOs through the Research Council of Norway continuously since 1995' (Stevens et al. 2022, p. 351), has now come to an end.

[6] Kunnskapsdepartementet. (2020). Utredning av modeller for organisering og innretning av teknologioverføringskontorene. Konkurransegrunnlag. Anskaffelse etter anskaffelsesloven og anskaffelsesforskriften del I. Sak20/1071

[7] https://prosjektbanken.forskningsradet.no/explore/projects?Kilde=FORISS&distribution=Ar&chart=bar&calcType=funding&Sprak=no&sortBy=score&sortOrder=desc&resultCount=30&offset=0&source=FORISS&projectId=257618&Fritekst=LOkale+prosjektmidler

[8] https://www.forskningsradet.no/utlysninger/2023/teknologioverforing/

3 Theoretical framework

For good ideas and true innovation, you need human
interaction, conflict, argument, debate.
(Margaret Heffernan, 1955–)

As outlined in Chapter 1, the overall objective of this thesis is to provide the fields of innovation studies and economic geography with scientific and practical knowledge about knowledge and technology transfer to and from public research organisation in innovation ecosystems. Accordingly, I have constructed a theoretical framework for analysing knowledge and technology transfer channels to and from universities in addition to the position of the university in an innovation system. This position includes the role of researchers, support structures such as internal departments and technology transfer offices (TTOs), and the collaboration with non-academic partners. The *ecosystem* concept has been used in the framework because of its importance for understanding the *dynamic* nature of knowledge and technology transfer from research. As a technology transfer professional, it is further of special interest for me to understand knowledge and technology transfer in terms of the role and participation of the knowledge transfer offices (KTOs)/TTOs as intermediate actors in the *innovation ecosystem*. I have therefore constructed a theoretical framework reflecting both the position of the TTOs in the innovation ecosystem and recent changes in the roles and tasks of TTOs and TTO executives in knowledge and technology transfer projects.

In this Chapter, I present the theoretical constructs that have been important as guidance when answering the research questions formulated in Section 1.2. However, first, I discuss *pragmatism*, the philosophical tradition underlying the theoretical, analytical, and methodological approaches in this thesis.

3.1 The pragmatic maxim – a practical view of truth

In everyday speech, to be *pragmatic* expresses how to deal with things in a more practical than a theoretical way.[9] As a philosophical tradition, pragmatism was developed in the US in

[9] https://www.oxfordlearnersdictionaries.com/definition/english/pragmatic?q=Pragmatic

the late 19th and early 20th centuries, and broadly speaking the philosophy argues that truth and reality can only be understood in their relation to how things work in the real world. This implies that all philosophical concepts should be tested by means of scientific experimentation and that a claim is true only if it is useful (*Stanford Encyclopaedia of Philosophy* 2021). The first generation of pragmatism was initiated by Charles Sanders Peirce, who was gripped both by the natural sciences and by deeper philosophical questions (Maxcy 2003). Peirce (1878 p. 293) wrote 'Consider what effects, which might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of those effects is the whole of our conception of the object.'

The study of innovation is driven by practice, and while there is a robust lesson to be learnt from past experiences, the field is constantly and rapidly evolving. The introduction to the *Oxford Handbook of Innovation Management* claims 'The challenge for innovation research is to determine and retain the value of the tried and tested, while maintaining interest in the new and emerging with sufficient degrees of circumspection and caution' (Dodgson et al. 2014, p. 7).

I have chosen to follow the advice from Dodgson et al. (2014) to determine and retain the value of testing by adding empirical data to existing conceptual frameworks, rather than constructing my own analytical frameworks. By doing this, I consider my work highly influenced by Pierce's pragmatic maxim. However, due to my approach, my research has also added new perspectives to theory within the field of innovation studies as well as to the field of economic geography. This is elaborated in Chapter 5, where my major findings are presented and discussed in the light of the theoretical framework presented below.

3.2 Innovation systems – a system approach to study innovation

The concept of innovation systems was first introduced by Lundvall (1985) and it provides a system approach to study innovation. Binz & Truffer (2017, p. 1285) describe innovation systems as the 'interaction between firms, universities, policymakers and various intermediaries [which] creates positive externalities that are of key importance in the innovation process, but very difficult to be produced or controlled by any actor on its own'. Innovation systems can be divided in two main categories: *territorial* innovation systems defined by geographical boundaries, ranging from global to regional innovation systems; and *sector* innovation systems, defined by the type of knowledge flows, value chains, industry, or technologies, such as like information and communication technology (ICT), biotechnology, and aquaculture.

The term *national innovation system* (NIS) refers to a territorial innovation system and was introduced by Freeman (1987). A NIS is defined as ‘the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies’ (Freeman 1987, p. 1). A country’s innovative performance largely depends on how these actors relate to each other as elements of a collective system of knowledge and technology creation (Lundvall 1992; Nelson 1993; Freeman 1995; 2004; Edquist 1997). One decade later, the idea that innovation is a territorial and systemic process in a region was put forward and in turn led to the emergence of the concept of a *regional innovation system* (RIS) (Cooke et al. 1997; Cooke 2001; Asheim & Gertler 2005). A RIS is described as an innovation system concept explaining how different industrial clusters or sectors interact with regional governance, research institutions, intermediates, support infrastructure, and the national and global levels of innovation policy and funding structures in order to gain a competitive advantage (Doloreux & Gomez 2017; Suominen et al. 2019).

Both NIS and RIS are frequently used concepts to study knowledge and technology transfer between institutions in a network. From this, there follows an understanding that the institutional relations are the most important interactions to stimulate (or prevent) innovation in a region or country. However, NIS and RIS are considered by some researchers as quite static systems focusing on the established *roles* of organisations and governments to foster innovation rather than *relations* among individual actors in the systems (Valkokari 2015; Smorodinskaya et al. 2017). Consequently, other, more dynamic innovation systems concepts developed alongside the NIS and RIS, such as the ecosystem concept described in the next section, which has become important for my research.

3.2.1 Ecosystems contextualised as innovation concepts

The *ecosystem* concept was first introduced to the management literature in the book *Predators and Prey: A New Ecology of Competition* by James Moore (1993), and it has since emerged gradually in line with the growing need to understand the importance and demands of non-linear and knowledge-based economies. The ecosystem metaphor is borrowed from biological ecosystem (Tansley 1935), and various sector innovation systems concepts have since emerged from this metaphor, such as *business*-, *knowledge*-, *digital*-, *entrepreneurial*-, *innovation*-, and, quite recently, *mission-based ecosystems* (World Economic Forum, 2021). Each of these concepts are described as having a different theoretical background (Valkokari 2015; Tsujimoto et al. 2018). An important feature of the ecosystem concept is the analytical use of networks which are evolving organically. Such networks are based on the competitive and collaborative activities of actors – in the system, as well as on their symbiotic behaviour. External physical factors affecting the system are also considered important. All the actors in the system have their own role to play, with different attributes, decision-making processes, and purposes. In contrast to the NIS and RIS, the boundary of an ecosystem is not limited to a geographical area, but is concentrated around either a value chain, a product, a platform, or an organisation (Valkokari 2015; Tsujimoto et al. 2018). Ecosystems evolve therefore dynamically through interactions between the actors, and their boundaries can be described in terms of being global, national, or regional, as permeable in terms of open or closed systems, as temporal such as time and history scales, or as types of flows such as knowledge, technology, products, or services (Valkokari 2015). The English prefix *eco-* serves to emphasis the non-linear and 'organic' nature of innovation (Smorodinskaya et al. 2017). This is in contrast to for example the strictly *linear* model of innovation as elaborated in Section 2.2. The emergence of the ecosystem concepts is also explained by the need to investigate complex innovation systems that dynamically co-evolve with markets and technologies and that are more self-organised than the RIS and NIS that are regulated by governmental bodies (Valkokari 2015; Smorodinskaya et al. 2017; Heaton et al. 2019). Ecosystems are shown to evolve dynamically through interactions between actors, as well as due to collaboration across various types of ecosystems, such as knowledge, innovation, and business ecosystems (Valkokari 2015). Moreover, different stages of maturation of ecosystems have been identified, and thus the role of its actors such as universities can vary depending on the stage of the system's life cycle (Heaton et al. 2019). Finally, an actor can be embedded in different ecosystems at the same time and have different roles in different ecosystems (Valkokari 2015).

The specific concept of *innovation ecosystems* became increasingly prominent after Adner's review article on innovation strategies and innovation ecosystems was published in *Harvard Business Review* (Adner 2006). The literature on innovation ecosystems typically focuses on *individual actors* and their *relations* (Adner 2006; Bogers et al. 2019). Although the concept of innovation ecosystem might be the most frequently used innovation system concept among scholars and policy makers today, it is nevertheless subject to debate. Especially the element 'eco' has been criticised for its lack of usefulness and distinctiveness in relation to other innovation systems such as NIS and RIS. It is further argued that the prefix has been used ambiguously and often in ways that are not fully understood (Oh et al. 2016). Granstrand & Holgersson (2020) have identified more than 20 different definitions of the term innovation ecosystem, and state that the concept needs to be better defined, and especially to context when employed by scholars and policy makers. In their extensive review article, they find that the most important components of an innovation ecosystem are *actors*, *artifacts* (e.g., products, services, resources, and technologies), and *activities*, which are dynamically linked through relations, collaborations, and competition. In addition, and in line with Valkokari (2015), Granstrand & Holgersson (2020) find that relations with other ecosystems are important. Based on the identified common components, they suggest the following definition of an innovation ecosystem: 'An innovation ecosystem is the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors' (Granstrand & Holgersson 2020, p. 3). I adhere to this definition in this thesis.

3.2.2 Universities as actors in innovation systems

As providers of knowledge and technology, innovative research ideas, education, and candidates, universities are important actors in all types of innovation systems. Hence, the execution of the third mission is closely linked to the role and position of universities within the various systems in which they are embedded. Universities are considered independent knowledge institutions within their innovation systems, but they are also expected to be open to collaboration with external stakeholders when it comes to knowledge and technology transfer (Freeman 1995; Meissner & Shmatko 2017). In addition, universities are increasingly expected to contribute to society through numerous links and connections in terms of policymaking, culture, architecture, and innovation infrastructures.

In recent decades the execution of the third mission has been coupled to the concept of the *entrepreneurial university*, a subcategory within the sector-based entrepreneurial ecosystem. An entrepreneurial university can be viewed as a natural incubator, prioritising and providing support structures for researchers and students to initiate new ideas and new ventures, which are intellectually and commercially beneficial to society (Guerrero & Urbano 2012; Sánchez-Barrioluengo & Benneworth 2019; Secundo et al. 2019; Compagnucci & Spigarelli 2020).

To establish interactions with academic institutions in general, spatial proximity and other geographical factors are considered to be important for the actors in innovation systems/ecosystems (Trippl et al. 2009; Uyarra 2010; Breznitz & Feldman 2012; Kitagawa et al. 2016; Uyarra & Ramlogan 2016; Sánchez-Barrioluengo & Benneworth 2019). Some scholars even claim that academic organisations are the regional *anchors* of the innovation systems in which they are embedded (for examples, see Charles 2006; Schaeffer et al. 2018).

3.3 New roles for TTOs in third mission activities

Even though technology transfer organisations have existed for more than 100 years (Stevens 2022), knowledge and technology transfer activities were for many years mainly considered the results of personal relationships between academic researchers and industrial or public actors. Consequently, the activities were usually not supported by dedicated organisational structures (Geuna & Muscio 2009). The classical university TTO of today, started to emerge after the Bayh-Dole Act was introduced in the US in 1980. This act implemented institutional ownership of research results and especially the intellectual property (IP) (Section 2.5). Today, most universities have established or have access to a TTO or KTO to help and execute their third mission activities (Link et al. 2015). As such TTOs and KTOs have a role as intermediate organisations within most innovation systems. Their role is traditionally to help lower barriers to value creation by stimulating and accelerating productive knowledge and technology transfer, as well as supporting commercialisation and entrepreneurship activities in universities (Etzkowitz & Leydesdorff 2000; Villani et al. 2017; Stam & van de Ven 2021).

Today, with a few exceptions, such as Sweden and Italy (Geuna & Rossi 2011; Mundell 2022), countries have abandoned the ‘professors’ privilege’ system[10]. As mentioned in Section 2.5, the establishment of university TTOs can be viewed in the light of the evolving

[10] The ‘professors’ privilege’ refers to a system whereby individual professors are free to own the inventions they create (and can chose to pay for to patent them). As explained in Paper 4, prior to the 1990s, with the exception of the US and UK, the ‘professors’ privilege’ was the preferred model for ownership and management of academic inventions in most countries. The success of institutional ownership in the US and the UK in the 1980s led other countries to convert to institutional ownership (Stevens & Kato 2013).

third mission, since TTOs were established partly as a result of governmental expectations of universities to increase their budgets with external sources of income, including income from innovation and commercialisation activities. As such, the establishment of TTOs can also be viewed as an important second-generation innovation policy instrument to enhance economic growth and well-being (see Section 2.2). However, TTO activities have been, and still are, in many ways strongly influenced by the first generation of innovation policy. Accordingly, many TTOs have traditionally been set up for, and are expected to by their university owners, to engage in a transaction-focused commercialisation practice, following a linear innovation process. This aligns with the fact that the performances of the TTOs are measured in rather simple output metrics such as (number of) patents, licencing agreements and income, and number of academic spin-offs (Link et al. 2015; Weckowska 2015) and where 'the goal is getting IP out of the door' (Bozeman, Rimes and Youtie, 2015, p. 37). In their revision of the *contingent effectiveness model*,[11] Bozeman et al. (2015) include an extensive literature review of the field of technology transfer and argue that a more non-linear technology transfer mechanism has emerged. They claim that focus on market and economic success in technology transfer fails to capture many of the other ways of creating impact in society, such as through collaborative research. Following this they suggest that technology transfer also should be viewed and evaluated in the light of a public value:

> the Public Value criterion in the Contingent Effectiveness Model acknowledge the fact that economic impacts are sometimes not the best measure of well-being. For example, if economic impacts are in aggregate favourable but exacerbate inequalities then such outcome may not in some circumstances be desired. (Bozeman et al. 2015, p. 35)

The authors argue that the public value criterion is consistent with the emphasis on the concept of responsible research and innovation (RRI) (Bozeman et al. 2015), which includes public participation and other stakeholders in research, innovation, and commercialisation projects (Owen et al. 2013, European Commission 2017).

In line with Bozeman et al. (2015), Baglieri et al. (2018) claim that identifying and measuring several factors associated with university technology transfer effectiveness has limited value

[11] The contingent effectiveness model (Bozeman 2000) has been used worldwide in applications and scores, as well as for the evaluation of technology transfer. It has also been used as a conceptual framework in a wide variety of articles (Bozeman et al. 2015).

without a better understanding of why the factors and relationships exist. Maicher et al. (2019) reviewed the state of the art of technology transfer research and identified a variety of factors that influence TTO performances, including the university and its environment, the size, competence, and structure of the TTO organisation, the research environment, industry, and financing. Finally, the overall technology transfer policy decided on at both the national level (the government) and locally by the research organisation itself will have an impact on the performance of the TTOs. In both Europe and the US there is a trend in TTOs moving away from the narrower technology transfer focus to a broader focus on knowledge transfer, often designated as a transition from TTOs to KTOs (Campbell et al., 2020). This change reflects that knowledge and technology transfer is very difficult to set up as a profitable business. Therefore, factors influencing the TTO performances should also be reflected in the expectations and measurement of output success of individual TTOs (KTOs) (Campbell et al. 2020; Stevens et al. 2022). Considering that innovation systems are becoming increasingly complex within knowledge-based societies, scholars have stressed that TTOs and other actors in innovation systems must engage in interactive learning processes to acquire the necessary knowledge to develop their innovation and commercialisation projects (Rasmussen & Borch 2010; Sadek et al. 2015).

Weckowska (2015) argues that the link between TTO learning processes and learning outcomes needs to be better understood. She makes the following argument:

> many studies assume implicitly that all TTOs aim to develop the same capabilities for the commercialisation of academic research, and that some have made more progress than others. This assumption arguably obstructs our understanding of TTO abilities because it directs the researcher’s attention to the abilities the TTOs are supposed to have rather than those that actually exist. (Weckowska 2015, p. 64)

Weckowska (2015) demonstrates that a relational practice can be beneficial for TTO compared with a more transactional practice. This relational approach involves complex relationship management during commercialisation activities and enables long-term learning and the co-creation of knowledge to support commercialisation projects. According to Weckowska (2015), a relational practice seems to be a better way of coping within complex innovation systems than the more traditional linear and transaction-focused approach that many TTOs are expected to apply. A relational approach acknowledges that the innovation process is not linear. On the contrary, it proceeds as an interactive process where all actors involved in commercialisation projects collaborate to meet research and market needs. Weckowska shows that while some TTOs use a relational approach in the early stages of a commercialisation process, the actions can be more transactional in the later stages of the process, such as negotiating licencing deals or participating in the establishment of spin-off companies. Several other scholars argue that a shift towards a more interactive and relations-focused role would should initiate a necessary change in the traditional role and functions of the TTOs (Jain et al. 2009; Rasmussen & Borch 2010; Zou et al. 2018).

Many universities are steadily striving to become entrepreneurial universities, and there is a growing body of literature showing how researchers are increasingly taking on innovation and entrepreneurial activities (e.g., Kidwell 2013). O'Kane (2018) argues that, due to this increased entrepreneurial engagement, technology transfer professionals are developing a more diverse role by probing deeper into traditional university operations and adopting an intermediary role between the university and various funding organisations. Furthermore, O'Kane et al. (2021) argue that TTOs are expanding their widely recognised role from a traditional binary university-industry intermediary to a more strategic entrepreneurial and innovation ecosystem broker. This intermediate role entails that TTO professionals must interact with a steadily increasing number of actors both inside and outside the university sphere who are important for the development of third mission activities and in particular innovation and commercialisation projects (Hossinger et al. 2020).

However, the linear model for innovation still has a strong standing within universities. Therefore, many university managers are still influenced by the first generation of innovation policy when arguing for more resources for their research and innovation activities. Fagerberg (2017) argues that this is because the linear model is easy to comprehend and fits very well with traditional academic norms and values. When considering knowledge and technology transfer, Bozeman et al. (2015, p. 40) emphasise that 'it is well worth recognizing that technology transfer is one of many missions of an agency or organization, and often not the one viewed as the most important'. As a result, a wide range of perspectives can be found among academics, university leaders, and support personnel regarding technology transfer, ranging from enthusiasm to hostility and cynicism (Bozeman 2000). Academics are in general anticipated to be mostly motivated by their own interest and research agenda and less driven by incentives and external drives like economic rewards (Lam, 2011; Orazbayeva et al. 2019; Van de Burgwal et al. 2019). However, lack of time, resources, incentives, and rewards are reported as important barriers for academics to engage with industry and society in their research (Muscio & Vallanti 2014; Hughes et al. 2016; Sjöö & Hellström 2019). In addition, university inflexibility and bureaucracy, missing organisational capabilities, and lack of university management support are also reported barriers (Muscio & Vallanti 2014; Rasmussen et al. 2014; Hossinger et al. 2020; Leitner et al. 2021). It has also been shown that strong governmental or university obligations to disclose inventions and use the TTO services may have an inverse effect on academics, who might the sidestep their TTOs (Clarysse et al. 2011; Abroeu & Grinvich 2013; Hvide & Jones 2018; van Burg et al. 2021). Additionally, it has also been shown that high royalty rates on university license agreements can lead academics to choose consulting rather than a licensing agreement (Halilem et al. 2017). Recognition among academic peers and motivations for basic research are traditionally viewed among the strongest drivers for researchers to hold their positions within their academic field (Rasmussen et al. 2006; Perkman et al. 2013). Most of the third mission activities are also conceived to conflict with the traditional academic culture and this is likely one of the most important barriers for academics reported in the literature (Perkman et al. 2013; Hossinger et al. 2020). However, there is little evidence suggesting that third mission activities such as academic engagement and commercialisation is skewing academic research towards more applied topics (Perkman et al. 2013). On the contrary, collaboration in third mission activities has been shown to have positive effect on research performance (Perkman et al. 2013; Reymert & Thune 2023). All these factors, motivations and barriers must be dealt with by the TTOs when taking responsibility for their roles and tasks to stimulate innovation, commercialisation, and entrepreneurship in the ecosystem(s) in which they are embedded.

In the next chapter, I present and discuss the methodology behind the research presented in this thesis.

4 Methods and research design

In theory, theory and practice are the same.
In practice, they are not.
(Albert Einstein, 1879–1955)

Inspired by the pragmatic maxim, including in my methodological approaches, I demonstrate and explain in this chapter on how and why I tested existing conceptual and analytical frameworks by adding empirical data. Methods discussed in the research papers in this thesis are not covered in detail here. However, considering the limited space for methodological discussions in research articles, I will describe the research process behind this thesis, including the research methods and methodological reflections on the research design and data generation processes, as well as choice of methods and analysis of the data.

In this thesis I take on a mixed method approach using both quantitative and qualitative methods (Johnson & Onwuegbuzie, 2004; Edmonds & Kennedy; 2017). The choice of methods was related to the three research questions formulated in Section 1.1, and the research resulting in the four individual papers in this thesis. The connection between the research questions and the research in the individual papers is shown in Figure 1 (Section 1.2).

The chapter opens with a brief description of four research projects that have been important pillars for this thesis. I then elaborate on the methods for generating data through territorial embedding assessment (the TEA method) developed by Robinson et al. (2016), which is also covered in Paper 1. I then explain the selection of cases for the two groups of semi-structured interviews, including the choice of research design and data collection. Then I move to the data analysis. The collection and analysis of data for Paper 4 on the TTO context is dedicated a separate section. The chapter ends with a reflection on my own position as a practitioner within the field of knowledge and technology transfer.

4.1 The research projects important for research design and data generation

My PhD project is funded by the by the Public Sector PhD Project (OFFPHD) scheme[12] by the Research Council of Norway (RCN). The overall objective of the OFFPHD scheme is as follows:

> The project must be relevant to the entity's area of responsibility and build knowledge and expertise that is relevant and applicable to the public sector body. (Research Council of Norway 2023)[13]

My employer, VIS, has been the project owner and University in Bergen and the Western University of Applied Sciences (HVL) has been partners in the project. In the OFFPHD scheme it is mandatory to apply for admission to a PhD programme, and to include a project description developed in consultation with the doctoral candidate's supervisor. Through my affiliation to the Horizon 2020 project 'European Marine Biological Research Infrastructure Cluster to promote the Blue Bioeconomy' (EMBRIC, project period 2016–2019) [14] I saw a potential for a PhD project and VIS, my employer, did take active part in defining the objectives of my research. The project description in my application to the PhD programme at the Faculty of Social Sciences at the University of Bergen, remained an important guideline for the design, choice of methods, and the papers on which this thesis is based.

A major part of the empirical work for this thesis, which resulted in two papers (Papers 1 and 2), has been done as an extension of EMBRIC project. The project, coordinated by Sorbonne University, France, was designed to accelerate the pace of scientific discovery and innovation from marine bioresources. EMBRIC had 27 partners, including those from academia, research institutes, not-for-profit organisations, and industry from 10 countries. RISIS project Integrating Activity,[15] which specialises in the analysis of innovation ecosystems across Europe, was included in the EMBRIC consortium. The University of Bergen (UiB) was a partner of EMBRIC, VIS was a subcontractor for UiB, and I was the project leader at VIS. The project was very important for providing access to a valuable network of research

---

[12] Teknologioverføringsfunksjonens rolle i regionale innovasjonssystemer (TTO-RIS) - Prosjektbanken (forskningsradet.no)
[13] Public Sector Ph.D. scheme (forskningsradet.no)
[14] https://cordis.europa.eu/project/id/654008
[15] RISIS 2 | Research Infrastructure for Science and Innovation Studies- RISIS 2

colleagues, to RISIS resources, and to informants and respondents and led to the generation of data for Paper 1 and 2.

The second additional project important for data generation was a three-year research project (2017–2020) led by the Mohn Center for Innovation and Regional Development at the Western University of Applied Sciences (HVL). The project, 'Drivers of regional economic restructuring: Actors, institutions, and policy',[16] was financed by the Regionalt forskningsfond Vestland. One task in that project was to investigate academic spin-offs with research-based ideas/ventures that potentially could create new paths in the region. I was invited to collaborate with the research team at HVL responsible for the task, led by Professor Inger Beate Pettersen, and the collaboration resulted in Paper 3.

The third important project was a national competence and infrastructure project, financed by the RCN, FORNY2020 Finansgruppen (2020–2022)[17], hereafter referred to as the 'FG project'. The aim of the FG project was to build competence and capabilities in Norwegian TTOs. Ten Norwegian TTOs were partners in the project. NTNU's TTO was the formal project owner. The processes and outcomes from the project formed an important background for my thesis and were especially important for Paper 4.

4.2 Data generation

4.2.1 Territorial embedding assessment

Territorial embedding assessment, the TEA method, was developed by Robinson et al. (2016) prior to the EMBRIC project. The method is based on the *research compass methodology*, originally developed as a framework to collect, and characterise the territorial embedding of universities (Laredo & Mustar 2000). The research compass methodology captures five dimensions of activities in which research organisations are considered to interact with industries and society: (1) certified knowledge instruments, (2) training as embodied knowledge, (3) competitive advantages – the innovation aspect, (4) research and public

[16] https://www.hvl.no/en/project/593661/

[17] https://prosjektbanken.forskningsradet.no/en/project/FORISS/308898?Kilde=FORISS&distribution=Ar&chart=bar&calcType=funding&Sprak=no&sortBy=score&sortOrder=desc&resultCount=30&offset=0&Fritekst=Kompetanseprosjekt+TTO

debate, and (5) policy and society links. Collectively, data relating to such activities can be used to create a unique *activity profile* for a research organisation. Based on their work on research laboratories, Laredo & Mustar (2000) argue that activity profiles are of great importance for demonstrating how research laboratories interact with society and industry. They further postulate that the combination of strategies developed by different laboratories, their logics of actions, and the norms, procedures, and policies that accompany, foster, or inhibit them are often superior to organisational structures. The way of thinking in activity profiling as described by Laredo & Mustar (2000) was important for both me and my colleagues when implementing the research compass methodology as an analytical framework in the case study of marine biology at UiB (Paper 1).

As emphasised in the introduction to this thesis (Chapter 1), I take on a holistic approach to innovation and commercialisation. The approach stands in contrast to reductionism, which holds that complex phenomena should be explained by statements about phenomena of a simpler nature and that science essentially means reduction (Keller & Golley 2000). In ecology, the wholes are generally groups of organisms of different species and the parts are individual organisms (Tansley 1935, which in the ecosystem concept corresponds to groups of actors consisting of persons or organisations. In line with the holistic approach the research compass methodology acknowledges that measuring the dynamics of science by codified knowledge through scientific publications, patents, or licence agreements alone is not sufficient, due to the complex nature and relationships between research organisations, industry, and society. By studying collaborative third mission links along all five dimensions covered by the research compass methodology, I argue that I have taken a more holistic approach than if I had studied elements from the various dimensions separately, such as patents, spin-offs or licencing agreements. In addition, through a qualitative approach, I have studied the actors involved in the links in question as a group, in support for my holistic approach.

In the EMBRIC project, a Data Gathering Protocol for the TEA method was developed describing how we, as individual partners, should collect data for each of the five dimensions listed in Table 2. The data were collected within the field of marine biology in the period 2018-2019. The collection included data from the fields of research, innovation, and training within marine biology, including aquaculture, and marine biotechnology in addition to stock-assessment/management and fisheries. Infrastructures are mediators and drivers of regions, The data provide further sustained connections with the various *spheres* of the research compass (Robinson et al. 2016). Also, research and innovation infrastructures are perceived as important parts of ecosystems (see Section 2.2). In order to understand the overall contribution of the EMBRIC partners as a participating actor in their ecosystem, the mapping of infrastructures for each partner in the EMBRIC project was added to the TEA. In the case of UiB, the mapping of infrastructures was done in 2019. See Paper 1 for more details on the data collection. The project partners in EMBRIC project were represented by researchers, TTO executives, or other categories of support personnel working with innovation and commercialisation, and we met regularly from 2017 to 2019 to carry out the tasks. During the workshops, the data collections from the partner institutions were compiled and interpreted to achieve datasets that were as similar as possible. The network and collective data curation became very valuable for my research, not only in the EMBRIC project, but also for additional data collection in the form of interviews, as described in Section 4.2.3. Table 2 gives an overview of the data collected in the EMBRIC project. A more detailed description of the various data collected, as well as the analytical framework used for further analysis of the data material and further research, is given in Paper 1. All data for UiB were used in the research presented in Paper 1.

In my research for this thesis, I have not addressed the same objectives as in the EMBRIC project. I have generated my own unique research questions based on my project description for this PhD thesis. However, it was important to take the embedded characteristics of ecosystems in general into consideration when planning the research design and where the relevance of personal and interorganisational contact was crucial. Hence, to gain a deeper understanding of the motivations and collaborations behind the various channels for third mission links, I included a qualitative approach involving in-depth semi-structured interviews with representatives of selected cases, as elaborated in the next section. The cases were selected from links collected from the third dimension of the research compass, the competitive advantage (innovation) in terms of economic or innovative links (Table 2). Through the TEA method, the EMBRIC project generated a rich dataset of quantitative data from the partner universities and marine research stations.

Additional interviews were done on cases based on academic spin-off projects as described in 4.2.4, but the selection of these cases was not based on the EMBRIC project as explained in the next section.

Table 2. Datasets used for the territorial embedding analysis were collected based on the method described by Robinson et al. (2016) and along the corresponding five dimensions of the research compass methodology as described by Laredo & Mustar (2000).

Dataset linked to the five dimensions in the research compass, for the period 2010–2016*	**Territorial embedding analysis (based on Robinson et al. 2016)**	**Data collected for this thesis**
1. Certified knowledge instrument Publication and project links	(1a) Peer-reviewed academic publications identified as broadly linked to the field in question. (1b) Competitive publicly funded projects, from public funding organisations (European Commission, national research councils). The collection also includes funding from regional funds and foundations.	All recorded marine biological publications (1712 in total) from the University of Bergen (UiB) in the period 2010–2017 (extraction based on keywords from bibliometric databases and information systems). Data collected on all competitively funded marine biological projects (386 in total) at UiB, financed by RCN, the EU, private foundations, and others, in the period 2010–2016.
2. Training as embodied knowledge Educational links	Professional and academic training activities from the research centre/university broadly linked to the field in question.	Data on all marine biological courses from UiB (42 in total) directed towards private and public professionals in the period 2010–2017. Data relating to all 'marine PhD' graduates from UiB (141 in total) and their first job in the period 2010–2017.
3. Competitive advantage (innovation) Economic (innovative) links	(3a) Economic relations between the research centre or university and the private and public sector. This includes contract research, consultancy, service provision, provision of a PhD student, spin-off creations, licencing agreements, and commercial use of infrastructure. (3b) Patents as broadly linked to the field in question.	Data collected relating to all economic (innovative) links and contracts involving UiB (192 in total), the European Humanities University EHU) (70), and Sorbonne University (82) within marine activities in the period 2010–2016. Data collected on all patents (29 in total) within the marine field from UiB in the period 2010–2016.
4. Collective goods, power, prestige, health, well-being, environment Policy links	Participation in standardisation organisations, on boards and policy committees, broadly linked to the field in question.	Data collected on a variety of policy links (77 in total) from UiB in the period 2010–2016 (not exhaustive).
5. Expertise and public understanding of science Civil society links	Links between the research centre (and individual researchers) with civil society broadly linked to the field in question (society links)	Data collected relating to a variety of society links (61 in total) from UiB in the period 2010–2016 (not exhaustive)

4.2.2 The qualitative approach – semi-structured interviews

In total, 51 semi-structured interviews from a total of 18 cases. were held with actors related to innovation ecosystems. All the respondents were linked to a case defined as a third mission activity (a link) from a university. These respondents included researchers and research group members, university department managers, university supportive personnel, TTO executives, investors, and respondents from the external partners. According to Kvale (1996), a research interview is a conversation that has a structure and a purpose. Furthermore, interviews are a good way of gaining access to others' observations, experiences, perspectives, and reflections, and what they think and feel regarding certain events (Weiss 1994). In semi-structured interviews the questions are not predefined in, but a scheme or a guide is normally used (Kvale,1996). I prepared interview guides for the two groups of interviews, as well as for the individual group of respondents.

To gain a deeper understanding of collaborative mechanisms and motivations behind the third mission activities, my unit of analysis in this thesis has therefore been the third mission activity – or link – represented by a collaborative project or contract identified at the university in question.

Two groups of semi-structured interviews were conducted during my PhD research, Group 1 and Group 2, which are discussed in Papers 2 and 3 respectively. For the Group 1, 22 interviews were held on selected cases, based third mission links collected from three selected universities in the EMBRIC project (see Section 4.2.3). The second group (Group 2) comprised interviews held with 29 representatives of academic spin-off cases based on commercialisation projects from VIS (see Section 4.2.4).

Qualitative research is not traditionally characterised by pre-determined response categories, and data is usually derived from a small sample of cases or respondents. For my qualitative research, I adopted an embedded multiple-case study design (Yin (2018). A multiple-case study includes either two or more cases or replications across the cases to investigate the same phenomena. A purposeful sampling approach was used, following the method described by Suri (2011), who describes the logic of the sampling as rooted in the selection of cases that are sufficiently rich in information for in-depth studies. The 18 cases were selected based on pre-selected criteria, which are described for each of the two study groups later in this section. In addition, information such as websites, project descriptions, and media presentations (articles/videos) concerning the induvial projects, were used, both prior to and after the interviews. This to get a better understanding of the cases. All 51 interviews were done as face-to-face, in-depth, semi-structured interviews, and they each lasted 50–90 minutes. Confidentiality and anonymity on both the third mission project and respondents were assured, and the data are protected by data protection service provided by Sikt,[18] (Norwegian Agency for Shared Services in Education and Research). For an overview of the 18 cases, I refer to Paper 2 and Paper 3.

4.2.3 Group 1 interviews

The 22 interviews in Group 1 were selected based on third mission links from three different universities in the EMBRIC project. These represented cases from the third dimension of the research compass and collected through the TEA method. More specifically, the cases were selected based on third mission links related to innovation and commercialisation activities, also termed *innovative links*. The purpose of choosing cases from EMBRIC partners other than UiB was to include an international perspective in my research, in addition to moving towards *theoretical informational redundancy* or *theoretical saturation* (Onwuegbuzie & Leech 2007) in my data collection. Theoretical informational redundancy or saturation can be explained as the point at which newly collected data no longer provides additional insights. In total, more than 40 potential cases were selected from five different EMBRIC partners: Sorbonne University (France), the University of the Basque Country and the University of Vigo (Spain), the University of St Andrews (UK), and the University of Bergen (Norway). Among the EMBRIC partners, these five were selected because they were the most advanced in their TEA analysis. In addition, the five partners represented four different countries. Furthermore, personal relations between me and the other persons working in the EMRBIC project were influential.

Some of the potential cases, especially those relating to innovation and commercialisation links, were reported as being categorised as confidential by the respective universities and none of them include information on the identity of the individual project leaders. Therefore, having good relationships with contact persons within the universities was of utmost importance for me to access both information and respondents. In most of the cases, my

[18] Home page: https://sikt.no/en/home

EMBRIC colleagues assisted in providing initial contact with the respondents. The preselection of the 40 potential cases was done as a purposeful sampling approach based on the collective TEA data in the EMBRIC project. The final selection of cases was done by using the snowball sampling method (Biernacki & Waldorf 1981). In snowball sampling, also known as chain referral sampling, already selected participants refer the researcher to others who might be able to contribute or participate in the study due to their embedded background knowledge of the project or case in question. The method is often helpful for finding and recruiting study participants - or as in this study also cases – who/which might otherwise be hard to find. In my approach, the collaborating partners in the EMBRIC project were actively engaged in both the process of identifying possible third mission links suitable for a case study and identifying the respondents from each case. The respondents then led me to other respondents who were important for the case, including external collaborative partners.

Finally, a total of 11 cases from Roscoff Marine Station at Sorbonne University, the Research Centre for Experimental Marine Biology & Biotechnology at the University of the Basque Country and from the Department of Biological Sciences, Plentzia Marine Station, at the University of Bergen were selected for interviews. All 22 interviews were held in 2019 and most of them were held in connection with meetings or conferences in the EMBRIC project. However, two separate trips, one to France and one to Spain, were necessary to meet with all respondents. Due to the COVID-19 pandemic in 2020, my planned trip to the University of St Andrews for interviews, as well as a second trip to the University of Vigo for supplementary interviews, had to be cancelled. Since I already had collected substantial data for the study, I decided to skip the planned cases from St Andrews, and I regarded the Vigo material as too incomplete to be included.

The interviews were based on the following questions defined in the interview guide:

1. What type of knowledge is the project/contract collaboration building on?
2. What is your motivation for doing this type of project and contract collaboration?
3. What kind of support have you received from your institution/TTO, and are there any internal incentives stimulating these kinds of activities?
4. What types of impact, knowledge, and results have resulted from the project/contract collaboration?

In addition, the respondents were asked about their prior background and experience, the background to the project in which they were involved, and general collaboration and relations among the actors in the project and about the importance of geographical proximity for their project. For a more detailed descriptions of the interviews, see Paper 2.

4.2.4 Group 2 interviews

The study of the second group of interviews, Group 2, consisted of 29 interviews from seven cases within life science and was done in connection with the project on regional structuring at the Western University of Applied Sciences (Norway) (described in Section 4.1). One specific task in the project was to investigate *academic spin-off*s (ASO) with research-based ideas/ventures that potentially could create new paths in the region. Life science represent a field that does have a well-defined sectoral ecosystem in Bergen, and were therefore considered suitable for selection of cases. Third mission links were the unit of analysis also for this study and more specifically the ASO links which originate from Vestlandets innovasjonsselskap (VIS), the regional TTO in Bergen. Together with Helse Bergen at Haukeland University Hospital, UiB has the second largest research base in medicine and life sciences in Norway. This research base is also reflected in the number of ideas within the life sciences received by their common TTO, VIS. Another reason for selecting cases from VIS was that the research teams had good insider knowledge of VIS as a TTO. This eased access to respondents and was helpful for validating research findings. The selection of cases for the interviews was based on literal replication (Eisenhardt & Graebner 2007; Yin 2018) to predict similarities. This mainly because the research team possessed much information about the cases in advance, as well as direct access to the respondents. Seven cases were selected, and 29 interviews were held with 28 respondents. As some of the respondents were involved in several ASOs, they were interviewed more than once. Also, some of the interviews were held as group interviews. The data were collected by semi-structured interviews in two rounds, one early in 2019 and one in late 2020/early 2021.

The study was designed to investigate the roles, complementary competencies, and learning among the team members who were responsible for the commercialisation process. Moreover, the study was concerned with the relational dynamics in what was termed the extended teams of the ASOs. The study wanted to explore how each team collaborated to commercialise the ASO successfully for market entry. Based on the interview guides, all respondents in the extended team were asked about their background, their competencies, roles, learning experiences, and how they executed their specific task and collaborated in their ASO team. When studying larger systems, findings from individual qualitative research studies can reveal patterns from concepts and insights and can be seen as a puzzle of pieces that combine to form an increasingly more complete picture. The themes outlined in the interview guides for the Group 1of interviews (Section 4.2) were, to a large extent, also covered in the interview guide for the Group 2 interviews. This was done as an additional attempt to move towards theoretical informational redundancy as described in Section 4.2.3. For more detailed descriptions of the interviews and data collection for the Group 2 interviews, see Paper 3.

4.3 Data analysis

The data analysis for this thesis has mainly been done by using an abductive approach (Dubois & Gadde 2002; Kennedy, 2018; Reichertz 2009; Tavory & Timmermans 2014), whereby researchers engage in recursive movements by continually going back and forth between the empirical data and existing research and theories. By using this process, the research objectives, analytical focus, and analytical categories can be refined (Tavory and Timmermans 2014). According to Dubois & Gadde (2002), such an approach allows for creativity and intuition to inform theoretical evolution, as well as to understand the generalisable and specifics regarding the observed phenomena. When analysing the interview data, I constantly went back and forth between the increasingly sorted and analysed data, the research questions formulated, and existing literature and theory, as described more in detail in this section.

In research, theoretical concepts and frameworks provide an important background for understanding the research topic. Both within the field of economic geography and within innovation and innovation management studies the literature includes a variety of conceptual frameworks that have been set up to understand the same topic. Granstrand & Holgersson (2020) identify more than 20 definitions of the term 'innovation ecosystem' and argue that the concept is used ambiguously both in science and by policymakers. Ron Adner (2006, p. 9) argues that 'Management frameworks in general, and strategy frameworks in particular, should be approached with suspicion. They rarely tell us anything we don't already know.' Adner's paper is often referred to as having kick-started the emergence of the concept of innovation ecosystems, and he further argues that 'the value of most frameworks lie not in changing a manager's initial intuition but in clarifying the issues that arise when managers with different instincts try to debate the right course of action' (Adner 2006, p. 9). I largely agree with Granstrand & Holgersson (2020) and Adner (2006) regarding their views on frameworks and how they are used, both in research and in practice. When leaning on the *pragmatic maxim* as formulated by Pierce (1878), my choice of methodology was mainly based on existing conceptual frameworks, to which I added my empirical data. In that way I was able to both test and clarify frameworks. I have also added new knowledge to the fields of innovation studies and economic geography by findings that can suggest modifications of both existing frameworks and theories.

4.3.1 Analysis of the data collected through the TEA method

Territorially bounded third mission links can often provide insights into the characteristics and geography of the various connections for a university (Laredo and Mustar, 2000; Robinson et al., 2016). In the case of the UiB and its role within the marine innovation ecosystem of Western Norway (Paper 1), we created an *ecosystem fingerprint*. This method can be seen as a useful means to clarify the third mission of universities through the links and interdependencies with various actors. The clarification was done by further grouping and analysing the dataset collected from UiB in the EMBRIC project in Excel. In addition, the RISIS analytical tool CorText[19] was used in the EMBRIC project to map relations and the geographical distribution of collaborations around the collected links of publications, projects, contracts, and patents. Furthermore, analysis for patterns was performed and distributions in the nature and type of links and of collaborating partners. In that process, the five dimensions and the theory behind the research compass methodology (Laredo & Mustar 2000) were used as an analytical framework to understand the activity profile of marine research at UiB.

I further analysed the activity profile of marine research in relation to the business, knowledge, and innovation ecosystems based on the conceptual framework developed by Valkokari (2015). The term *embeddedness* was introduced by Karl Polanyi (Polanyi 1944). Later, the use of the term was influenced by Mark Granovetter (1973; 1985). Embeddedness

[19] CorText Platform: https://www.cortext.net/

explains how, in addition to more rational economic factors, regional economic success is highly dependent on a spatial factor of which culture, personal relations, and trust are important elements. The TEA method aims to capture of this embeddedness along the five dimensions of the research compass (Robinson et al., 2016). To form an analytical framework with which to illustrate how a university's third mission efforts are impacted by the university's embeddedness in ecosystems of differing scales and scope, I therefore I added the concepts of *local buzz* and *global pipelines* (Bathelt et al. 2004) to the research compass methodology. The general lack of empirical evidence supporting the concept of local buzz and global pipelines has been pointed out and there has been a call for studies that explicitly examine whether or not local buzz and global pipelines merely substitute and reinforce each other (Aarstad et al. 2016; Musil & Eder 2016). By using this concept, and by adding a spatial dimension to the ecosystem framework, I have answered this call and added new insights to theory relating to the concept of local buzz and global pipelines (see Paper 1).

4.3.2 Analysis of the interview data

All interviews were tape recorded and transcribed. In addition, the interviewers took notes during the interviews. Most of the interviews were held in English. For the interviews held in Norwegian the quotes used in the papers were translated to English by me. Based on the themes defined and questions from the interview guides, a first round of analysis was performed, and a rich data corpus was produced. The corpus consisted of quotes based on categorisation for each group of respondents. The corpus was then analysed several times and the findings organised based on the themes partly determined by the interview guides and partly that emerged from the sorted corpus during the analysis. The decision on selection of the final themes in the papers was influenced by continuously reading about relevant theory, and data from additional interviews and the group interviews were included, following the abductive approach described by Dubois & Gadde (2002). For the Group 1 interviews, the process was done by me alone, but for the Group 2 interviews the process was done by me and my co-authors of Paper 3. Relevant quotes for Papers 2 and 3 were then identified and, together with the fully transcribed interviews, they were sent to the respondents for assessment. For more information about the analyses of the interviews, see Paper 2 and Paper 3.

4.4 Collecting and analysing data relating to the TTO context

The FG project had five work packages (WPs)s: (1) Benchmarking, (2) Operating and funding models, (3) Spin-off making, (4) Investor relations, and (5) a collaborative WP that summarised and analysed the other four WPs. Working groups were set up for all five WPs, and I was participating in four of these, in addition to the writing group for the final report.[20] Additionally, 18 subreports were written as part of the project, in which the methods and data collection for each subreport was documented using a common template made by the project leader. All subreports are listed in the final report from the FG Project[21] . Paper 4 in this thesis is based on the FG project. In this section I elaborate only on the data collection and analysis resulting in sub reports 5, 8, and 18, as they are the main sources of data in Paper 4, which not include a separate method section.

The subreport 5, headed 'Litteraturgjennomgang', presents the most relevant and recent scientific literature, as well as other reports on knowledge and technology transfer functions, with emphasis on TTOs. The intention was not to construct a scientific literature review, but to provide an overview of the field of knowledge and technology transfer upon which the FG project could be based. The literature review has been an important source of information for Sections 2.5 and 3.3, as well as for all four papers in this thesis.

Subreport 8, headed 'Kommersialisering av forskning i et historisk perspektiv', documents the historic development of public-funded instruments for the commercialisation of research in Norway, with an emphasis on TTOs and the FORNY programme. Relevant documents were collected from Research Council of Norway (RCN), ministries, and universities. In addition, key personnel were contacted directly to answer questions that arose when the collected documentation was unclear or seemed to be incomplete. The report includes a timeline for the development of public-funded instruments for the commercialisation of research in Norway. The timeline, with its corresponding documentation forms the basis of the history of the Norwegian TTO system presented in Paper 4.

[20] 'Fra mulighet til virkelighet i spennet mellom forskning - forvaltning – forretning'. Unpublished report from kompetanseprosjektet Finansgruppen (FG-prosjektet), a TTO kompetanseprosjekt.

[21] The FG report produced in 2021 and the subreports can be accessed by contacting the project leader, Lasse Olsen, at NTNU TTO (https://www.ntnutto.no/about-us/employees/)

Subreport 12, headed 'Nøkkeldata fra TTOene', is a collection of all the reported result indicators from the TTOs to the RCN's FORNY programme. Relevant for this thesis are: number of incoming ideas, patents, licencing agreements and academic spin-offs. The reporting is part of the Norwegian government's '*mål and resultatstyring* (MRS)' (target and results management) method, as defined in §4 of the 'Økonomireglementet' (DFØ 2023a). The MRS method is based on New Public Management principles (DFØ 2023b). Data from the period 2006–2020 were provided from the RCN and used as a basis for the documentation and analysis of the TTO development in several of the subreports in the FG project. For Paper 4, the development of the number of incoming ideas to the TTOs, the number and incoming licencing agreements, and the number of academic spin-offs were used to describe and analyse some aspects of the development and the results from the Norwegian TTOs. All data presented in Paper 4 are based on the MRS data collected from the RCN.

The TTO competence projects funded by the RCN in the period 2020–2022 (see footnote 17) and the FG project in particular (see footnote 20) constituted an important background and context for this thesis. However, as elaborated in the introduction (Chapter 1), I have been working as a professional within the field of knowledge production for the most of my career and with technology transfer for more than eleven years. Before discussing the main findings from my research in Chapter 5, I first reflect on how this might have affected my role as a researcher within the fields of innovation studies and economic geography.

4.5 My role in research as a practitioner

During my PhD project I have been aware of my position as a practitioner within the field of knowledge and technology transfer and reflected upon how could have influenced my research. In this section, I highlight some aspects relating to those reflections.

The OFFPHD programme requires that doctoral candidates will engage in research that is relevant for their public sector employer (Research Council of Norway 2023):

> The project must be relevant to the entity's area of responsibility and build knowledge and expertise that is relevant and applicable to the public sector body.
> [...]

> A Public Sector PhD project is a collaboration between three parties: the public body, a degree-conferring institution or university and the candidate.

During my PhD period, I have been constantly challenged to consider my close connection to the field of technology transfer and especially whether I was being biased or had prior assumptions in my research design, data collection, and data analysis, as well as in the research questions and the selection of relevant theoretical and analytical frameworks. I have also been warned, by my supervisors, about the risk of having findings that might not be considered favourable by colleagues or managers within my own profession, technology transfer.

In the PhD course 'Philosophy and Ethics of Social Sciences', I used Bourdieu's *field theory* (Bourdieu 1977; 1984) to reflect on my own background, as well as to guide my reflections on academic motivations and culture. In the methodological PhD course 'Production and Interpretation of Qualitative Data', I found the course sections on the interview situation very useful for my upcoming data collection. I also read about *action research*, which is now a widely accepted philosophy and methodology of research aimed at transformative change through the simultaneous processes of doing research and taking action in a field through a collaborative partnership of participants and researchers (Somek 2006, pp. 6–7). Although I did not do action research directly for my thesis, I realise that my methodology was quite close. I have worked on TTO competence and infrastructure projects, assisted TTO managers in policy questions, and contributed to public debate that relates to the topic of my PhD work. As such, the aforementioned contributions have been influenced by the knowledge created in my research and based on critical reflection, which is one of the criteria in action research methodology.

The overall objective of this thesis is to provide the research field of knowledge and technology transfer with both scientific and practical knowledge. During my research I have been aware that my background could make me jump to conclusions without sufficiently empirically or theoretically foundation. Especially when findings fit well in describing recognisable practical challenges. Due to awareness of this risk, I have been hesitant to use my findings prematurely. Sometimes my reluctance to conclude has even caused frustrations among my colleagues in technology transfer who sometimes did see the same opportunities as me. Reading the literature on action research was particularly helpful for me to understand my role as a researcher in my own field of practice. For example, Lewin (1946, p. 43) states: 'We will have to recognize the difference between fact finding and policy setting and to study carefully the procedures by which fact finding should be fed in the social machinery of legislation to produce a democratic effect.'

This thesis focuses on knowledge and technology transfer in innovation ecosystems, which are systems characterised by highly embedded actors. When studying such complex systems, I have realised that a multifaceted background can be an advantage when interviewing actors from different fields. With regard to this reflection, I found Bourdieu's field theory (Bourdieu 1977) and his concept of *habitus* quite useful. Not only to help me understand my own background, but also to give me a better understanding of the different cultural factors that influence the behaviours and processes relating to the third mission activities in the academic landscape. Habitus was defined by Bourdieu (1984, p. 170) as 'A structuring structure, which organises practices and the perception of practices.' According to Bourdieu, habitus consisted of our thoughts, tastes, beliefs, interests, bodily stances, and understanding of the world around us. My personal background has been formed by a typical middle-class home, while my educational background has been formed by two master's degrees, one within the natural sciences (biology) and one in the social sciences (technology management). I have work experience as a researcher, administrator, and manager in the university sector and as a technology transfer professional. Moreover, I have worked within the field of knowledge management as a library director at UiB and I am a fruit farmer. With this diverse background, in addition to my pragmatic nature, I consider myself able to assess a case from many angles and perspectives, both in research and in my (working) life in general.

As outlined in Section 4.2.2, I have chosen semi-structured interviews the most suitable method for collecting my qualitative empirical data. According to Martin Hess, researchers need to interact with their research subjects. Yet this is difficult to achieve when administering a questionnaire.[22] Furthermore, Hess is stressing that it is imperative for researchers to have some degree of practical knowledge and understanding of the field in which they are conducting research on. Moreover, as stated by Oinas (1999), it is important to understand and respond to the speech genres and social languages used by interviewees.

[22] Martin Hess, lecture titled 'Investigating embeddedness: Qualitative methods and cross-cultural research', delivered at University of Bergen in October 2017 for PhD Course GEO901 'The Production and Interpretation of Qualitative Data'.

My background was certainly an advantage during my research, as it allowed me to interact with my respondents in the different social fields during my data collection. In the Group 2 interviews, which resulted in Paper 3, my co-authors held all the interviews with VIS employees. This avoided me having to interview my own colleagues.

As already mentioned, I have been careful about revealing conclusions from my research too early. However, during the entire research process I have been active in disseminating information by taking part in ongoing processes and public debates when relevant. I have seen this as not only a natural part of a public PhD programme, but also as a way of giving something back to my community. I have also given advice and provided input to VIS management and VIS processes, as well to other TTO leaders, based on knowledge and insights acquired from my research. Through my participation in the EMBRIC project, my research has also benefitted UiB. The presentations, papers, and ultimately this thesis must therefore also be considered a contribution to practitioners within the field of innovation, knowledge, and technology transfer at universities and in other research organisations, as well as in TTOs, innovation companies, and governmental bodies. My plan is to continue this knowledge exchange and dissemination of my research findings, but with a reflective approach.

5 Main findings and contributions

The secret of change is to focus all of your energy,
not on fighting the old, but building on the new.
(Socrates (470–399 BC)

In this section, I return to the four research papers and discuss their main findings and implications considering the research questions and the theoretical framework and concepts outlined in Chapters 1–4. However, first, I present the individual papers and briefly describe their content and contributions. I refer to Papers 1, 2, 3, and 4, in sequential order.

5.1 Presentation of the four papers

5.1.1 Paper 1

Randi Elisabeth Taxt, Douglas K.R. Robinson, Antoine Schoen and Arnt Fløysand (2022). The embedding of universities in innovation ecosystems: The case of marine research at the University of Bergen. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* 76(1), 42–60.

The main purpose of this paper is to illustrate an approach that captures the various contributions of universities to their innovation ecosystems. In the paper, my co-authors and I assume that while often territorially bounded, such third mission links, provide insights into the characteristics and geography of the various connections for a university. With a rich case from the University of Bergen, which is also based on the data collected in the EMBRIC project, we demonstrate how the university is embedded within the marine innovation ecosystem of Western Norway. We do this by using the TEA method (Robinson et al. 2016), based on the research compass methodology described by Laredo & Mustar (2000). We also add a spatial dimension to this methodology by including the concepts of *local buzz and global pipelines* (Bathelt et al. 2004). Finally, by using the framework developed by Valkokari (2015), we empirically demonstrate how the actors are positioned and how they collaborate in third mission links across various ecosystems, such as *knowledge*, *innovation,* and *business* ecosystems.

One of the main contributions of this paper is the empirical demonstration that while UiB is mainly embedded in the knowledge system, its TTO, VIS, belongs to the innovation ecosystem and the business partners in the business ecosystem. Additionally, we claim that dividing the roles of a university between the knowledge, innovation, and the business ecosystem better corresponds to traditional values of a university within research and education. Moreover, we suggest that this may help practitioners, as well as policymakers, to understand, communicate and act more effectively when it comes to the different roles and contexts of universities. The paper also shows how UiB contributes important knowledge to ecosystems through global networks and international project collaboration, but we also demonstrate that regional cooperation is of importance for UiB, also scientifically. Hence, the findings imply a degree of 'global buzz' and 'local pipelines'. By these findings the paper provides an empirical insight into the mechanisms by which actors gain knowledge and expertise at different spatial scales. In this way, our findings support the criticism of the concept of the local buzz and global pipelines as being too general and that the distinction between local and non-local relationships is too broad. A further contribution is the empirical demonstration of how a university through third mission links is orienting its strategy and culture towards activities relating to the provision of scientific advice/policy advice with emphasis on the UN's sustainable development goals (SDGs) (United Nations n.d). Finally, though this study we have developed an *ecosystem fingerprint*, which can be seen as a useful means to clarify the third mission activities, roles, and position of universities in ecosystems.

5.1.2 Paper 2

Randi Elizabeth Taxt (2023) Motivations for academic engagement and commercialisation: A case study of actors' collaboration in third mission activities from three European universities. *Industry and Higher Education* (resubmitted March 2023).

The overall goal of the study presented in this paper is to investigate the differences that exist in motivations of researchers and other collaborating actors to engage in third mission activities. The paper considers the evolving third mission of universities and explores whether this has had any effect on the motivations of the actors involved. By exploring cases within marine biology from three universities in Europe, namely Sorbonne University, the University of the Basque Country, and the University of Bergen, I empirically demonstrate how the universities perform their third mission activities in terms of collaborative projects with public and private actors. The paper investigates how researchers are motivated and how they collaborate with their external partners, as well as with university support structures and technology transfer offices. The cases were selected based on data collected through the TEA method in the EMBRIC study. The data used for the analysis were collected through 22 semi-structured interviews relating to 11 cases.

The research questions in the paper were formulated based on identified research gaps in the literature. The findings give new insights into motivations for academic engagement as opposed to commercialisation activities in light of the evolving concept of the third mission of universities. Empirically, the paper demonstrates that while commercialisation projects are based on ideas originating from novel and basic research, academic engagement is based more on the general knowledge and capabilities of researchers and their research environment. For all groups of actors involved in the study, the identified motivations for engaging in third mission activities were mainly concerned with getting the results of research out into society rather than driven by monetary rewards. Furthermore, the findings imply that researchers are more satisfied with the internal support structure set up at universities for academic engagement projects than with the support structures for commercialisation activities, such as TTOs.

The findings presented in the paper challenge some existing theories in the literature on the distinction between the nature of and motivation for academic collaboration as opposed to commercialisation of research (Perkmann et al. 2013; 2021). By examining in depth the processes and mechanisms for knowledge and technology transfer, possible new findings about motivations for collaboration in third mission activities are revealed for several groups of actors. The findings also have some implications for practitioners and policymakers. I advise that universities might consider giving researchers more freedom to choose between academic engagement and commercialisation paths to achieve greater impacts from research for society. Moreover, policymakers, university managers, and support structures such as TTOs, should consider academic engagement and commercialisation activities as equally important parts of the third mission. As a consequence, they should consider broadening the roles and tasks of their TTOs (KTOs). A more seamless inclusion of the TTO activities in universities' third mission projects could be mediated towards more 'non-money driven' contributions. Furthermore, different funding models or mechanisms for the TTOs could be considered, to prevent the quest for financing for their activity's priori to collaboration in the projects. Finally, universities might reconsider their incentive for third mission activities, including avoiding too high expectations regarding income from commercialisation projects. However, I also advise universities to balance their incentives when promoting third mission activities, since scholars have demonstrated that researchers might act in the opposite way when universities become too eager regarding their obligations.

5.1.3 Paper 3

Randi Elisabeth Taxt, Øystein Stavø Høvig and Inger Beate Pettersen (2022). The relational dynamics in the extended teams of academic spin-offs: a Norwegian case-study. *International Journal of Research, Innovation and Commercialisation* 4(1), 31–51.

The main goal of this paper is to investigate the inherent complexities and tensions, and the balancing role of the different actors in the commercialisation process of academic spin-off (ASO) projects. In particular we investigate the role of technology transfer offices executives in commercialising ASOs, but also include other actors, such as academic entrepreneurs, department leaders, chief executive officers of companies, and investors. We name this group of actors *the extended team*. We assume that the actors in the extended teams have different roles, identities, and competencies, and need to cope with inherent challenges, conflicts, and dilemmas in the process of performing the third mission activities of universities, namely commercialising of ASOs. Thus, the paper responds to a call to adopt a more dynamic view in analyses of the commercialisation of ASOs (Hayter 2016; Hossinger et al. 2020. Furthermore, a need to integrate the interplay between different levels and actors surrounding the spin-off is identified. The data collection was done through semi-structured interviews with representatives of seven cases selected from VIS's portfolio of ASO projects within health and life sciences.

By taking a relational approach to the commercialisation processes, the qualitative study presented in in this paper contributes to the literature by showing how an extended team of various actors communicate and co-create in a dynamic process, and how they exhibit balancing roles and tensions in that process. The results also demonstrate that actors that gain experience within technology transfer will in turn initiate systems and build capabilities within their universities, TTOs, and even investor companies, to support commercialisation activities such as the development of ASOs. We also claim that, as a collective, the extended team may provide the necessary industrial, managerial, and entrepreneurial experience to spin-off growth. An example is how investors' close engagement in the team may overcome problems in the fundraising process. Furthermore, in support of theories developed by Weckowska (2015) and O'Kane (2018), the paper demonstrates how interactive learning and relation-focused practice was crucial for the studied TTO executives to handle complex tasks in spin-off processes. Finally, the study shows how relations-focused commercialisation practices might produce conflicting roles and tensions, such as when academic entrepreneurs develop a hybrid identity between research and entrepreneurial activities or when TTO executives become 'too' engaged in an ASO project.

The paper also includes some implications relevant for practitioner and policymakers. We show that relation-oriented practice is superior to transaction-focused practice, especially in early phases of a project. This might have implications for TTO leaders, TTO owners, and policymakers. Furthermore, we show that competence and learning acquired through commercialisation practices are beneficial for all actors involved. Finally, we demonstrate the importance of including the parent organisation of the ASO, especially at departmental level, in the extended team. This could be important knowledge for TTOs, as well as for universities, when they set up their internal rules and procedures for commercialisation projects in general and ASO in special.

5.1.4 Paper 4

Randi Elisabeth Taxt, Anne Christine Fiksdal, Lasse Olsen and Jorun Pedersen (2022). The Development of Technology Transfer in Norway – A System in Flux. *les Nouvelles* LVII(4), 285–292.

This paper elaborates on the history and background of the development of the Norwegian TTO system and is a contribution to a special section on independent, third-party, multi-institutional technology transfer organisations (MiTTOs), in the American journal *les Nouvelles*.[23] The paper refers back to the first technology transfer from a university patent in Norway, by the physicist Professor Kristian Birkeland at University of Oslo. The patent paved the way for Eyde and Birkeland to set up Norsk Hydroelektrisk Kvælstof-Aktieselskab

[23] https://lesi.org/publications/les-nouvelles/about-les-nouvelles (Licensing Exectutives Society International, n.d.)

in 1905. The paper then moves into the more recent history of technology transfer in Norway and how the development has resulted in the establishment of the 11 technology transfer offices (TTOs) that exist today, 8 of which can be classified as MiTTOs. The paper makes a point about how the establishment of the TTOs in connection with the universities was a result of the abandoning of the 'professors' privilege' in Norway in 2003, a process very much influenced by the 1980 Bayh-Dole Act in the US. The paper elaborates on the first years of that development, which was characterised by growth, structuring, and professionalisation development of the TTO structure. Thereafter, followed a period of merger and restructuring, starting with Inven2[24] in 2010.

The final sections of the paper describe the last 5–7 years, characterised by a tendency towards stagnation of classical TTO measures such as licencing agreements and academic spin-offs. This is followed by a presentation of the ongoing TTO debate in Norway and how the TTOs have become subjects for evaluations, both by the Norwegian government and by their individual owners. The paper ends with a discussion and some concluding remarks. The discussion concerns whether the stagnation might be a result of the emergence of the entrepreneurial university, but without the proper inclusion of the TTOs in this process and stresses the need for the special type of competence that TTO executives hold. In conclusion, the authors hope is that the ongoing changes in Norway will result in a system that is able to maintain and use the specialised competencies that have been developed in the TTOs and that the Norwegian TTOs will be able to embrace and exploit the ongoing changes and not just stick to 'business as usual'.

In the following section, I discuss and summarise the main findings from Papers 1–4 in the light of the research questions from section 1.1 and theory outlined in Chapters 2 and 3.

5.2 Summary and discussion of the main findings

In the summarising and discussing of my main findings, I return to the main objective of this thesis, which is to provide knowledge generated both scientifically and through professional practice about knowledge and technology transfer to and from public research organisations in innovation ecosystems. I have done this by applying theories, concepts, and framework

[24] Inven2 - Innovation through research and development - Clinical studies

outlined in Chapters 2 and 3, and by addressing the research questions (RQ) formulated in Section 1.1. My main findings can be briefly summarised by the following points:

- *The nature of third mission activities in ecosystems.* Universities, TTOs, and external collaborative partners are embedded in different types of ecosystems with different logics of actions. When collaborating in third mission activities these actors span the boundaries of the ecosystems in which they are embedded. Through its focus on third mission links, my thesis provides new insights into the mechanisms for collaboration and relational dynamics across ecosystems borders, in both time, and space. In addition, an ecosystem fingerprint is developed, which can be seen as a useful means to clarify the third mission activities, roles, and position of universities in ecosystems. My findings and contributions associated to this point are addressing RQ1, on how knowledge and technology transfer activities are involved as part of the third mission activities of universities in ecosystems. This point also addresses RQ2 on how university third mission activities are impacted by the embeddedness of the actors and by the different scales and scopes in the various ecosystems.

- *Motivations and collaboration of actors involved in third mission activities*. The nature of and motivations for third mission activities seem to reflect social engagement rather than economic rewards. This is not only the case for researchers, but also for other involved actors, such as department leaders and TTO executives, as well as external collaborative partners. These findings demonstrate the ongoing transition of third mission activities from the monetary-driven and commercial-oriented *second generation innovation policy* actions towards more diverse and mission-oriented *third generation innovation policy* actions. This point is mainly addressing RQ3 on how actors in ecosystems are motivated to take part in third mission activities and what they do experience as challenging during those activities.

- *The role of TTOs in the third generation of innovation policy*. When supporting research based innovation and commercialisation activities, universities seem to be, along with other research organisations and public funding institutions, still influenced by the second generation of innovation policy and possibly to some degree the first generation. In other words, they still favour economic rewards and considering TTOs mainly to play a part of commercial activities alone. However, the third mission of universities is in transition towards the third generation of innovation policy. The question remains as to whether this transition is well enough reflected in a in the roles and missions of KTOs and TTOs, or if these need to be better aligned with this emerging third generation of innovation policy actions. This point is also mainly addressing RQ 3, about the challenges actors are experiencing in the collaboration in third mission activities. However, this point is also enlightening RQ2 about the embeddedness of the actors in the various ecosystems, as well as RQ1 on how knowledge and technology transfer activities are involved as part of the third mission activities of universities in ecosystems.

In the following chapter, I discuss my findings and especially how they are supported by my research. This is followed by suggesting some implications for future research. Finally, I close my thesis with a reflection on the implications for policymakers and practitioners, including some advisory comments.

5.2.1 The nature of third mission links in ecosystems

I have argued that the framework developed by Valkokari (2015) is very useful to demonstrate how universities are embedded in several ecosystems simultaneously and how they are connected to other actors in the systems, such as TTOs, industrial companies, and funding organisations. In line with the *pragmatic maxim*, I have demonstrated this through empirical testing of the framework (as discussed in Chapter 4). As deduced in the theoretical framework in Chapter 3, an actor can be embedded in several kinds of ecosystems, each with different logics of actions. In Paper 1, my co-authors and I demonstrate empirically that while the studied university (UiB) is mainly embedded in the knowledge system, its TTO belongs to the innovation ecosystem and its business partners belong mainly in the business ecosystem. Other external collaborative partners in third mission activities can belong to other sectoral ecosystems such as ICT or to ecosystems built up along various platforms and infrastructures important in the value chain. One of the findings in Paper 1 is that when categorised according to the five dimensions of the research compass, the collected third mission links seems to correspond closely to the actor's involvement in business, knowledge, and innovation ecosystems, as described by Valkokari (2015). A schematic illustration of the interaction of actors who collaborate in third mission links within three different ecosystems is provided in Figure 2.

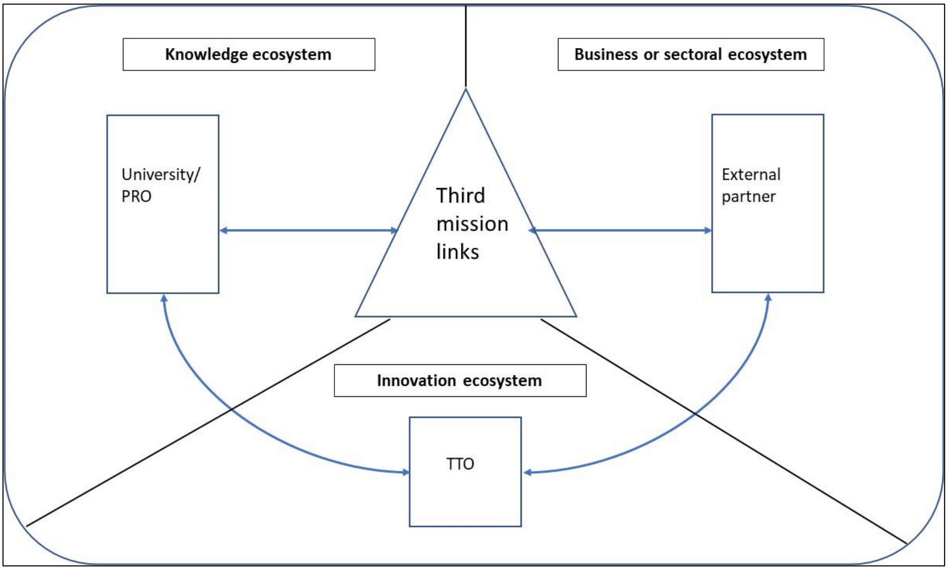

Figure 2. A framework for understanding collaboration through universities' third mission links, showing how the actors involved cross the boundaries of knowledge, innovation, and business ecosystems to execute the activities in the third mission link. PRO = public research organisation. The external partner can be both from public and private sector.

The framework presented in Figure 2 illustrates that when actors collaborate to achieve impacts from third mission links, they (the actors) must cross the boundaries of their 'natural' ecosystem and enter other ecosystems. Depending on the nature of the third mission link, collaboration can take many forms and can be highly influenced by external factors, including policy and funding instruments. The framework supports the non-linear nature of innovation and demonstrates a mechanism for collaboration across ecosystems, as called for by Valkokari (2015). In Papers 2 and 3, the mechanisms for these types of collaborations are studied more in detail through a qualitative approach. Both papers reveal how crossing ecosystem boundaries can help to produce new and innovative products and processes, but also create tension and conflicts. These two papers also reveal that when conflicts occur, the support actors such as department managers and TTO executives might tend to 'return' to their natural ecosystem and the innovative and commercialisation processes will slow down. However, the cases presented in the two papers also demonstrate that when the involved actors understand the logics of actions in ecosystems other than their 'own', they are more capable solving problems that arise through the collaboration.

I argue that by dividing the roles of a university between the knowledge ecosystem, innovation ecosystem, and the business or sector ecosystem, they will in many ways correspond more closely to the traditional (academic) roles and values of a university. Hence, the division may help to communicate in a better way the different roles for a university, as well for other actors in the various ecosystems. In addition, I claim that such a division might help to clarify the ambiguous use of the term ecosystem. The division would especially help to clarify the term innovation ecosystem, which has been described as having been used imprecisely, both in the literature and by policymakers and practitioners (Granstrand & Holgersson 2020; Hossinger et al. 2020) and must be considered a contribution to the existing literature. Furthermore, by this approach, I have illustrated how key actors in the different ecosystems are placed in connection to each other in the overlapping ecosystems, thus demonstrating some of the relational dynamics between those systems, which has been called for by Valkokari (2015). As such the 'ecosystem fingerprint', developed in Paper 1, can be seen as a contribution to clarify the third mission of universities through the links and interdependencies with various actors.

Thus, by highlighting the complexity of the various ecosystems with their different logics of actions this thesis contributes to a better understanding of the roles that the various actors, including TTOs, possess within the various ecosystems. Especially within innovation, commercialisation, and co-creation of value (Granstrand and Holgersson, 2020; Valkokari, 2015). In addition, I have demonstrated empirically how, through its third mission links, a university can both act as a global pipeline provider and contribute to local buzz. I have done this by combining the concepts of local buzz and global pipelines developed by (Bathelt et al. 2004) with the research compass methodology developed by Laredo & Mustar (2000). Moreover, my research clearly demonstrates how the number of various intermediates, research centres, industry cluster organisations, and infrastructures (artifacts) have increased over time, especially in the innovation ecosystem (Paper 1). In line with Hossinger et al. (2020), I argue that this increased complexity particularly affects the TTOs as actors in the innovation ecosystem, a topic that I return to in Section 5.2.3.

5.2.2 Motivations and collaboration of actors involved in third mission activities

By examining the processes and mechanisms for knowledge and technology transfer, my research has generated new findings about the motivation for collaboration in third mission activities. In addition, I have demonstrated empirically how university support structures have contributed to this process. One important contribution is that drivers for third mission activities are evolving from being monetary-oriented to more societal and mission-oriented in the case of universities as organisations, individual researchers, TTOs, and even external project partners. These findings emerged from the analysis of the qualitative interviews reported in Papers 2 and 3 and collectively, the analyses of the 18 cases moved towards generalisation of this finding. Supportive of this, Paper 1 presents the case of a university that has been orienting its strategy and culture towards international activities relating to scientific advice and emphasis on the UN's sustainable development goals (SDGs) (United Nations n.d.). Therefore, I argue that I have empirically demonstrated how the transition of third mission collaborations in a university is gradually moving towards the third generation innovation policy in a way that has not been demonstrated previously in the literature. I have also demonstrated empirical data that actors in knowledge, innovation and business different ecosystem are transitioning towards sustainability and mission-oriented collaboration.

However, the studies presented in Papers 2 and 3, have demonstrated that the support system at the universities and TTOs are lacking strategies and capabilities for promoting and supporting third mission activities. From the analysis of the cases in Paper 2, this finding seems especially associated with commercialisation of research. Based on my research, as well as on existing literature (Bozeman et al., 2015; Fagerberg et al. 2009; Fagerberg 2017), I argue that university support structures for third mission activities, including most of their TTOs, are caught in the perception that economic growth is the major goal of third mission collaboration. This perception stands in contrast to the social and mission-oriented collaboration across actors and ecosystems, including the involvement of external stakeholders that characterise the third generation of innovation policy instruments (Technopolis Group 2019). I further argue, in line with Fagerberg (2017), that most universities and funding institutions in many regards seem to be stuck even in the first generation of innovation policy and favour a linear approach when setting up support structures, funding, and evaluation instruments for third mission activities. In the next section, I discuss how these conflicting landscapes influence the roles and tasks of TTOs in ecosystems.

5.2.3 The role of TTOs in the third generation of innovation policy

In my research, I have found that university researchers are disappointed when they experience lack of support from their peers and department leaders. I have also found that absence of support and even opposition to the commercialisation processes from university managers can disincentivise researchers who are interested in developing their ideas in an innovative direction. In Chapter 3, I highlight how the process of transitioning into entrepreneurial universities capable of supporting innovation and commercialisation in a favourable way both for the involved actors and the wider society, can be slowed down by the fact that they are large, bureaucratic, impersonal, hierarchal, and multilevel organisations based on rules, procedures, and control (Kirby 2006, Hossinger et al. 2020). My research has added empirical data to the literature in this regard. Paper 4 is discussing whether the stagnation in classical output results from the TTOs in Norway in recent years might be a result of the emergence of the entrepreneurial university, but without proper inclusion of the TTOs in that process. The paper also stresses how this affects the TTO executives in a negative way. However, along with Perkmann et al. (2013), I argue that a resistance towards activities or tasks that do not contribute to stimulate research or academic careers to a large extent can be explained by academic culture and affected by social capital as described by Bourdieu (1984). I further argue, based on my findings, that this might also be the case for university managers and supportive personnel within a university.

My findings suggest that TTO executives seem to benefit from a more relational approach in their commercialisation processes supporting the research by Weckowska (2015). In line with a study by O'Kane (2018), I have also found that TTO executives are expanding their services to include funding opportunities, as well as establishing close connections with possible investors. However, my research has revealed that academics do not always accept or acknowledge the support they receive, as elaborated in Paper 2 and Paper 3. TTOs and TTO executives especially struggle with acceptance and recognition from their collaborative researchers, as well as from university managers, support personnel, and industrial project partners. This seems to reflect two major challenges. First, it seems to be difficult for researchers to abandon their traditional way of thinking and doing research –in other words, to cross the boundaries of the knowledge ecosystem in which they are embedded. Secondly, TTOs must in many cases receive economic compensation for their services, which by many was reported as counterproductive for the commercialisation process. For the first challenge, conflicts, or tensions between researchers and TTO executives seemed to occur when the researchers become more entrepreneurial. This seems to be especially the case in the early stages of the collaboration, and the level of tension and conflict seems to cease over time in the collaboration partnership. Furthermore, a researcher's journey into an entrepreneurial transition seems to worry department leaders who see the entrepreneurial and commercial activities as time-consuming and not in favour of research and education. In my research this was stressed by many of the respondents as very counterproductive and inhibitory for the inclusion of TTOs in innovation or collaboration projects. On the contrary, departments leader with prior experience with commercialisation projects, was active in initiating capabilities and establish a culture within their department for better support for commercialisation activities. The second challenge about funding of TTO services, was not only reported as stressful, or even provocative by researchers and TTO executives, but also by external collaborating partners and university managers. The funding challenge seems specially connected to the external TTOs (MiTTOs). As also pointed out by Stevens et al. (2022), MiTTOs are external to the research organisations and in contrast to internal TTOs must receive payment for their services.

Based on the findings from my research, my own experience, and the literature, I argue that universities that want to increase their social and industrial impact through knowledge and technology transfer will need to develop more relevant incentives and support structures for academics to engage in such activities. Furthermore, they need to reduce bureaucracy and control mechanisms for both their researchers and their TTOs (KTOs). Through my case studies, I have demonstrated that the TTOs' competence is specialised, and that TTO contributions are valuable and sometimes highly crucial for creating impact through universities' third mission activities. However, the TTOs and TTO executives need to develop better processes for how to include departmental leaders (or the ones appointed by the department leader) in their project development processes. Even more importantly, *both* universities and their TTOs need to align their support processes more closely with the evolving third mission, also specified by other authors (Sjöö & Hellström 2019, Perkman et al. 2021). Therefore, universities may need to tailor their support functions, strategies, and management, and they may even need to prioritise some specialisations of their support functions, such as the TTOs (Guiri et al. 2019, Arnold & Patriksson 2021). Finally, the literature highlights considerable concern regarding the 'one-size-fits-all' approach to how the third mission activities can best be performed, managed, measured, and applied either in countries or in universities (Secundo et al. 2019). My research findings support this concern, and in Section 5.4 I will highlight some implications for practitioners working in TTOs, universities, and governmental bodies, and who deal with policy and funding instruments for the Norwegian TTO context. Next, I will highlight some implications that my research findings might have for future research.

5.3 Implications for further research

My research findings have added some important aspects to existing theory. First, through my empirical findings, I question the existing distinctions between academic engagement and commercialisation of research that have been established in the literature. Some authors claim that academic engagement is closer to researchers' own field of interest (D'Este and Perkmann, 2011; Lam, 2007; Perkman et al., 2013), while the individual motivation and institutional support for commercialisation projects are more monetary driven (Bretznitz and Feldman .2012; Perkmann et al., 2013). Furthermore, it is also argued that, to a large extent, universities favour strategies and support for commercialisation activities (Lam, 2011, Muscio et al., 2017). However, my research has revealed that commercialisation projects more often seem to arise from basic research. Moreover, the motivation for taking on commercial activities seem to be less monetary driven than anticipated in the literature (Perkmann et al. 2013; 2021). Based on my findings and the theory presented in this thesis (Chapters 2 and 4), I argue that this development can partly be explained by the transition from a second generation of innovation policy towards a third generation of innovation policy in society, including in universities. In addition, I argue, in line with Lam (2011) that commercialisation projects also can be driven by academic interest and societal responsibilities. This transition is in turn affecting researchers and their collaborating partners in third mission links towards more social engagement (Orazbayeva et al., 2019 van de Burgwal, et al., 2019). Furthermore, the three universities in my study seem all to have better capabilities to support academic engagement than commercialisation activities, despite many years of governmental and managerial push, and the establishment of TTOs. However, these two lines of argument need more research to be further validated. In addition, the role of department levels and university support for both academic engagement and commercialisation activities needs to be further explored. Also, the funding structure for TTO support in relation to the transition of the third mission of universities towards a third generation of innovation policy should be included in future research agendas.

A second important contribution from my research is the clarification of the roles and collaboration of actors across various types of ecosystems, as called for by Valkokari (2015). In this regard, I argue that my schematic illustration in Figure 2 can be used as a theoretical framework to explain the interaction of the actors when collaborating across different ecosystems in third mission links. This contribution therefore adds to the theory of how different ecosystems interact dynamically and it also helps to clarify the ambiguous use of the term ecosystem. However, the topic is still in need of further research.

Finally, in Paper 3 my co-authors and I suggest how the extended team as a collective could provide the necessary industrial, managerial, and entrepreneurial experience to spin-off growth in a region. We also observed empirically how investors' close engagement in the team could overcome problems in the fundraising process. While the role of the academic entrepreneur has been well investigated, the role of investors in academic spin-offs seems underdeveloped in the literature and should therefore be further explored in future research.

5.4 Implications for policymakers and practitioners

The third mission of universities is a politicised activity and dependent on funding and funding mechanisms, as well as complex support structures and collaboration patterns. Through my research on the embedding of universities in innovation ecosystems, I have provided the fields of innovation studies and economic geography with empirical insights and contributions to theory. Based on my findings I argue that universities can benefit from acquiring more in-depth knowledge about their third mission activities within the innovation systems in which they are embedded. In Paper 1, my co-authors and I develop an *ecosystem fingerprint*, based on activity profiling (Laredo & Mustar 2000). Moreover, our rich case in Paper 1 demonstrates that the links and interdependencies with various actors in the ecosystems can be seen as a useful means to clarify the third mission of universities. I therefore suggest that the *ecosystem fingerprint* presented in Paper 1 can be further developed to characterise mission-oriented innovation ecosystems (Hekkert et al. 2020), as has recently been called for in the literature (Jütting 2020).

In general, I hope that this thesis, with its individual papers, will be useful for people interested in or working with knowledge and technology transfer based on research. Based on my findings, I allow myself question whether universities actually have succeeded in the implementation of strategies and support structures for their third mission activities in their daily operations. Furthermore, in Chapters 2 and 3, I have described how the performance of TTOs is influenced by their external environment, such as ecosystems, as well as by the institutional research base from which they draw (Maicher et al. 2019; Campell et al. 2020). Furthermore, Bozeman et al. (2015) show how TTO performance is extensively influenced by non-economic value criteria. Moreover, as pointed out by Stevens et al. (2022), it has been demonstrated that worldwide it is very difficult to secure funding to make MiTTOs economically sustainable. I therefore argue, in line with researchers such as Bozeman et al. (2015) and Fagerberg (2017), that a linear innovation approach supporting TTO activities is by no means in favour of developing a third-generation innovation policy.

It is important for readers of this thesis to make up their own mind about the most significant implication(s) for their particular situation. Nevertheless, I wish to offer some specific advice to practitioners, TTO and university managers, as well as policymakers. First, I would advise Norwegian policymakers to push the process of transitioning research-based knowledge and technology transfer processes to reflect the third innovation generation policy in a better way. This advice is also in line with the OECD’s recommendations for long-term plans for research in Norway (Larrue & Santos 2022). Second, in line with the recommendation in the NIFU report by Borlaug et al. (2022), knowledge and technology transfer should be considered more as a social mission than as an economic activity, especially in the early stages of innovative project development. Following this, consideration should be given to a shift in the perception of the roles and tasks for the TTOs in Norway towards the broader defined KTO and consequently, this mission should also be reflected in the funding schemes of TTOs. Given the geography and sizes of the Norwegian research organisations, these funding schemes should ideally be set up independently of whether the TTOs are internally or externally organised. In my experience, the funding challenge is a constantly recurring topic in the Norwegian TTO debate. Third, the universities, as well as other research organisations, must take clearer ownership of their TTOs (KTOs) and involve them in their goal setting and strategies. This includes adding the TTOs (KTOs) as collaborating partners at an operational level through innovation and commercialisation projects. Such project collaboration will create a learning space in both the TTOs and the universities, where culture and capabilities for creating impact from research (and education) can be developed, as demonstrated in Paper 3. As stressed by Debackere & Veugelers (2005) and by Maicher et al. (2018), KTOs (TTOs) with strong institutional support are more likely to succeed in what they do than if they lack such support.

As discussed in Paper 4, the pressures on the TTOs in the last few years have existed in many different forms simultaneously, such as changes in framework conditions and increased competition. However, successful innovation and commercialisation processes are reported in the literature as a result of close relationships and good collaboration between the various partners and stakeholders in the project. The university KTO and TTO competence has been built up in recent decades, both in Norway and elsewhere. Furthermore, intellectual property (IP) stemming from public funded research provides many opportunities but does need a certain type of competence in order to be properly managed and exploited to create impact. Seen through the lens of knowledge and technology transfer in innovation ecosystems in this thesis, I argue that the exclusion of KTOs and TTOs can result in many missed opportunities. I therefore end this thesis in the same way as Paper 4, with the expressed hope that the ongoing changes seen worldwide will result in a system being able to maintain and use the specialised and valuable competencies that have been developed in the KTOs and TTOs over a long period of time. Finally, my hope is that the Norwegian TTOs will succeed in the ongoing transformation away from a linear perception of innovation and commercialisation. Finally, I hope that in that process they (we) can embrace and exploit the opportunities and will not stick to ‘business as usual’.

6 References

Aarstad, J. Kvitastein, O.A & Jakobsen, S.E. 2016. Local buzz, global pipelines, or simply too much buzz? A critical study. *Geoforum* 75, 129–113. https://doi.org/10.1016/j.geoforum.2016.07.009

Abreu, M. and Grinevich V. 2013. The nature of academic entrepreneurship in the UK: Widening the focus on entrepreneurial activities. *Research Policy* 42(2), 408–422. https://doi.org/10.1016/j.respol.2012.10.005

Adner, R. 2006. Match your innovation strategy to your innovation ecosystem. *Harvard Business Review* 84(4), 98–107.

Argote, L. & Ingram, P. 2000. 'Knowledge transfer: A basis for competitive advantage in firms. *Organizational Behavior and Human Decision Processes* 82(1), 150–169. https://doi.org/10.1006/obhd.2000.2893

Arnold, E. & Patriksson, P. 2021. *Moving the Digital Life Sciences in Norway Towards Increased Innovation: Lessons from International Innovation Practices.* https://www.digitallifenorway.org/services/innovation/documents/2021.12.05---3290-to-be-report---final.pdf (accessed 9 February 2023).

Asheim, B. & Gertler, M.S. 2005. The geography of innovation: Regional innovation systems. In: Fagerberg, J., Mowery, D.C. & Nelson, R.R. (eds.) *The Oxford Handbook of Innovation*, pp. 291–316. Oxford: Oxford University Press.

ASTP. 2020. *ASTP 2020 Survey Report on Knowledge Transfer Activities in Europe: Financial Year 2018 Data*. https://www.astp4kt.eu/assets/resources/impact/ASTP%202020%20Survey%20Report%20on%20KT%20Activities%20in%20Europe.pdf (accessesd 16 January 2023).

Baglieri, D., Baldi, F. & Tucci, C.L. 2018. University technology transfer office business models: One size does *not* fit all. *Technovation* 76–77, 51–63. https://doi.org/10.1016/j.technovation.2018.05.003

Bathelt, H., Malmberg, A. & Maskell, P. 2004. Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography* 28(1), 31–36.

BDO. 2019. *Rapport gjennomgang av inven2*. https://khrono.no/files/2020/03/10/Rapport%20-%20Gjennomgang%20av%20Inven2.pdf (accessed 10 February 2023).

Benneworth, P., Pinheiro, R. & Sánchez-Barrioluengo, M. 2016. One size does not fit all! New perspectives on the university in the social knowledge economy. *Science and Public Policy* 43(6), 731–735. https://doi.org/10.1093/scipol/scw018

Bercovitz, J. & Feldman, M. 2006. Entrepreneurial universities and technology transfer: A conceptual framework for understanding knowledge-based economic development. *Journal of Technology Transfer* 31, 175–188. https://doi.org/10.1007/s10961-005-5029-z

Berkun, S. 2010. *The Myths of Innovation*. Seabstopol: O'Reilly.

Biernacki, P. & Waldorf, D. 1981. Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research* 10(2), 141–163. https://doi.org/10.1177/004912418101000205

Binz, C. & Truffer, B. 2017. Global innovation systems—A conceptual framework for innovation dynamics in transnational contexts. *Research Policy* 46(7), 1284–1298. https://doi.org/10.1016/j.respol.2017.05.012

Bogers, M., Sims, J. & West, J. 2019. What is an ecosystem? Incorporating 25 years of ecosystem research. *Academy of Management Proceedings* 1. https://ssrn.com/abstract=3437014

Borlaug, S.B., Korseberg, L., Gulbrandsen, M., Thune, T.M. & Svartefoss, S.M. 2022. *Organisering av teknologioverføring ved norske forskningsinstitusjoner: Mulige modeller*. NIFU-rapport 2022:4. https://hdl.handle.net/11250/2975758 (accessed 20 August 2022).

Borrás, S. & Edler, J. 2014. The governance of change in socio-technical and innovation systems: Three pillars for a conceptual framework. In: Borrás, S. & Edler, J. (eds.) *The Governance of Socio-Technical Systems*, Chapter 2. https://doi.org/10.4337/9781784710194 (accessed 2 February 2023).

Bourdieu, P. 1977. *Outline of a Theory of Practice*. Cambridge: Cambridge University Press.

Bourdieu, P. 1984. *Distinction: A Social Critique of the Judgment of Taste*. Cambridge, MA: Harvard University Press.

Bozeman, B. 2000. Technology transfer and public policy: A review of research and theory. *Research Policy* 29(4–5), 627–655. https://doi.org/10.1016/S0048-7333(99)00093-1

Bozeman, B., Rimes, H. & Youtie, J. 2015. The evolving state-of-the-art in technology transfer research: Revisiting the contingent effectiveness model. *Research Policy* 44(1), 34-49. https://doi.org/10.1016/j.respol.2014.06.008

Brescia, F., Colombo, G. & Landoni, P. 2016. Organizational structures of knowledge transfer offices: An analysis of the world's top-ranked universities. *Journal of Technology Transfer* 41(1), 132–151. https://doi.org/10.1007/s10961-014-9384-5

Breznitz, S.M. & Feldman, P. 2012. The larger role of the university in economic development: Introduction to special issue. *Journal of Technology Transfer* 37, 135–138. https://doi.org/10.1007/s10961-010-9184-5

Bush, V. 1945. *Science the Endless Frontier*: *A Report to the President on a Program for Postwar Scientific Research.* Washington: United States Government Printing Office.

Campbell, A., Cavalde, C., Haunold, C., Karanikic, P. & Piccaluga, A. 2020. *Knowledge Transfer Metrics: Towards a European-wide Set of Harmonised Indicators*. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/907762 (accessed 19 August 2022).

Carayannis, E.G. & Campbell, D.F.J. 2009. 'Mode 3' and 'Quadruple Helix': Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management* 46 (3–4), 201–234. 10.1504/IJTM.2009.023374

Charles, D. 2006. Universities as key knowledge infrastructures in regional innovation systems. *Innovation: European Journal of Social Science Research* 19(1), 117–130. https://doi.org/10.1080/13511610600608013

Chatterton, P. & Goddard, J. 2000. The response of higher education institutions to regional needs. *European Journal of Education* 35(4), 475–496. https://doi.org/10.1111/1467-3435.00041

Çinar, R. 2022. *Towards an Engaged University in the Periphery: Innovation, Regional Development and Institutional Change*. PhD thesis, Faculty of Engineering and Science, Western Norway University of Applied Sciences. https://hvlopen.brage.unit.no/hvlopen-xmlui/bitstream/handle/11250/2976863/Cinar.pdf?sequence=4 (accessed 16 January 2023).

Clarysse, B. Wright, M., Lockett, A., Van de Velde, E. & Vohora, A. 2005. Spinning out new ventures: A typology of incubation strategies from European research institutions. *Journal of Business Venturing* 20(2), 183–216. https://doi.org/10.1016/j.jbusvent.2003.12.004

Clarysse, B., Tartari, V. & Salter, A. 2011. The impact of entrepreneurial capacity, experience and organizational support on academic entrepreneurship. *Research Policy* 40(8), 1084–1093. https://doi.org/10.1016/j.respol.2011.05.010

Compagnucci, L. & Spigarelli, F. 2020. The third mission of the university: A systematic literature review on potentials and constraints. *Technological Forecasting & Social Change* 161: Article 120284. https://doi.org/10.1016/j.techfore.2020.120284

Cooke, P. 2001. Regional innovation systems, clusters, and the knowledge economy. *Industrial and Corporate Change* 10, 945–974. https://doi.org/10.1093/icc/10.4.945

Cooke, P., Uranga, M.G. & Extebarria, G. 1997. Regional innovation systems: Institutional and organisational dimensions. *Research Policy* 26(4–5), 475–491. https://doi.org/10.1016/S0048-7333(97)00025-5

Cunningham, J.A., Harney, B. & Fitzgerald, C. 2020. *Effective Technology Transfer Offices: A Business Model Framework.* Newcastle upon Tyne: Springer.

Debackere, K. & Veugelers, R. 2005. The role of academic technology transfer organizations in improving industry science links. *Research Policy* 34(3), 321–342. https://doi.org/10.1016/j.respol.2004.12.003

D'Este, P. & Perkmann, M. 2011. Why do academics engage with industry? The entrepreneurial university and individual motivations. *Journal of Technology Transfer* 36: 316–339. https://doi.org/10.1007/s10961-010-9153-z

DFØ. 2023a. Hva er må og resultatstyring. Direktoratet for forvaltning og økonomistyring. https://dfo.no/fagomrader/etats-og-virksomhetsstyring/mal-og-resultatstyring/hva-er-mal-og-resultatstyring (accessed 10 February 2023).

DFØ. 2023b. Hva skiller mål- og resultatstyring fra New Public Management? Direktoratet for forvaltning og økonomistyring. https://dfo.no/fagomrader/etats-og-virksomhetsstyring/mal-og-resultatstyring/hva-skiller-mal-og-resultatstyring-fra-new-public-management (accessed 10 February 2023).

Dodgson, M., Gann, D.M. & Phillips, N. 2014. Perspectives on innovation management. In: Dodgson, M., Gann, D.M. & Phillips, N. (eds.) *The Oxford Handbook of Innovation Management*, pp. 3–26. Oxford: Oxford University Press.

Doloreux, D. & Gomez, I.G. 2017. A review of (almost) 20 years of regional innovation systems research. *European Planning Studies* 25(3), 371–387. https://doi.org/10.1080/09654313.2016.1244516

Dubois, A. & Gadde, L.E. 2002. Systematic combining: An abductive approach to case research. *Journal of Business Research* 55(7), 553–560. https://doi.org/10.1016/S0148-2963(00)00195-8

Edler, J. & Fagerberg, J. 2017. Innovation policy: What, why, and how. *Oxford Review of Economic Policy* 33(1), 2–23. https://doi.org/10.1093/oxrep/grx001

Edler, J., Gök, A., Cunningham, P. & Shapira, P. 2016. Introduction: Making sense of innovation policy. In: Edler, J., Gök, A., Cunningham, P. & Shapira, P. (eds.) *Handbook of Innovation Policy Impact*, pp. 1–17. Cheltenham: Elgaronline.

Edmonds, A.W. & Kennedy, T.D. 2017. *An Applied Guide to Research Designs: Quantitative, Qualitative, and Mixed Methods*. Thousands Oaks: SAGE

Edquist, C. (ed.) 1997. *Systems of Innovation: Technologies, Institutions and Organizations*. London: Pinter.

Eisenhardt, K.M. & Graebner, E.M. 2007. Theory building from cases: Opportunities and challenges. *Academy of Management Journal* 50(1), 25–32. https://doi.org/10.5465/amj.2007.24160888

Etzkowitz, H. 2017. Innovation lodestar: The entrepreneurial university in a stellar knowledge firmament. *Technological Forecasting and Social Change* 123, 122–129, https://doi.org/10.1016/j.techfore.2016.04.026

Etzkowitz, H. & Leydesdorff, L. 1997. Universities and the global knowledge economy: A triple helix of university-industry-government relations. [archival reprint] https://ssrn.com/abstract=3404823 (accessed 10 February2022).

Etzkowitz, H. & Leydesdorff, L. 2000. The dynamics of innovation: From national systems and 'mode 2' to a triple helix of university–industry–government relations. *Research Policy* 29, 109–123. https://doi.org/10.1016/S0048-7333(99)00055-4

Etzkowitz, H., Schuler, E.J. & Gulbrandsen, M. 2000. The evolution of the entrepreneurial university. In: Jacob, M. & Hellström, T. (eds.) *The Future of Knowledge Production in the Academy*, pp. 40–60. Buckingham: SRHE and Open University Press.

European Commission. 2003. *Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. Innovation Policy: Updating the Union's Approach in the Context of the Lisbon Strategy*. Brussels, 11.03.2003, COM(2003) 112 final. https://ec.europa.eu/invest-in-research/pdf/download_en/innovation_policy_updating_union.pdf (accessed 8 February 2023).

European Commission. 2017. *Horizon 2020. Work Programme 2016–2017: 16. Science with and for Society*. European Commission Decision C (2017)2468 of 24 April 2017. https://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-swfs_en.pdf (accessed 8 February 2023).

European Commission. 2020. What is technology transfer? https://knowledge4policy.ec.europa.eu/technology-transfer/what-technology-transfer_en (accessed 24 February 2023).

Fagerberg, J. 2017. Innovation, policy: Rationales, lessons and challenges. *Journal of Economic Surveys* 31(2), 497–512. https://doi.org/10.1111/joes.12164

Fagerberg, J. & Verspagen, B. 2009. Innovation studies – The emerging structure of a new scientific field. *Research Policy* 38(2), 218–233. https://doi.org/10.1016/j.respol.2008.12.006

Fagerberg, J., Mowery, D.C. & Nelson, R.R. 2005. *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

Fagerberg, J., Mowery, D.C. & Verspagen, B. 2009. Introduction: Innovation in Norway. In: Fagerberg, J., Mowery, D.C. & Verspagen, B. (eds.) *Innovation, Path Dependency, and Policy: The Norwegian Case*, pp. 1–32. New York: Oxford University Press.

Fraser, A. Navarre, A. & Stevens, A. 2022. introduction and background to this special issue on the role and contribution of multi-institutional technology transfer offices. *les Nouvelles* LVII #4, 246–247.

Freeman, C. 1974. *The Economics of Industrial Innovation*. Harmondsworth, Penguin Books.

Freeman, C. 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter.

Freeman, C. 1995. The 'national system of innovation' in historical perspective. *Cambridge Journal of Economics* 19(1), 5–24. https://doi.org/10.1093/oxfordjournals.cje.a035309

Freeman, C. 2004. Technological infrastructure and international competitiveness. *Industrial and Corporate Change* 13(3), 541–569. https://doi.org/10.1093/icc/dth022

Galvao, A., Mascarenhas, C., Marques, C., Ferreira, J. & Ratten, V. 2019. Triple helix and its evolution: A systematic literature review. *Journal of Science and Technology Policy Management* 10(3), 812–833. https://doi.org/10.1108/JSTPM-10-2018-0103

Geels, F.W. 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy* 33(6–7), 897–920. https://doi.org/10.1016/j.respol.2004.01.015

Geuna, A. & Muscio, A. 2009. The governance of university knowledge transfer: A critical review of the literature. *Minerva* 47, 93–114. https://doi.org/10.1007/s11024-009-9118-2

Geuna, A. & Rossi, F. 2011. Changes to university IPR regulations in Europe and the impact on academic patenting. *Research Policy* 40(8), 1068–1076. https://doi.org/10.1016/j.respol.2011.05.008

Giuri, P., Munari, F., Scandura, A. & Toschi, L. 2019. The strategic orientation of universities in knowledge transfer activities. *Technological Forecasting & Social Change* 138, 261–278. https://doi.org/10.1016/j.techfore.2018.09.030

Godin, B. 2008. In the shadow of Schumpeter: W. Rupert Maclaurin and the study of technological innovation. *Minerva* 46(3), 343–360. https://doi.org/10.1007/s11024-008-9100-4

Godin, B. 2012. 'Innovation studies': The invention of a specialty. *Minerva* 50, 397–421. https://doi.org/10.1007/s11024-012-9212-8

Granstrand, O. & Holgersson, M. 2020. Innovation ecosystems: A conceptual review and a new definition. *Technovation* 90–91: Article 102098. https://doi.org/10.1016/j.technovation.2019.102098

Granovetter, M. 1973. The strength of weak ties. *American Journal of Sociology* 78, 1360–1381.

Granovetter, M. 1985. Economic action and economic structure: The problem of embeddedness. *American Journal of Sociology* 91, 481–510.

Grimpe, C. & Hussinger, K. 2013. Formal and informal knowledge and technology transfer from academia to industry: Complementarity effects and innovation performance. *Industry and Innovation* 20(8), 683–700. https://doi.org/10.1080/13662716.2013.856620

Grünfeld, L.A., Teie, M.G., Hvide, H., Spilling, O. & Borlaug, S. 2018. *Insentiver for kommersialisering av forskning*. Menon-publikasjon No. 9/2018. https://www.menon.no/publication/insentiver-kommersialisering-forskning/ (accessed 16 February 2023).

Guerrero, M. & Urbano, D. 2012. The development of an entrepreneurial university. *Journal of Technology Transfer* 37, 43–74. https://doi.org/10.1007/s10961-010-9171-x

Gulbrandsen, M. & Slipersæter, S. 2007. The third mission and the entrepreneurial model. In: Bonaccorsi, A. & Daraio, C. (eds.) *Universities and Strategic Knowledge Creation*, pp 112–143. Cheltenham: Edward Elgar.

Halilem, N., Amara, N., Olmos-Peñuela, N. & Mohiuddin, M. 2017. ‘To own, or not to own?’ A multilevel analysis of intellectual property right policies on academic entrepreneurship. *Research Policy* 46(8), 1479–1489. https://doi.org/10.1016/j.respol.2017.07.002

Hayter, H. 2016. A trajectory of early-stage spinoff success: The role of knowledge intermediaries within an entrepreneurial university ecosystem. *Small Business Economics* 47, 633–656. https://doi.org/10.1007/s11187-016-9756-3

Heaton, S., Siegel, D. & Teece, D.J. 2019. Universities and innovation ecosystems: A dynamic capabilities perspective. *Industrial and Corporate Change* 28, 921–939. https://doi.org/10.1093/icc/dtz038

Hekkert, M.P., Janssen, M.K., Wesseling, H.J. & Negro, S.O. 2020. Mission-oriented innovation systems. *Environmental Innovation and Societal Transitions* 34, 76–79. https://doi.org/10.1016/j.eist.2019.11.011

Hossinger, S.M., Chen, X. & Werner, A. 2020. Drivers, barriers and success factors of academic spin-offs: A systematic literature review. *Management Review* 70, 97–134. https://doi.org/10.1007/s11301-019-00161-w

Hughes, A., Lawson, C., Salter, A., Kitson, M., Bullock, A. & Hughes, R.B. 2016. The *Changing State of Knowledge Exchange: UK Academic Interactions with External Organisations 2005–2015*. NCUB. https://eprints.lancs.ac.uk/id/eprint/145906/1/NCUB_The_Changing_State_of_Knowledge_Exchange_Feb16_WEB.pdf (accessed 16 February 2023).

Hvide, H.K. & Jones. B.F. 2018. University innovation and the professor’s privilege. *American Economic Review* 108(7), 1860–1898. doi: 10.1257/aer.20160284

Jain, S., George, G. & Maltarich, M. 2009. Academics or entrepreneurs? Investigating role identity modification of university scientists involved in commercialization activity. *Research Policy* 38(6), 922–935. https://doi.org/10.1016/j.respol.2009.02.007

Jütting, M.S. 2020. Exploring mission-oriented innovation ecosystems for sustainability: Towards a literature-based typology. *Sustainability* 12(16): Article 6677. https://doi.org/10.3390/su12166677

Kaloudis, A., Aspelund, A., Koch, P.M., Lauvås, T.A., Mathisen, M.T., Strand, Ø., Sørheim, R. & Aadland, T. 2019. *How Universities Contribute to Innovation: A Literature Review-Based Analysis*. Report 2019. NTNU. https://www.ntnu.edu/documents/1272711283/1276140112/Rapport_How+universities+contribute+to+innovation_web.pdf/86b6a699-0499-820e-0f52-35a7b7101de5?t=1574848729613 (accessed 5 February 2023).

Kennedy, B. 2018. Deduction, Induction, and Abduction. In Flick, U. (ed) *The SAGE Handbook of Qualitative Data Collection,* pp 49-64. SAGE Publications Ltd. https://doi.org/10.4135/9781526416070

Keller, D.R. & Golley, F.B. 2000. *The Philosophy of Ecology: From Science to Synthesis*. Athens, GA: University of Georgia Press.

Kidwell, D.K. 2013. Principal investigators as knowledge brokers: A multiple case study of the creative actions of PIs in entrepreneurial science. *Technological Forecasting and Social Change* 80(2), 212–220. https://doi.org/10.1016/j.techfore.2012.05.004

Kirby, D.A. 2006. Creating entrepreneurial universities in the UK: Applying entrepreneurship theory to practice. *Journal of Technology Transfer* 31, 599–603. https://doi.org/10.1007/s10961-006-9061-4

Kirchenberger, M.A. & Pohl, L. 2016. Technology commercialization: A literature review of success factors and antecedents across different contexts. *Journal of Technology Transfer* 41, 1077–1112. https://doi.org/10.1007/s10961-016-9486-3

Kitagawa, F., Sánchez Barrioluengo, M. & Uyarra, E. 2016. Third mission as institutional strategies: Between isomorphic forces and heterogeneous pathways. *Science and Public Policy* 43(6), 736–750. https://doi.org/10.1093/scipol/scw015

Kline, J. & Rosenberg, N. 1986. An overview of innovation. In: Landau, R. & Rosenberg, J. (eds.) *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, pp. 275–306. Washington, DC: National Academy Press.

Kvale, S. 1996. The 1,000-page question. *Qualitative Inquiry* 2(3), 275–284. https://doi.org/10.1177/107780049600200302

Lam A. 2007. Knowledge networks and careers: Academic scientists in industry–university links. *Journal of Management Studies* 44(6), 993–1016. https://doi.org/10.1111/j.1467-6486.2007.00696.x

Lam A. 2011. What motivates academic scientists to engage in research commercialization: 'Gold', 'ribbon' or 'puzzle'? *Research Policy* 40(10), 1354–1368. https://doi.org/10.1016/j.respol.2011.09.002

Laredo, P. 2007. Revisiting the third mission of universities: Toward a renewed categorization of university activities? *Higher Education Policy* 20(4), 441–456. https://doi.org/10.1057/palgrave.hep.8300169

Laredo, P. & Mustar, P. 2000. Laboratory activity profiles: An exploratory approach. *Scientometrics* 47(3), 515–539. https://doi.org/10.1023/A:1005671901143

Larrue, P. & Santos, R. 2022. Towards a new stage in Norway's science, technology and innovation system: Improving the long-term plan for research and higher education. *OECD Science, Technology and Industry Policy Papers* 133. https://doi.org/10.1787/ce07b7c3-en

Leitner, K.-H., Bergner, S. & Rybniecek, R. 2021. The role of heads of departments in the commercialization of university research. *Journal of Business Economics* 91, 353–378. https://doi.org/10.1007/s11573-020-01003-y

Lekve, K. 2019. *Adding Value: From World-Leading Research to Profitable Commercialization*. https://www.simula.no/sites/default/files/report_adding_value_simula_2019_0.pdf (accessed 20 August 2022).

Lewin, K. 1946. Action research and minority problems. In: Lewin, G.W. (ed.) *Resolving Social Conflicts*, 201–216. New York: Harper & Row.

Link, A.N., Siegel, D.S., & Wright, M. 2015. *The Chicago Handbook of University Technology Transfer and Academic Entrepreneurship*. Chicago: University of Chicago Press.

Lundvall, B.Å. 1985. *Product Innovation and User-Producer Interaction*. Industrial Development Research Series 31. Ålborg University Press. https://vbn.aau.dk/ws/portalfiles/portal/7556474/user-producer.pdf

Lundvall, B.Å. (ed.) 1992. *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning*. London: Pinter.

Maicher, L., Mjos, K.D. & Tönisson, L. 2019. Intervention opportunities for capacity building in technology transfer. In: Granieri, G. & Basso, A. (eds.) *Capacity Building in Technology Transfer*, pp. 29–46. Cham: Springer. https://link.springer.com/chapter/10.1007/978-3-319-91461-9_3 (accessed 24 February 2023).

Maxcy, S.J. 2003. Pragmatic threads in mixed methods research in the social sciences: The search for multiple modes of inquiry and the end of the philosophy of formalism. In: Tashakkori, A. & Teddlie, C. (eds.) *SAGE Handbook of Mixed Methods in Social and Behavioral Research*, 51–89. Thousand Oaks, CA: SAGE.

MedlinePlus. (2021). What is DNA? https://medlineplus.gov/genetics/understanding/basics/dna/ (accessed 23 February 2023).

Meissner, D. & Shmatko, N. 2017. 'Keep open': The potential of gatekeepers for the aligning universities to the new knowledge triangle. *Technological Forecasting and Social Change* 123, 191–198. https://doi.org/10.1016/j.techfore.2016.03.012

Ministry of Education and Research. 2005. *Act Relating to Universities and University Colleges*. https://lovdata.no/dokument/NLE/lov/2005-04-01-15 (accessed 24 February 2023).

Montesinos, P., Miguel, J.C., Martinez, J.-M., & Mora, F. 2008. Third mission ranking for world class universities: Beyond teaching and research. *Higher Education in Europe* 33(2–3), 259–271. https://doi.org/10.1080/03797720802254072

Moore, J.F. 1993. Predators and prey: A new ecology of competition. *Harvard Business Review* 71(3), 75–86.

Mundell, I. 2022. The ecosystem: Italy must live a little longer with professor's privilege. *The Science|Business Network*, 18 October 2022. https://sciencebusiness.net/news/ecosystem-italy-must-live-little-longer-professors-privilege (accessed 20 December 2022).

Muscio, A. & Vallanti, G. 2014. Perceived obstacles to university-industry collaboration: Results from a qualitative survey of Italian academic departments. *Industry and Innovation* 21(5), 410–429. https://doi.org/10.1080/13662716.2014.969935

Muscio, A., Ramaciotti, L. & Rizzo, U. 2017. The complex relationship between academic engagement and research output: Evidence from Italy. *Science and Public Policy* 44(2), 235–245. https://doi.org/10.1093/scipol/scw057

Musil, R. & Eder, J. 2016. Towards a location sensitive R&D policy: Local buzz, spatial concentration and specialisation as a challenge for urban planning – Empirical findings from the life sciences and ICT clusters in Vienna. *Cities* 59, 20–29.

Nelson, R.R. (ed.) 1993. *National Innovation Systems: A Comparative Analysis*. Oxford: Oxford University Press.

Nonaka, I. & Takeuchi, N. 1995. *The Knowledge Creating Company*. New York: Oxford University Press.

Norges forskningsråd. 2017. *Programplan 2019 -. Forskningsdrevet Nyskaping – FORNY*. https://www.forskningsradet.no/contentassets/3de73268bacf406d851a2c8fda4e847a/forny2020-programplan-2019---norsk.pdf (accessed 5 December 2021).

Normann, R., Kyllingstad, N. & Bjorvatn, T. 2018. *Utredning av alternative modeller for kommersialisering av forskning ved Universitetet i Agder*. Prosjektrapport 7/2018, NORCE. https://norceresearch.brage.unit.no/norceresearch-xmlui/bitstream/handle/11250/2633735/AF-Norce%20project%20report%207-2018%20_%20Utredning%20av%20alternative%20modeller%20for%20kommersialisering%20av%20forskning%20ved%20Universitetet%20i%20Agder.pdf?sequence=1&isAllowed=y (accessed 9 February 2023).

NOU 2003: 25. *Ny lov om universiteter og høyskoler*. https://www.regjeringen.no/no/dokumenter/nou-2003-25/id148008/ (accessed 9 February 2023).

NTNU. n.d. NTNU Strategisk program for kunnskapsbasert injovasjon (SKI). https://www.ntnu.no/nyskaping/kunnskapsbasert-innovasjon (accessed 5 December 2021).

OECD. 2004. *Science and Innovation Policy: Key Challenges and Opportunities*. Meeting of the OECD Committee for Scientific and Technological Policy at Ministerial level, 29–30 January 2004. https://www.oecd.org/science/inno/23706075.pdf (accessed 16 February 2023).

OECD. 2013. *Commercialising Public Research: New Trends and Strategies*: https://ec.europa.eu/futurium/en/system/files/ged/oecd_9213031e.pdf (accessed 15 March 2020).

OECD. 2019. *University-Industry Collaboration. New Evidence and Policy Options*. https://www.oecd.org/fr/innovation/university-industry-collaboration-e9c1e648-en.htm accessed 24 February 2023).

Oh, D.-S., Phillips, F., Park, S. & Lee, E. 2016. Innovation ecosystems: A critical examination. *Technovation* 54, 1–6. https://doi.org/10.1016/j.technovation.2016.02.004

Oinas, P. 1999. Voices and silences: The problem of access to embeddedness. *Geoforum* 30(4), 351–361. https://doi.org/10.1016/S0016-7185(99)00026-3

O’Kane, C. 2018. Technology transfer executives’ backwards integrations: An examination of interactions between university technology transfer executives and principal investigators. *Technovation* 76–77, 64–77. https://doi.org/10.1016/j.technovation.2016.08.001

O’Kane, C., Cunningham, J.A., Menter, M. & Walton, S. 2021. The brokering role of technology transfer offices within entrepreneurial ecosystems: An investigation of macro–meso–micro factors. *Journal of Technology Transfer* 46, 1814–1844. https://doi.org/10.1007/s10961-020-09829-y

Onwuegbuzie, A.J. & Leech, N.L. 2007. A call for qualitative power analyses. *Quality & Quantity* 41, 105–121. https://doi.org/10.1007/s11135-005-1098-1

Orazbayeva B., Davey T., Plewa C. & Galán-Muros V. 2020. Engagement of academics in education-driven university-business cooperation: A motivation-based perspective. *Studies in Higher Education* 45(8), 1723–1736. https://doi.org/10.1080/03075079.2019.1582013

O’Shea, R.P., Allen, T.J., Chevalier, A. & Roche, F. 2005. Entrepreneurial orientation, technology transfer and spinoff performance of U.S. universities. *Research Policy* 34(7), 994–1009. https://doi.org/10.1016/j.respol.2005.05.011

Owen, R., Bessant, J.R & Heintz, M. 2013. *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*. Chichester: Wiley.

Perkmann, M. & Walsh, K. 2007. University industry relationships and open innovation: Towards a research agenda international. *Journal of Management Reviews* 9(4), 259–280. https://doi.org/10.1111/j.1468-2370.2007.00225.x

Perkmann, M., Tartari, K., McKelvey, M., Autioa, E., Broström, A., D’Este, P., Fini, F., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A. & Sobrero, M. 2013. Academic engagement and commercialisation: A review of the literature on university-industry relations. *Research Policy* 42(2), 423–442. https://doi.org/10.1016/j.respol.2012.09.007

Perkmann, M., Salandra, R., Tartari, V., McKelvey, M. & Hughes, A. 2021. Academic engagement: A review of the literature 2011–2019. *Research Policy* 50(1): Article 104114. https://doi.org/10.1016/j.respol.2020.104114 (accessed 7 July 2022).

Pierce, C.S. 1878. How to make our ideas clear. *Popular Science Monthly* 12, 286–302.

Polanyi, K. 1944. *The Great Transformation: The Political and Economic Origins of Our Time*. Boston, MA: Beacon Press.

Polanyi, M. 1956. *Personal Knowledge: Towards a Post-Critical Philosophy*. Chicago, IL: University of Chicago Press.

Rasmussen, E. & Borch, O. 2010. University capabilities in facilitating entrepreneurship: A longitudinal study of spin-off ventures at mid-range universities. *Research Policy* 39(5), 602–612. https://doi.org/10.1016/j.respol.2010.02.002

Rasmussen, E., Moen, Ø. & Gulbrandsen, M. 2006. Initiatives to promote commercialization of university knowledge. *Technovation* 26(4), 518–533. https://doi.org/10.1016/j.technovation.2004.11.005

Rasmussen, E., Mosey, S. & Wright, M. 2014. The influence of university departments on the evolution of entrepreneurial competencies in spin-off ventures. *Research Policy* 43(1), 92–106. https://doi.org/10.1016/j.respol.2013.06.007

Reichert, S. 2019. *The Role of Universities in Regional Innovation Ecosystems*. https://eua.eu/downloads/publications/eua%20innovation%20ecosystem%20report%202019-3-12.pdf (accessed 16 February 2023).

Reichertz, J. 2009. Abduction: The logic of discovery of grounded theory. *Forum Qualitative Sozialforschung/Forum Qualitative Social Research* 11(1). https://doi.org/10.17169/fqs-11.1.1412 (accessed 16 February 2023).

Reillon, V. 2017. EU framework Programmes for research and innovation. Evolution and key data from FP1 to Horizon 2020 in view of FP9. European Union.

https://www.europarl.europa.eu/thinktank/en/document/EPRS_IDA(2017)608697 (accessed 5 February 2023).

Research Council of Norway. 2023. Public Sector PhD scheme. https://www.forskningsradet.no/en/apply-for-funding/funding-from-the-research-council/public-sector-phd-scheme/ (accessed 28 February 2023).

Reymert, I. & Thune, T. 2023. Task complementarity in academic work: A study of the relationship between research, education and third mission tasks among university professors. *Journal of Technology Transfer* 48, 331–360. https://doi.org/10.1007/s10961-021-09916-8

Ridder-Symoens, H. de. (ed.) 1992. *A History of the University in Europe.* Vol. 1 in the series *Universities in the Middle Ages* edited by W. Rüegg. Cambridge: Cambridge University Press.

Roberts, E.B. & Malonet, D.E. 1996. Policies and structures for spinning off new companies from research and development organizations. *R&D Management* 26(1), 17–48. https://doi.org/10.1111/j.1467-9310.1996.tb00927.x

Robinson, D.K.R., Schoen, A., Laurens, P., Horellou, S., Colas, P. & Larédo, P. 2016. Assessing marine biotechnology research centres in peripheral regions: Developing global and local STI indicators. In: Rafols, I., Molas-Gallart, J., Castro-Martinez, E., &Woolley, R.d (eds.) *Congress UPV Proceedings of the 21st International Conference on Science and Tecnology Indicators*, pp. 575–580. Conference held in Valencia, Spain, 14–16 September 2016. http://dx.doi.org/10.4995/STI2016.2016.4543 (accessed 24 February 2022).

Sadek, T., Kleiman, R. & Loutfy, R. 2015. The role of technology transfer offices in growing new entrepreneurial ecosystems around mid-sized universities. *International Journal of Innovation and Regional Development* 6(1), 61–79. https://doi.org/10.1504/IJIRD.2015.067648

Salter, A.J. & Martin, B.R. 2001. The economic benefits of publicly funded basic research: A critical review. *Research Policy* 30(3), 509–532. https://doi.org/10.1016/S0048-7333(00)00091-3

Sánchez-Barrioluengo, M. & Benneworth, P. 2019. Is the entrepreneurial university also regionally engaged? Analysing the influence of university's structural configuration on third mission performance. *Technological Forecasting & Social Change* 141, 206–218. https://doi.org/10.1016/j.techfore.2018.10.017

Schaeffer, P.R., Fischer, B. & Querioz, S. 2018. Beyond education: The role of research universities in innovation ecosystems. *Foresight and STI Governance* 12(2), 50–61. http://doi.org/10.17323/2500-2597.2018.2.50.61

Schot, J. & Steinmueller, W.E. 2018. Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy* 47(9), 1554–1567. https://doi.org/10.1016/j.respol.2018.08.011

Schumpeter, J.A. 1934. *The Theory of Economic Development*. Opie, R. (transl.). Cambridge: Harvard University Press.

Scott, J.C. 2006. The mission of the university: Medieval to postmodern transformations. *Journal of Higher Education* 77(1), 1–39. https://doi.org/10.1080/00221546.2006.11778917

Secundo, G., Ndou, V., Del Vecchio, P. & De Pascale, G. 2019. Knowledge management in entrepreneurial universities: A structured literature review and avenue for future research agenda. *Management Decision* 57(12), 3226–3257. https://doi.org/10.1108/MD-11-2018-1266

Siegel, D.S. & Wright, M. 2015. University technology transfer offices, licensing and start-ups. In: Link, A.N., Siegel, D.S. & Wright, M. (eds.) *The Chicago Handbook of University Technology Transfer and Academic Entrepreneurship*, pp. 22–61. Chicago, IL: University of Chicago Press.

Sjöö, K. & Hellström, T. 2019. University-industry collaboration: A literature review and synthesis. *Industry and Higher Education* 33(4), 275–285. https://doi.org/10.1177/0950422219829697

Smits, R.E, Kuhlmann, S. & Shapira, P. 2010. *The Theory and Practice of Innovation Policy: An International Research Handbook*. Cheltenham: Edward Elgar.

Smorodinskaya, N., Russel, M., Katukov, D. & Still, K. 2017. Innovation ecosystems vs. innovation systems in terms of collaboration and co-creation of value. [Proceedings of the 50th Hawaii International Conference on System Sciences, 4–7 January 2017]. http://hdl.handle.net/10125/41798 (accessed 6 February 2022).

Somek, B. 2006. *Action Research: A Methodology for Change and Development*. New York: Open University Press.

Spilling, O.R., Borlaug, S. B., Iversen, E. J., Rasmussen, E. & Solberg, E. 2015. *Virkemiddelapparatet for kommersialisering av forskning – status og utfordringer: Sluttrapport fra evalueringen av virkemiddelapparatet for kommersialisering av offentlig finansiert forskning*. NIFU-rapport 18-2015. https://www.nifu.no/publications/1258280/ (accessed 23 February 2023).

Stam, E. & van de Ven, A. 2021. Entrepreneurial ecosystem elements. *Small Business Economics* 56, 809–832. https://doi.org/10.1007/s11187-019-00270-6

Stanford Encyclopedia of Philosphy. 2021. Pragmatism. 6 April 2021. https://plato.stanford.edu/entries/pragmatism/#Bib (accessed 15 December 2022).

Stevens, A.J. 2022. The emergence of university-based innovation and organized systems for its transfer and utilization. *les Nouvelles* LVII #4, 334–345.

Stevens, A.J. & Kato, K. 2013. Technology transfer's twenty five percent rule. *les Nouvelles* XLVIII #1, 44–51.

Stevens, A.J., Fraser, J.A. & Navarre, A. 2022. An analysis of the history, business/funding models, strengths and challenges of multiinstitutional tech transfer offices. *les Nouvelles* LVII #4, 346–359.

Suominen, A., Seppänen, M. & Dedehayir, O. 2019. A bibliometrical review on innovation systems and ecosystems: A research agenda. *European Journal of Innovation Management* 22(2), 335–360. https://doi.org/10.1108/EJIM-12-2017-0188

Suri, H. 2011. Purposeful sampling in qualitative research synthesis. *Qualitative Research Journal* 11(2), 63–75. https://doi.org/10.3316/QRJ1102063

Tansley, A.G. 1935. The use and abuse of vegetational concepts and terms. *Ecology* 16(3), 284–307. https://doi.org/10.2307/1930070

Taxt, R.E. 2008. Research collaboration and knowledge transfer in university-industry links: An empirical study of research collaboration and knowledge transfer between the University of Bergen and industrial companies. Master's thesis. Fakultet for informasjonsteknologi, matematikk og elektroteknikk, NTNU. https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/249852 (accessed 30 September 2022).

Technopolis Group. 2019. *Raising the Ambition Level in Norwegian Innovation Policy. Final Report*. https://www.forskningsradet.no/siteassets/publikasjoner/2019/technopolis-naringsrettede-virkemidler.pdf (accessed 16 February 2023).

Tavory, I. & Timmermans, S. 2014. *Abductive Analysis: Theorizing Qualitative Research*. Chicago, IL: University of Chicago Press.

Tidemann, G. 2022. Universitetet i Oslo får en ny innovasjonsenhet. https://www.uniforum.uio.no/nyheter/2022/01/universitetet-i-oslo-far-en-ny-innovasjonsenhet-.html (accessed 10 February 2023).

Trippl, M., Todtling, F. & Lengauer, L. 2009. Knowledge sourcing beyond buzz and pipelines: Evidence from the Vienna software sector. *Economic Geography* 85(4), 443–462. https://doi.org/10.1111/j.1944-8287.2009.01047.x

Tsujimoto, M., Kajikawa, Y., Tomita, J. & Matsumoto, Y. 2018. A review of the ecosystem concept – Towards coherent ecosystem design. *Technological Forecasting and Social Change* 136, 49–58. https://doi.org/10.1016/j.techfore.2017.06.032

Varnai, P., Arnold, E., Rentel, M., King, R. & Melin, G. 2020. *Digital Life Norway: As Is Report*. https://www.digitallifenorway.org/services/innovation/documents/digital-life-norway-as-is_report-18-june-2020.pdf (accessed 25 February 2023).

UiA. n.d. Innovation and impact. https://www.uia.no/for-ansatte/forskning/prosjektstoette-og-finansiering/innovasjon-og-impact (accessed 25 February 2023).

United Nations. n.d. The 17 Goals. https://sdgs.un.org/goals (accessed 24 January 2022).

University of Bergen. 2020. *Research and Innovation within Marine biology at the University of Bergen 2010–2017: A Territorial Embedding Assessment Report.* https://www.uib.no/sites/w3.uib.no/files/attachments/matnat_tea_uib_report_2020_final_samlet_oversikt_over_var_virksomhet.pdf (accessed 13 January 2022).

U.S. Government Publishing Office. 2011. *Chapter 18—Patent Rights in Inventions Made with Federal Assistance*. 35 U.S.C. (201) United States Code, 2011 Edition, Title 35 – Patents. Part II. Patentability of Inventions and Grant of Patents. https://www.govinfo.gov/content/pkg/USCODE-2011-title35/html/USCODE-2011-title35-partII-chap18.htm (accessed 10 February 2023).

Uyarra. E. 2010. Conceptualizing the regional roles of universities, implications and contradictions. *European Planning Studies* 18(8), 1227–1246. https://doi.org/10.1080/09654311003791275

Uyarra, E. & Ramlogan, R. 2016. The impact of cluster policy on innovation. In: Edler, J., Gök, A., Cunningham, P. & Shapira, P. (eds.) *Handbook of Innovation Policy Impact*, pp. 196–238. Elgaronline. https://doi.org/10.4337/9781784711856.00014 (accessed 16 February 2023).

Valkokari, K. 2015. Business, innovation, and knowledge ecosystems: How they differ and how to survive and thrive within them. *Technology Innovation Management Review* August 2015, 17–24.

van de Burgwal, L.H.M., Hendrikse, R. & Claassen, E. 2019. Aiming for impact: Differential effect of motivational drivers on effort and performance in knowledge valorisation. Science and Public Policy 46(5), 747–762. https://doi.org/10.1093/scipol/scz027

van Burg E., Du, J. & Kers, J.D. 2021. When do academics patent outside their university? An in-depth case study. *Technovation* 107: Article 102287. https://doi.org/10.1016/j.technovation.2021.102287.

Villani, E., Rasmussen, E. & Grimaldi, R. 2017. How intermediary organizations facilitate university–industry technology transfer: A proximity approach. *Technological Forecasting and Social Change* 114, 86–102. https://doi.org/10.1016/j.techfore.2016.06.004

Weckowska, D. 2015. Learning in university technology transfer offices: transaction-focused and relations-focused approaches to commercialization of academic research. *Technovation* 41–42, 62–74. https://doi.org/10.1016/j.technovation.2014.11.003

Weiss, R.S. 1994. *Learning from Strangers. The Art and Method of Qualitative Interview Studies*. New York: Free Press.

World Economic Forum 2021. A new paradigm for collaboration: mission-based ecosystems. https://www.weforum.org/agenda/2021/01/a-new-paradigm-for-collaboration-mission-based-ecosystems-better-business-oliver-wyman-great-reset-davos-agenda (accessed 31.01.2023).

Wright, M., Clarysse, B., Lockett, A. & Knockaert, M. 2008. Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries. *Research Policy* 37(8), 1205–1223. https://doi.org/10.1016/j.respol.2008.04.021

Wyckoff, A.W. 2013. The OECD Innovation Strategy: science, technology and innovation indicators and innovation policy. In: Gault, F. (ed.) *Handbook of Innovation Indicators and Measurements*, pp. 301–319. Elgaronline. https://doi.org/10.4337/9780857933652.00023 (accessed 16 January 2023)

Yin, R.K. 2018. *Case Study Research and Applications*. Thousands Oaks, CA: SAGE.

Zomer, A. & Benneworth, P. 2011. The rise of the university's third mission. In: Enders, J., de Boer, H.F. & Westerheijden, D.F. (eds.) *Reform of Higher Education in Europe*, pp. 80–101. SensePublishers. https://doi.org/10.1007/978-94-6091-555-0_6 (accessed 16 January 2023).

Zou, B., Guo, J., Guo, F., Shi, Y. & Li, Y. 2018. Who am I? The influence of social identification on academic entrepreneurs' role conflict. *International Entrepreneurship and Management Journal* 15(2), 363–384. https://doi.org/10.1007/s11365-017-0492-1

Appendix

Full versions of Papers

Paper 1

Norsk Geografisk Tidsskrift–Norwegian Journal of Geography
2022, VOL. 76, NO. 1, 42–60
https://doi.org/10.1080/00291951.2022.2041718

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

The embedding of universities in innovation ecosystems: The case of marine research at the University of Bergen

Randi Elisabeth Taxt[1,2], Douglas K.R. Robinson[3,4], Antoine Schoen[3] & Arnt Fløysand[5]

[1]Department of Geography, University of Bergen, Bergen, Norway
[2]Vestlandets Innovasjonsselskap AS, Bergen, Norway
[3]Laboratoire Interdisciplinaire Sciences Innovations Sociétés (LISIS), Université Gustave Eiffel, Champs-sur-Marne, France
[4]Institute for Innovation and Public Purpose, University College London, London, UK
[5]Mohn Centre for Innovation and Regional Development, Western Norway University of Applied Sciences, Bergen, Norway

ABSTRACT
While historically the core missions of universities have been research and teaching, it has become increasingly recognised that universities have become significant sources of knowledge and capabilities. This third mission is cementing the role of universities as suppliers of qualified labour and generators of knowledge and technologies that promote innovation in a variety of innovation ecosystems. The main goal of the paper is to illustrate an approach that captures the various contributions of universities to their innovation ecosystems. Often territorially bounded, such links provide insights into the characteristics and geography of the various linkage for a university. With the case of the University of Bergen and its role within the marine innovation ecosystem of Western Norway, this 'ecosystem fingerprint', can be seen as a useful means to clarify the third mission of universities through the linkages and interdependencies with various actors. The authors demonstrate that a university can act both as a global pipeline provider and take active part in the local buzz, providing this concept with new empirical insight. The authors conclude that the university is highly embedded in both the marine innovation ecosystem and the knowledge ecosystem, but with linkages extended to interconnected business ecosystems.

ARTICLE HISTORY
Received 14 February 2021
Accepted 9 February 2022

EDITORS
Arne Isaksen; Catriona Turner

KEYWORDS
innovation and knowledge ecosystems, ecosystem fingerprint, local buzz and global pipelines, research and innovation links, universities' third mission

Taxt, R.E., Robinson, D.K.R., Schoen, A. & Fløysand, A. 2022. The embedding of universities in innovation ecosystems: The case of marine research at the University of Bergen. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* Vol. 76, 42–60. ISSN 0029-1951.

Introduction

Universities embedded in ecosystems

Universities, as well as other research organisations, are considered important players in innovation systems. This can be in terms of collaborative research with industry and public sector organisations, as providers of human capital, through production of academic publications, patents, and though the creation of knowledge-intensive new enterprises. Stimulated by different stakeholder policies, universities are becoming increasingly aware of, and acting on, their role as contributors to economic and social development in a global, national, and regional manner. This role is often referred to as the universities' 'third mission' (Etzkowitz & Leydersdorff 2000; Gulbrandsen & Slipesæter 2007; Laredo 2007).

Thus, universities impact regional, market, and societal actors through interconnections, whereby knowledge and other university-sourced capabilities are shared, transferred, or exchanged. To understand such actor interrelations, the ecosystem metaphor has become increasingly mobilised in the literature to understand a bounded system of innovating actors. In this metaphor, an ecosystem consists of a variety (or

CONTACT Randi Elisabeth Taxt randi.taxt@uib.no
Supplemental data for this article can be accessed at https://doi.org/10.1080/00291951.2022.2041718

ecology) of organisms, the physical environment in which they are located, and the variety of interdependencies and interactions at play in a bounded system. The ecosystem concept was introduced into the innovation management literature by James Moore in the early 1990s (Moore 1993) and it adds to the concept of 'systems of innovation' that are frameworks for understanding innovation, such as industrial clusters, national innovation systems, and regional innovation systems (Freeman 1987; Porter 1990; Lundvall 1992; Cooke 2001; Asheim & Gertler 2005). Common to all these frameworks is that they describe actors, networks, different components, and the relations among them as influencing the innovation activities within a geographical area, a value chain, or an organisation.

Ecosystems are described as innovation systems that dynamically evolve over time and consist of networks and clusters of multiple firms, types of organisations, and individuals (Moore 1993; Autio & Thomas 2014). However, within the field of management and innovation studies there are now many, partially overlapping concepts, such as business, innovation, and knowledge ecosystems (Valkokari 2015). In addition, a variety of definitions exists for each concept, with clear emphasis on innovation ecosystems (Granstrand & Holgersson 2020; Klimas & Czakon 2021). Unfortunately, this has resulted in limited consensus and understanding among researchers and practitioners with regard to how and when to use the concepts (Valkokari 2015; Granstrand & Holgersson 2020). The different types of ecosystems have different logics of action. This means that the same actor can be involved in and play different roles in each ecosystem. Furthermore, the various ecosystems have a high degree of interconnectivity and they are evolving and emerging next to each other (Valkokari 2015). Accordingly, universities' third mission efforts are influenced by the ecosystems in which they are embedded. Hence, there have been calls for further research on the interaction between the different types of ecosystems, as well as studies of how particular ecosystem actors perceive their concurrent roles in different ecosystems (Valkokari 2015; Heaton et al. 2019).

The use of ecosystem linkages as a diagnostic tool

To understand the role, contributions, and interrelations between universities and other ecosystem actors, it is desirable to have an approach that uses an ecosystem-linkage diagnostic to capture (1) the types of connections and/or entanglements with ecosystem actors and (2) their intensity. The goal of this paper is to develop and demonstrate such a diagnostic tool with an ecosystem perspective.

The primary motivation for adopting the ecosystem perspective has been the desire to exploit a more self-organising system than the static structures regulated by government bodies (Valkokari 2015; Smorodinskaya et al. 2017). We also recognise the value of insights that shed light on the concept of 'regional buzz and global pipelines', as described by Bathelt et al. (2004). Benneworth & Hospers (2006) show that universities can become temporary venues for local buzz, and Brown (2016) illustrates how a university can engage very actively as policy actor in a region. For university managers at various levels, mobilising such a broader and deeper understanding of the university linkages within various ecosystems can be a first step towards developing a strategy for improved embedding of ecosystems (Robinson et al. 2016). The second step is to *distinguish* these 'understandings' in terms of descriptors and indicators that characterise the degree and form of embedding in various types of ecosystems with regard to the university and its collaborating actors in the systems.

This paper focuses on the second step towards developing a strategy for improved embedding of ecosystems, specifically the development and application of descriptors and indicators. Such indicators should provide knowledge with which to answer the following questions:

1. What types of links do universities have within innovation ecosystems?
2. How can the links provide insights into the performing of third mission activities in universities?
3. What can the links tell us about the relationships and dynamics between overlapping ecosystems?

We apply the ecosystem-sensitive 'research compass methodology' developed by Laredo & Mustar (2000) to the marine research environment in the University of Bergen in Western Norway, to which we add the concept of local buzz and global pipelines as presented by Bathelt et al. (2004). In a third mission context, research has traditionally aimed for excellence through global collaboration and output in terms of codified knowledge such as academic publications, which can easily lead to the conclusion that most universities have a role as a global pipeline provider. However, our study shows that universities in many ways contribute to the local buzz and thus illustrates how a university's third mission efforts are impacted by its embeddedness in ecosystems of different scale and scope.

The remaining part of this paper is structured as follows. The literature overview fleshes out the central goal of understanding the role and performance of the third mission of universities in various innovation systems, with emphasis on the innovation ecosystem. Subsequent sections describe the analytical frameworks and methods to show how the modified research compass framework, together with the concept of local buzz and global pipelines, can be tailored to such settings, and hence how we apply the tailored framework to the specific case of the University of Bergen in the marine innovation ecosystem of Western Norway. Thereafter, we present and discuss our findings. Finally, we draw some conclusions, address the initial research questions, and suggest some implications for practitioners.

Literature overview

Innovation systems

Research on innovation systems was first introduced by Lundvall in the mid-1980s (Lundvall 1985) and has been done and developed in economic and social contexts since the 1990s. Such systems are characterised by the interactions of organisations (actors), networks (relations and/or linkages), and institutions ('rules of the game' such as legislation, and cultural and technical norms). There are several conceptualisations of innovation systems, including global, national, regional, corporate, sectoral, and technological. Research on national innovation systems (NIS) as defined by Freeman in the late 1980s (Freeman 1987) has concentrated mainly on the role of organisations such as firms, universities, and national government in stimulating technological innovation (Lundvall 1992; Nelson 1993; Freeman 1995; 2004; Suominen et al. 2019). The idea that innovation is a territorial and systemic process in a region led to emergence of the concept of a regional innovation system (RIS) (Cooke et al. 1997; Cooke 2001; Asheim & Gertler 2005). The most important aim of research on RISs has been to understand how different clusters or sectors interact with regional governance, research institutions, intermediates, support infrastructure, and the national and global levels of innovation policy and funding structures in order to obtain a competitive advantage (Doloreux & Gomez 2017; Suominen et al. 2019). The ecosystem concept has been developed in parallel with the both the NIS and RIS concepts. This is explained by the need to exploit more complex innovation systems that dynamically evolve over time and are self-organised compared with the structured and static innovation systems regulated by government bodies (Valkokari 2015; Smorodinskaya et al. 2017).

Ecosystems in management literature

James Moore's article 'Predators and prey: A new ecology of competition' (Moore 1993) is considered as marking the establishment of the ecosystem concept within management literature. The metaphor is taken from biological ecosystem and various concepts have since emerged such as business ecosystems, innovation ecosystems, knowledge ecosystems, and digital and entrepreneurial ecosystems, and each of the concepts seems to have a different theoretical background (Valkokari 2015; Tsujimoto et al. 2018). The significance of the ecosystem concept lies in its use in the analysis of organic networks that are based on the competitive and collaborative and/or symbiotic behaviour of the organisms in the system, as well as external physical factors affecting the system. In addition, all actors in the system have their own role to play, with different attributes, decision-making, and purposes. In common with NISs and RISs, the boundary of an ecosystem is not limited to a geographical area or a cluster, but is concentrated around a value chain, a product, a platform, or an organisation, and it consists of both business and non-business actors (Valkokari 2015; Tsujimoto et al. 2018). Ecosystems evolve dynamically through interactions between actors and their boundaries can be set by geographical (global, national, or regional), permeability (open or closed), or temporal (time and/or history) scale or by type of flows (knowledge, technology, products, or services) (Valkokari 2015).

Valkokari (2015) distinguishes between three types of ecosystems: business, knowledge, and innovation ecosystems. In *business ecosystems* the economic outcomes and business relations among actors are highlighted. The value creation for customers is in focus and typical key actors are larger firms. Concepts such as digital, industrial, and service ecosystems are considered subconcepts of the business ecosystem concept. *Knowledge ecosystems* are concentrated on the generation of new knowledge and technologies through joint research, commercialisation projects, and other forms of knowledge and technology transfer. Research organisations and technological entrepreneurs have a central role in such systems. *Innovation ecosystems* are considered as integrating mechanisms between the exploration of new knowledge and the exploitation of such knowledge for value creation. Typical actors are regional clusters, intermediates, and innovative start-ups, policymakers, funding agencies, seed funders, and venture capitalists.

The concept of innovation ecosystems has emerged gradually in line with the growing importance and demands of the non-linear and knowledge-based economies, and the literature on innovation ecosystems typically focuses on the individual actors, assets (such as platforms), links, and networks within a region (Adner 2006; Bogers et al. 2019; Granstrand & Holgersson 2020). The informal English adjective 'eco' serves to emphasise the non-linear nature of innovation (Smorodinskaya et al. 2017). However, the value of adding 'eco' to innovation system concepts has been questioned (Oh et al. 2016). In a comprehensive review of different definitions of 'innovation ecosystem', Granstrand & Holgersson (2020) argue that the concept does contribute to innovation system research, but it needs to be sufficiently well-defined and employed in an appropriate context. They also find that the most important components of an innovation system are 'actors', 'artifacts' (defined as items such as products, services, resources, and technologies), and 'activities', which are dynamically linked through relations, collaborations, and competition, as well as their relations with other ecosystems. Valkokari (2015) highlights that the relationships and dynamics between overlapping ecosystems is an important research theme and that there is a need to develop tools to enable boundaries between the ecosystems to be crossed.

Universities and the third mission

The concept of the third mission is described as nebulous (Laredo 2007; Gregersen et al. 2009), but it is an evolving and widely recognised concept linked to knowledge and technology transfer and to the engagement of universities with industry and society beyond the two other missions of education and research (Giuri et al. 2019; Compagnucci & Spigarelli 2020). There has been a widespread recognition that the third mission is becoming increasingly important, especially for regional development (Etzkowitz & Leydersdorff 2000; Laredo 2007; Benneworth & Sanderson 2009; Sánchez-Barrioluengo & Benneworth 2019). Encouragement has come from governments and industrial actors, as well as from university managers themselves (Gulbrandsen & Slipersæter 2007; Perkmann et al. 2013; Jiao et al. 2016; Hayden et al. 2018). In addition, there has been a substantial increase in internal university support for entrepreneurship, innovation, and commercialisation activities, and this illustrates the transformation towards entrepreneurial universities (Etzkowitz et al. 2000; Etzkowitz 2017; Sánchez-Barrioluengo et al. 2019). This development has been fuelled by the increasing prevalence of innovative clusters at the regional level and universities' collaboration with them (Dodgson et al. 2014; Etzkowitz 2017).

The ability of actors within innovation systems to absorb knowledge depends on their capability to recognise, assimilate, and apply new academic information for innovation purposes, a process that is often termed 'absorptive capacity' (Cohen & Levinthal 1990; Cockburn & Henderson 1998; Agrawal 2001; Powell & Grodal 2005; Salge & Vera 2012). Universities have been shown to have different roles influenced by their location, and geographical factors are important for how universities execute their third mission (Trippl et al. 2009; Breznitz & Feldman 2012; Kitagawa et al. 2016; Heaton et al. 2019).

Traditionally, universities have been evaluated based on how they execute their third missions according to their ability to patent and license technology and to create spin-off based on university research (Guldbrandsen & Slipesæter 2007; Breznitz & Feldman 2012). However, universities are in a wider sense societal actors through their education of skilled workforces, their participation in policymaking, culture, architecture, and innovation infrastructures, and through their creation and dissemination of knowledge (Breznitz & Feldman 2012; Sánchez-Barrioluengo & Benneworth 2019). According to a broader definition of the third mission, universities are expected to engage in their respective region's social and societal deliberations and decision-making processes, and by providing a window to the world for their local region (Chatterton & Goddard 2000; Pawlowski 2009; Breznitz & Feldman 2012; Blume et al. 2017). Recently, a stronger focus on the transition of universities' strategies to sustainability and to green and social innovation has emerged (Benneworth et al. 2016; Reichert 2019).

By exploring our case, we aim to contribute to a broader understanding of how the linkages between the universities and different actors in an innovation ecosystem both function and evolve.

Analytical framework

The embeddedness of innovation systems and the concept of local buzz and global pipelines

Innovation systems in general and regional-based systems in particular are highly embedded by nature. As stated by Bathelt et al. (2004), when locally embedded knowledge is combined in novel ways with codified and accessible external knowledge, new value can be generated. This concept has become known as local buzz and global pipelines. Local buzz refers to the thick web of information and knowledge that is embedded within and circulates among actors within a cluster. It is created by face-to face contacts in mutual arenas with the possibility to meet and co-locate people, companies, and other organisations within the same industry or region. Such local buzz consists of specific information, knowledge, and technology transfer, and the possibility for learning, associated with continuous updating. The nature of the buzz is spontaneous and flows easily within the cluster, and the various actors can access the buzzing information without much investment in time or other resources. By contrast, global pipelines refer to a deliberately established connection to global knowledge linkages. The information and knowledge that flows through such pipelines are far from being automatic and participation does not come without costs. The establishment of global pipelines with new partners requires that new trust will be built in a conscious and systematic way, which takes time and involves investments. Bathelt et al. (2004) argue further that the extra-local knowledge coming from the global pipelines is spread by the mechanism of the local buzz within a cluster, and due to global pipelines' potential to intensify local interaction, they support and strengthen the translation processes within a cluster.

The concept of local buzz and global pipelines has often been discussed in the literature and is acknowledged for deepening our understanding of the interrelatedness of local and non-local knowledge linkages that promote innovation processes within a cluster (Trippl et al. 2009; Fitjar & Rodríguez-Pose 2015; Aarstad et al. 2016; Musil & Eder 2016) However, the concept has also been subject to criticism for being too general and because the distinction between local and non-local relationships is too broad, which does not allow for deeper insights into the mechanisms by which actors gain knowledge and expertise at different spatial scales. In addition, it has been pointed out that there is a lack of empirical evidence in support of the concept and there has been a call for studies that explicitly examine whether the local buzz and global pipelines merely substitute and reinforce each other (Aarstad et al. 2016; Musil & Eder 2016).

The research compass methodology

To create an ecosystem linkage diagnostic tool for universities, as well as to capture the important territorial context and embedding described in the preceding subsection, we operationalise the 'research compass methodology', which was developed as a framework to collect and characterise the territorial embedding of universities (Laredo & Mustar 2000; Robinson et al. 2016). By exploring the characteristics and geography of the various links to and from a university, we aim to clarify how universities perform their third mission activities and position themselves as actors within an innovation ecosystem. The methodology acknowledges that measuring the dynamics of science by codified knowledge (e.g. through scientific publications) alone is not sufficient, due to the complex nature and relationships between research organisations, industry, and society.

A research laboratory is described as a laboratory for conducting research or investigation into science and can be both public and private, a separate organisation, or part of a larger organisation or company (Laredo & Mustar 2000). The research compass methodology captures five dimensions of activities in which research laboratories are considered to interact with industries and society: (1) certified knowledge instruments, (2) training as embodied knowledge, (3) competitive advantages – the innovation aspect, (4) research and public debate, and (5) policy and society links (Fig. 1). The degree of involvement within each of the five dimensions, or impacts, of the compass defines a mix specific to the laboratory in question and is called its 'activity profile'. It also demonstrates that simple indicators are sufficient to measure the levels of involvement in each activity. The methodology acknowledges that it is difficult for research laboratories to be strongly involved in all activities and it describes two extreme situations where (1) the only contributions are in the form of codified knowledge such as publications, and (2) activities are dedicated solely to gaining competitive advantages in order to foster innovation in industry.

For our study we used the research compass methodology in data collection and contextualisation of links to and from the marine biological and biotechnological activities at the University of Bergen (UiB) in Norway. The marine activity at UiB is not strictly defined as a research laboratory. However, Laredo & Mustar (2000) convincingly argue that activity profiles across institutional and disciplinary barriers are of more importance to how a laboratory interacts with society and industry than to the organisation of the laboratory itself. By this, they mean that the combination of strategies developed by the different laboratories and the organisations to which they belong, their logics of actions, and the norms, procedures, and policies that accompany, foster, or inhibit them are superior to organisational structures. Therefore, we hold that the research compass methodology is transferable to the creation of an ecosystem-linkage diagnostic tool for a university, which can consist of many types of research laboratories. We have used the research compass methodology to capture the five dimensions of activities in which universities interact with industry and society in a specific field, namely marine research. This field corresponds to a research laboratory in the methodology. We have also added the concept of local buzz and global pipeline (Bathelt et al. 2004) to our methodology, thereby contributing a spatial quality to the five dimensions in the research compass. To put our

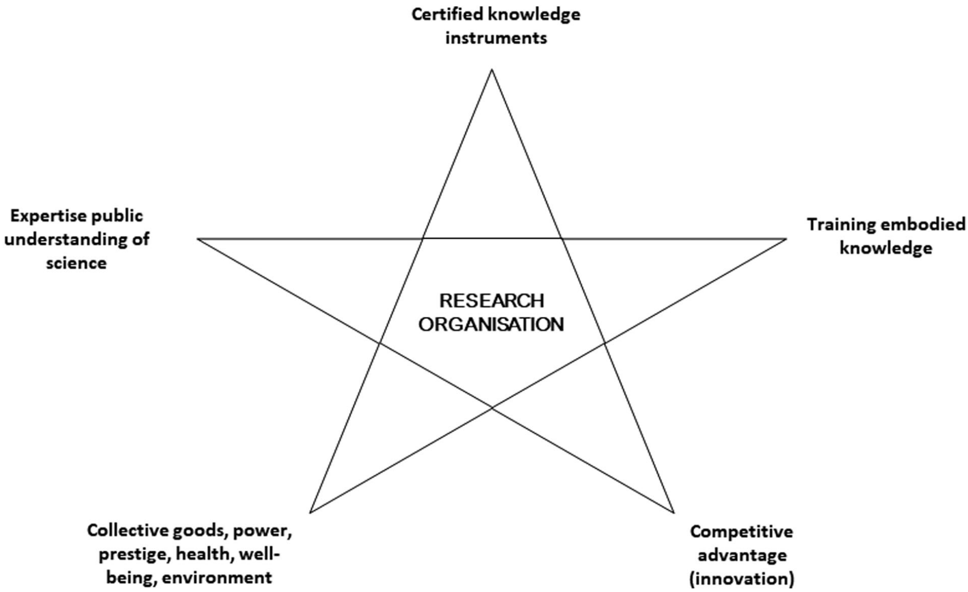

Fig. 1. The research compass and its five forms of impact to be measured in the activity profiling methodology (adapted from Laredo & Mustar 2000, 521)

research in context, we use the definition of innovation ecosystem formulated by Mazzucato & Robinson (2018, 168): 'The network of interconnected actors, organised around a particular value chain/industry where the actors include public agencies, firms, intermediates and other actor that contributes to the production and use of a product or service stemming from that value chain/industry'. Mazzucato & Robinson point out that according to their definition the innovation ecosystem can be both regionally bounded to a city and/or region or it can be global. We assume that the definition covers the components of an innovation ecosystem as described by Granstrand & Holgersson (2020). Accordingly, we have created a lens through which to understand the meaning and position of the various links a university has within the innovation ecosystem and beyond.

Research design and methodology

Robinson et al. (2016) developed the 'territorial embedding analysis' (TEA method) as an assessment tool, based on the research compass methodology, as a part of the Horizon 2020 project EMBRIC: 'European Marine Biological Research Infrastructure Cluster to promote the Blue Bioeconomy'. The tool captures the links and indicators used for activity profiling. A description of the items in the data set linked to the compass is provided in Table 1. In addition, in acknowledging the importance of artifacts and infrastructures such as platforms, intermediates, networks, and common resources in innovation ecosystems, we collected a comprehensive list of the most important platforms, intermediates, and networks in which UiB either plays or has played an important role. Our methodology, although not new in origin, corresponds very well to state of the art within knowledge and technology transfer measurements (Campbell et al. 2020).

Our data cover the field of 'marine research' at UiB, which in this study, and in accordance with the definition in the EMBRIC project, we define as 'research, innovation, and training within marine biology, including aquaculture, and marine biotechnology in addition to stock-assessment/management and fisheries'. The data presented in this paper relate to the period 2010–2017 and were systematically collected in 2017 and 2018. However, also some newer data have been included, especially in the case of data concerning infrastructure, policy, and society links. To identify relevant publications (Table 1, 1a), we identified a set of scientific keywords and extracted data from the database for Norwegian academic publications, Cristin. The database Web of Science was then used to extract the names of all co-authors. To identify the competitively funded

Table 1. Descriptions for data collection for territorial embedding analysis (TEA method, Robinson et al. 2016) along the corresponding five dimensions of the research compass methodology

Data set linked to the five dimensions in the research compass	Territorial embedding analysis description (based on Robinson et al. 2016)	Data collected in this study
Scientific institutions 1. Certified knowledge instrument	(1a) Peer-reviewed academic publications identified as broadly linked to the field in question	All recorded marine publications from the University of Bergen (UiB) in the period 2010–2017 (extraction based on keywords from bibliometric databases and information systems)
	(1b) Competitive publicly funded projects, most often from public funding organisations (e.g. European Commission, national research councils) but can also include, for example, regional funds and foundations	Data collected on all competitively funded projects at UiB financed by the Research Council of Norway, the EU, and others, in the period 2010–2016
Educational system 2. Training embodied knowledge	Professional and academic training activities from the research centre broadly linked to the field in question	Data on all marine courses directed towards professionals in the period 2010–2017 Data on all the marine PhD graduates from UiB and their first job in the period 2010–2017
Economic system 3. Competitive advantage (innovation)	(3a) Economic relations between the research centre or university and the private and public sector. This includes, for example, contract research, consultancy, service provision, provision of a PhD student, and commercial use of infrastructure.	Data collected on all economic links and contracts involving UiB within marine activities in the period 2010–2016
	(3b) Patents as broadly linked to the field in question	Data collected on all patents within the marine field from UiB in the period 2010–2016
Public authorities 4. Collective goods, power, prestige, health, well-being, environment	Participation in standardisation organisations, for example on boards and policy committees, broadly linked to the field in question	Data collected on a variety of policy links from UiB in the period 2010–2016 (not exhaustive)
Museums, public debate 5. Expertise and public understanding of science	Links between the research centre (and individual researchers) with civil society broadly linked to the field in question (society links)	Data collected on a variety of society links from UiB in the period 2010–2016 (not exhaustive)

research projects (Table 1, 1b), we used lists from the Research Council of Norway (RCN), the Horizon 2020 database (EUPRO and Cordis), and additional lists provided by departments at UiB and the Sars International Centre for Marine Molecular Biology, which is based at the university. Additionally, information about the various data and projects was collected from the research projects' webpages and databases.

Information relating to training portfolios (Table 1, row 2) was provided by the Department of Biological Sciences at UiB. To obtain information on doctoral degrees, we used lists from a database held by NIFU (Nordisk institutt for studier av innovasjon, forskning og utdanning), supplemented by information from institutional websites, social networks such as Facebook and LinkedIn, and personal contact by e-mail or personal communication. Contracts with public and private sector actors (Table 1, row 3) were provided by departments at UiB, Vestlandets innovasjonsselskap AS (VIS), and UiB's Technology Transfer Office (TTO). Data on relevant patents (Table 1, 3b) were collected from the VIS patent database. Additional information on the patents was extracted from the European Patent Office's PATSTAT database and Google Patent. For policy and society links (Table 1, rows 4 and 5), data from UiB were extracted from Cristin and a variety of sources provided by UiB. For the collection of data not formally registered by UiB, we contacted 50 scholars. The departments and contacted persons were selected due to their associated activities, which were deemed relevant for the data in question as suggested by department and university managers in various positions, and by the 'snowball' method. The data collection was not exhaustive for the period in question and the timespan might have varied for the different data sets, especially for data within the area of research, training, policy, society areas, and infrastructures. However, we consider the material provided an adequate description of the activities. Strategic documents were collected in collaboration with UiB managers, researchers, VIS, and representatives from the regional industry clusters. The CorTexT platform was used to analyse both publication and project data.[1]

Characterising the ecosystem embedding of the marine research environment at the University of Bergen

Setting the scene

In this section we apply the research compass framework to the marine research environment at the University of Bergen in Western Norway. The region has a longstanding tradition in harvesting seafood and holds

[1]For additional inks to data sources and other resources used in the research, but not cited or referenced in this paper, see Supplementary Appendix 2.

a prominent position in the global seafood market for fish, production, processing, and sales. Since the early 1970s the region has been central in the development of the modern global aquaculture industry. Additionally, it has all the components for 'blue bio' knowledge and innovation ecosystems (Valkokari 2015; Andersen et al. 2016; Fløysand & Jakobsen 2016; Connected Places Catapult 2021). The actors within the ecosystems cover the whole value chain, ranging from the production of fry and fish to the processing and export, equipment suppliers, R&D institutions, common technological platforms (i.e. industrial catapults), and several intermediates such as industry cluster organisations, incubators, and a technology transfer office. Furthermore, the region hosts the headquarters of a number of Norway's multinational and international seafood companies, several of which have been central in innovation and in developing market opportunities for fresh fish, making Norwegian seafood, especially farmed salmon, an important export commodity.

Western Norway is home to many important research organisations within marine sciences, which contribute in terms of educational programmes within aquaculture and engineering, as well as the scientific management of fisheries. These research organisations have also contributed to the development of modern aquaculture through collaborative research and development, along with education within fields such as fish biology and farming technologies. UiB has marine research as a strategic priority (University of Bergen n.d.) and is recognised internationally across a diverse range of marine sciences, and for excellence within selected areas of teaching in marine disciplines (Kiørboe et al. 2014; QS Top Universities 2018). The university is also the official United Nations Academic Impact (UNAI) SDG Hub14: Life Below Water, as well as a member of the International Association of Universities. UiB has been active in both the establishment and maintenance of many of the marine infrastructure initiatives in Western Norway, both within research and innovation.

We believe the marine research environment at UiB, as an integrated part in the marine innovation ecosystem described above and with its overlapping links to business and knowledge ecosystems, serves well as a case for the application of ecosystem-linkages as a diagnostic tool. In the following subsections we elaborate on our key findings and interpretations of these links.

Scientific institutions: profiling through certified knowledge instruments

The CorTexT-based analysis in our study revealed that marine scientists at UiB engaged in a large amount of international collaboration. However, other national universities and research institutions, and even regional ones, are still the most frequent collaborators (Fig. 2).

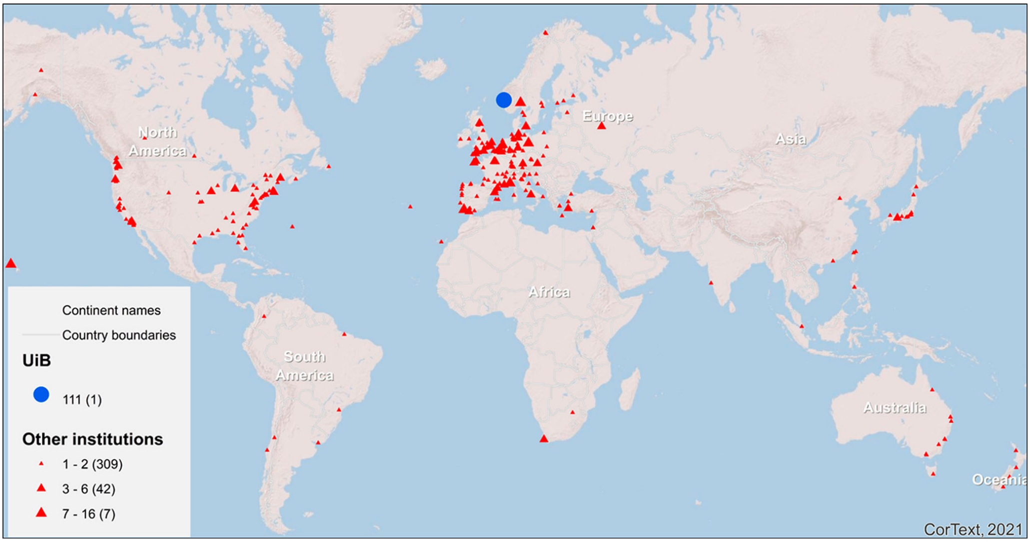

Fig. 2. Location of co-authoring institutions mentioned in publications within marine biology produced by UiB between 2010 and 2014 (map not to scale) (Generated by CorText, based on the data sources the Sars International Centre for Marine Molecular Biology, Cristin, and Web of Science)

Table 2. Collaborative partners in competitive-funded 'blue bio' related research projects (data are from projects for which UiB was a coordinator or partner, 2010–2016)

Institution	Type	No. of projects
Institute of Marine Research (including NIFES)	Pub	49
NORCE (formerly Uni Research AS)	Pub	36
VIS AS (formerly BTO AS)	Pub	15
University of Oslo (UiO)	Pub	13
Norwegian University of Science and Technology (NTNU)	Pub	12
Nofima AS	Pub	11
The Norwegian Seafood Research Fund (RCN)	Pub	8
Consejo Superior de Investigaciones Científicas (CSIC), Spain	Pub	7
Norwegian Biodiversity Information Centre	Pub	7
Stichting Dienst Landbouwkundig Onderzoek, Netherland	Pub	7
Centre national de La recherche scientifique (CNRS), France	Pub	5
Hellenic Centre for Marine Research, Greece	Pub	5
L'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), France	Pub	5
Lerøy Seafood Group Asa	Priv	5
Norwegian Centre for International Cooperation in Education	Pub	5
University of Helsinki, (UH), Finland	Pub	5
Wageningen University and Research Centre, Netherland	Pub	5
Technical University of Denmark (DTU)	Pub	4
Natural Environment Research Council, UK	Pub	4
Norwegian University of Life Sciences (NMBU)	Pub	4

Furthermore, we collected data on competitive projects that had been awarded funding based on expert reviews. The source of funding, as well as the size and form of finance, can provide useful insights into the institutional profile. In total, 82% of the funding came from national funding sources, mainly the Research Council of Norway (RCN) and the Norwegian Seafood Research Fund (FHF). Public funding agencies are considered important governmental actors in the innovation ecosystem and therefore we have reason to believe that the RCN, FHF, and EU, through their research and innovation programmes and strategies, all have significant influence on the evolvement and dynamics of the marine innovation ecosystem in Western Norway. The regional funding sources were mostly from private research foundations based in the region, and the absence of regional governmental funding was striking.

Regional and national institutions dominate the top 20 collaborative partners in research projects in Norway. The Institute of Marine Research (IMR) and NORCE, both of which are national research institutes with head offices in Bergen, are top collaborators (Table 2). It is noteworthy that an intermediate organisation, VIS, which is a regional innovation company and UiB's TTO, is listed in third place, thus indicating the close involvement of innovation in UiB's marine biology research.

Education system: profiling training

According to Laredo & Mustar (2000), profile training constitutes an important activity for many research organisations. Through training, research organisations can become vehicles for capacity building, especially in the local sphere of an innovation ecosystem, and can provide skilled workforces to build socio-economic value. Also, research centres and universities involved in such training can attract talent to a region (Benneworth & Hospers 2006). For our study, we characterised the training activities into four different categories (Table 3, a). In addition, we tracked all biology PhD candidates who graduated in the period 2010–2017 (n = 141). Of those, 79% were awarded a PhD within a marine field and 92% of those, regardless of nationality, eventually found their first job in Norway. The two local institutions, IMR and UiB, were by the far the dominant first employers for the PhD graduates.

Table 3. Categories of training (2010–2017), contracts (2010–2016), policy (2010–2016), and social links (2010–2016) identified in the study (sources: UiB and VIS databases, supplemented with information from departments and individual researchers at UiB)

3a) Course/event directed towards following types of attendees	**No. of courses/ events**	**%**
Professional from industry	1	2.4
Professionals from public organisations (incl. schools)	9	21.4
Graduate	27	64.3
Postgraduate	2	4.8
Researcher	3	7.1
Total	**42**	**100**
3b) Type of contractual relation	**No. of contracts**	**%**
Consultation/contract research	98	51.0
Product development/commercialisation	55	28.6
Licence agreements	17	8.9
Other*	11	5.7
Start-up/Spin-off	6	3.1
Services	4	2.1
Collaborative groups/laboratories	1	0.5
Total	**192**	**100**
3c) Type of policy link	**No. of links collected**	**%**
Building markets	6	7.8
Participation in politics of a domain	13	16.9
Producing data for policy	13	16.9
Research and innovation agenda setting	45	58.4
Total	**77**	**100**
3d) Type of society links	**No. of links collected**	**%**
Participation in debates	19	31.1
Public outreach (self-organised)	40	65.6
Other	2	3.3
Total	**61**	**100**

*Mainly contract research in terms of PhD candidates engaged in doctoral projects in industry as part of the Research Council of Norway's industrial PhD scheme, funding of master's projects, and adjunct professorships funded by the industry

Alumni from universities facilitate communication between universities and wider society, and thus strengthen both social capital and learning (Pavitt 2005; Perkmann & Walsh 2007; Grimpe & Hussinger 2013). A survey of master's students (Høgestøl & Bjørnebekk 2018) and our findings relating to PhD graduates showed that such UiB alumni tend to stay in the region, and thus contribute to knowledge and technology transfer through research and innovation activities within the regional innovation ecosystem.

Economic system: profiling competitive advantages

Contracts

The vast majority of the economic links and contracts within marine biology are with private companies, and where contracts with a few multinational aquaculture companies situated in Western Norway dominate (Table 1 and Table 3, a). We categorised the links into seven types of contractual relations (Table 3, b). Fig. 3 shows the geographical distribution of the links to and from UiB. Only six contracts involved insitutions outside Europe. The European links were diverse, but larger multinational companies dominated. More than half of the national contracts involved local companies and public organisations. This is in accordance with our findings that the international contracts mainly involved larger multinational companies, many within pharmaceuticals and biotechnology, and were not necessarily dependent on proximity to the coast. The geographical distribution along the coast for the regional and national links illustrates the historical emergence and genesis of a marine innovation ecosystem and the 'blue bio' profile at UiB. The nature and distribution of the links in our data

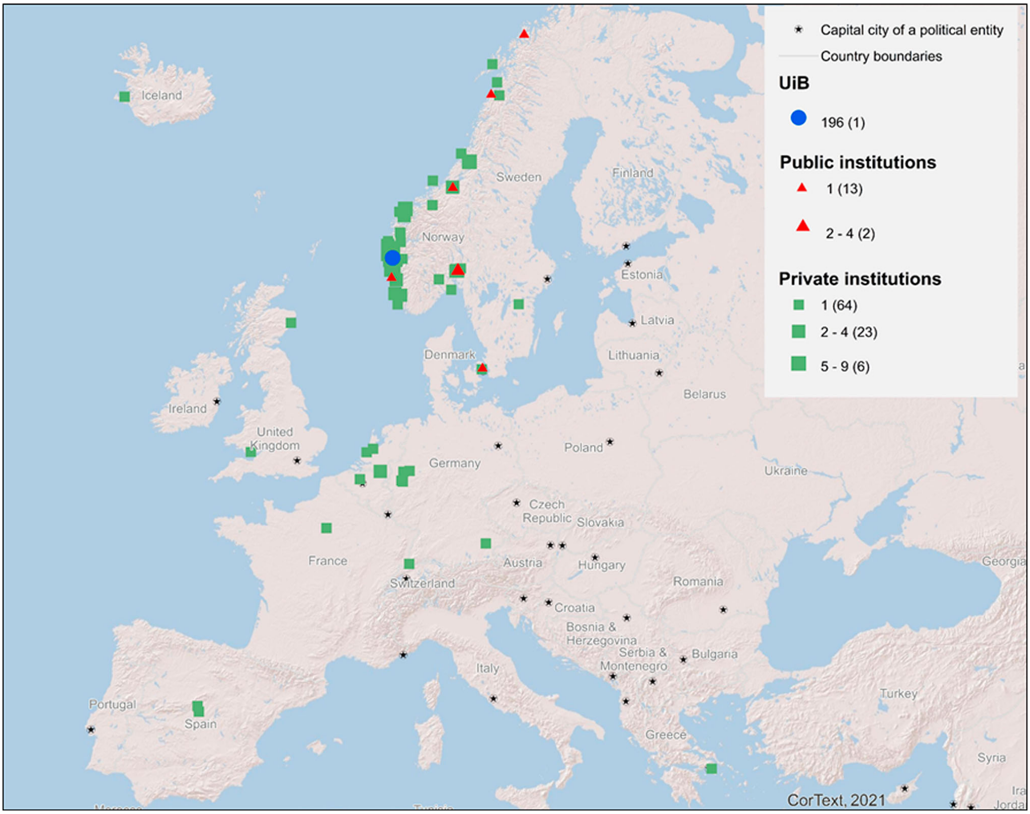

Fig. 3. Location of partner institutions with economic linkages to and from UiB in the period 2010–2016 (map not to scale) (Sources: UiB databases and VIS databases, supplemented with information from the Faculty of Mathematics and Natural Sciences and the Department of Biological Sciences at UiB)

indicate the presence of a business ecosystem, as defined by Valkokari (2015). The business ecosystem seems to be dominated by a few strong regional-based multinational firms but is not strictly restricted to a regional sphere. The business ecosystem also consists of many small and medium enterprises (SMEs) along the value chain and with which UiB collaborates. These links suggest that UiB may take part in the local buzz, as defined by Bathelt et al. (2004). Our findings also show the presence of a global network in which UiB has long-term collaborations with multinational firms, thus suggesting that UiB may act as global pipeline in the region. Furthermore, UiB is a contributor to innovation and commercialisation activities through licence agreements and academic spin-offs within 'blue bio', thus indicating the presence of a marine knowledge ecosystem.

Patents

According to the research compass methodology, the transformation of an idea into proprietary knowledge is considered an important part of the competitive advantages for a research organisation. A total of 29 marine biology patents were registered in the VIS patent database by inventors at UiB in the period 2010–2016. Seven of the patents were priority patents and all but one were linked to marine biological applications and projects where the inventors were strictly local and the applications and projects were the result of long-term collaboration.

The exploitation of marine resources is considered a new frontier and the value of patents within the field has been discussed, especially with regard to marine genetic resources (Strand 2013). The willingness to patent within aquaculture, marine biology, and biotechnology seems low in Norway compared within the life sciences (Herstad & Sandven 2017). The FHF, which is an important funder of aquaculture research in Norway, requires that all results generated from their projects must be openly accessible. This may partly explain the limited patenting within marine resources. In addition, according to a research and innovation manager at Lerøy Seafood Group, the marine industry has reduced interested in research collaboration when research organisations want to patent the results themselves (H. Sveier, personal communication, 2020). Norway generally performs low in terms of patent generation, and in this regard the former county of Hordaland (now part of the county of Vestland), where Bergen is situated, is below average by Norwegian standards (Norges forskningsråd 2019). Furthermore, Strand (2013) shows that Hordaland has also performed low in the industry part of R&D expenditures and average in terms of securing industry-related rights, such as patents. However, VIS has a large portfolio of marine commercialisation projects compared with other TTOs and has been appointed by the Research Council of Norway as a national coordinator for marine commercialisation activities.

Thus, our findings demonstrate the existence of an innovation ecosystem where the innovation and commercialisation activities are taking place without a high dependency on patents within the field. This in turn suggests there is a more open and transparent innovation system fuelled by the policy of the funding agency, FHF.

Public authorities: profiling connections with policy

Universities and other research institutions are linked to the overall research and innovation ecosystems through various policy and societal links at local, national, and global scale. Representatives from research organisations can be highly involved in political and economic forums and committees as experts and advisors, as well as through board memberships in companies, public organisations, and associations. In the case of the University of Bergen, data on 77 links from activities within the period 2010–2017 were identified and collected from different sources and divided into four categories: (1) building markets, (2) participation in the politics of a particular domain, (3) production of data for policy, and (4) research and innovation agenda setting (Table 3, c). The geographical distribution of the policy links was evenly distributed. It should be emphasised that many of those links are associated with themes within sustainability and environmental issues supporting a transition of UiB's strategies and activities into sustainability and green and social innovation.

Media, museums, and public debate: profiling connections with civil society

Research organisations can be embedded in their regions through strong relationships with civil society (specific and general publics) (Table 3, d). Our findings show that the links were quite diverse, but the public outreach category (e.g. open seminars, conferences, fairs, meetings) was most prominent, followed by participation in debates. The links were highly dominated by regional events (92%), implying that these kinds of links contribute to the local buzz.

UiB's role in developing and maintaining marine infrastructures and networks

Infrastructures are mediators and drivers of regions (Robinson et al. 2016), and they provide sustained connections with the various 'spheres' of the research compass. In addition, they are important part of the innovation ecosystem. Therefore, many of the infrastructures connected to UiB are important for understanding the overall contribution of the university as a participating actor in society. We assume that the start of the marine innovation ecosystem occurred in 1989, with the establishment of the High Technology Centre in the city of Bergen (Høyteknologisenteret i Bergen) and the shared Industrial and Aquatic Laboratory (ILAB) at UiB (Table 4), in which the university was central. Since then, the innovation ecosystem has grown substantially, and many new intermediates and shared technological platforms have emerged, especially in the last decade.

Summarising the activity profile in relation to the business, the knowledge, and the innovation ecosystem

The links identified through the activity profiling in our study demonstrate a university with many connections and different roles in the innovation ecosystem surrounding the marine value chain in Western Norway. A summary of our main findings and key interpretation is presented in Supplementary Appendix 1.

The local connections between UiB and other research organisations, companies, intermediates, and networks are dominant in all dimensions of the research compass, also in addition to many global connections. This is especially the case with the many links from co-authorship in publications and partnerships in research projects, but also found in contracts with international companies and through the various policy links from international committees, global infrastructure, and networks. Together, these links demonstrate how UiB contributes as a global pipeline in Western Norway. We also see that the research compass dimensions of the certified knowledge instruments, training embodied knowledge, and, to a certain degree, the dimension of competitive advantage in many ways correspond to a knowledge ecosystem, as described by Valkokari (2015). The knowledge ecosystem is characterised by knowledge exploration and knowledge exchange, and it consists typically of research organisations and technology entrepreneurs. We also see, mainly through the links from the dimension of competitive advantage, the contours of a marine business ecosystem, with actors such as suppliers, customers, and focal companies as a core, many of them multinational.

The innovation ecosystem integrates the exploration (knowledge) ecosystems and exploitation (business) ecosystems, and the baseline of the ecosystem is co-creation of value (Valkokari 2015). In our study we found the innovation ecosystem around UiB expressed by all the geographically clustered links to various actors in the region. We identified the influence of funding agencies such as the RCN, EU, and FHF in competitive funded projects, the connections to intermediates such as VIS, and collaboration with industry cluster organisations. Many infrastructures, platforms, and networks within research and innovation, and where UiB has a role in establishment and/or maintenance, must also be considered important part of the innovation ecosystem. In addition, the training events for professionals and the various industrial-tailored educational programmes established by the university, along with the absorptive capacity associated with the many master's and PhD candidates who tend to stay in the region after graduating, are recognised components of the system, adding to the local buzz.

Intermediates are considered an important part of innovation ecosystems (Kivimaa et al. 2019). Based on the frequencies and nature of the links, we see that many of the intermediates, such as VIS and industry cluster organisations, and infrastructures and platforms, such as industry-related catapults, typically span the boundaries between the three different ecosystems, as illustrated in Fig. 4. It should also be emphasised that the large number of such intermediates and platforms in the marine innovation ecosystem, indicating a numerous and intricate set of actors, adds to the complexity of the system.

The marine innovation ecosystem in Western Norway has a typical regional concentration but must be considered global in its boundaries. Furthermore, it seems characterised by a transparent and open innovation culture, fuelled by the policy of the funding agencies such as the FHF and encouraged by the multinational leading aquaculture companies in the business ecosystem. Historically, UiB has been very active in the development of important elements of the innovation ecosystem such as the High Technology Centre, the shared marine infrastructure platform ILAB, and the establishment of the intermediate innovation company and TTO, VIS. However, our links from the period 2010–2017 indicate a story of the university's declining role as a leading actor in the innovation ecosystem. Although present, UiB does not seem to have a significant leading role in the regional policy links or local infrastructures included in our study. In addition, important local governmental bodies such as Vestland County Council and Bergen Municipality seem to have few visible research or innovation links to and from UiB. However, we find that national and global organisations such as the RCN, EU, and FHF seem to

Table 4. The University of Bergen's role in the establishment and maintenance of important infrastructure in the marine innovation ecosystem (sources: information on affiliation from both the Faculty of Mathematics and Natural Sciences and the Department of Biological Sciences at UiB, in addition to available web pages for the listed infrastructures and networks)

Infrastructure	Description*
Collaborative structures and/or spaces	
ILAB (Industrial and Aquatic Laboratory) (1989) Regional	A foundation for management of the wet laboratory facility for aquaculture and other tank-based research set up between the UiB and Marineholmen, in Bergen
Espeland Marine Biological Station (1957) Regional	The station is owned by UiB and has several specialized marine facilities.
Norwegian Ocean Observation Laboratory (2016) National	This is an open infrastructure on Marineholmen, established byUiB, the Institute of Marine Research, and the Norwegian Defence Research Establishment (FFI).
Marineholmen, including the High Technology Centre Regional	This physical area (owned by Marineholmen Research Park) is a cluster containing several companies, many of them multinational and with a strong innovative edge.
Vestlandets innovasjonsselskap AS (VIS) (2004) Regional	VIS is an innovation company and technology transfer office (TTO) and is owned by UiB and most of the other research and higher organizations in Bergen. VIS is organised into two different segments: VIS Startup and VIS TTO.
Ocean Industries Accelerator (OIA) (2017) Regional	OIA is a community for companies in ocean industries. It is run by VIS and the marine industrial clusters in Bergen for entrepreneurial start-ups and companies from the ocean industries.
Hatch (2017) Global	Hatch operates as a global catalyst for start-ups within aquaculture and alternative seafood innovation. It is situated in Marineholmen and is a close collaborator with VIS and UiB (project-based).
KG Jebsen Centre for Deep Sea Research (JC-DeepSea) (2017) Global	JC-DeepSea was established based on funding from the Kristian Gerhard Jebsen Foundation. It aims to be a leading international centre for deep ocean research.
Austevoll Research Station (1978) and Matre Research Station (1971), Regional	The two marine research stations are owned by the Institute of Marine Research but have close links to UiB. The stations are open for other users on commercial basis when there is capacity.
Research Vessel Department, Institute of Marine Research	A shipping unit in the Research Vessels Department at the Institute of Marine Research (IMR), which runs the national research vessel fleet. The unit runs research vessels owned by IMR, UiB, NORAD, UiT The Arctic University of Norway, and the Norwegian Polar Institute.
Computational Biology Unit (CBU) National (2002), Global (2014)	CBU is a joint research centre at UiB, which has an open service unit assisting departments and researchers, as well as Haukeland University Hospital in their work on bioinformatics.
Centre for Digital Life Norway (DNL) (2016) National	Centre for Digital Life Norway (DLN) is a unique transdisciplinary research centre creating the biotechnology for tomorrow within health sciences, marine disciplines, and agriculture. UiB is an active partner in this centre.
Ocean Sustainability Bergen (OSB) (2019) Global	OSB is a virtual centre at UiB and works with partner institutions worldwide in ocean science and education. The centre is part of the university's strategic initiative, SDG Bergen, and UiB's status as the Hub for SDG 14: Life below water, as appointed by the United Nations Academic Impact (UNAI) initiative and is also the SDG 14 representative in the International Association of Universities (IAU) SDG Cluster.
Sars International Centre for Marine Molecular Biology (1977) Global	The Sars Centre is a research facility under UiB. It is a member of the European Molecular Biology Laboratories (EMBL) for which it serves as the marine hub.
Sea Lice Research Centre (2011) National	The Sea Lice Research Centre was established as a research-based innovation centre at UiB focusing on salmon lice. It is funded by the Research Council of Norway.
Networks, platforms, and industry cluster organisations	
NCE Seafood Innovation (2015) National	The NCE [National Centre of Expertise] Seafood Innovation cluster is a cluster funded by Innovation Norway and its headquarters are in Bergen. UiB is a member of the cluster and collaborates closely with the cluster management and administration.
GCE Ocean Technology National (2006), Global (2014)	The Global Centre of Expertise (GCE) Ocean Technology is an industry-driven initiative within ocean technology. UiB is a member of the cluster and collaborates closely with the cluster management and administration.
NCE Maritime CleanTech Regional (2011), National (2014)	The NCE Maritime CleanTech cluster represents one of the world's most complete maritime commercial hub and is also active within the aquaculture sector. UiB is a member of the cluster.
Ocean Innovation Norwegian Catapult Centre (OINC) (2019) National	OINC, at Marineholmen, is a national test, simulation, and visualization centre for effective prototype development. From 2021 a Makerspace has been included in OINC. UiB is a member of the centre.
Sustainable Energy Catapult Center (2019) National	The centre is a Norwegian Catapult Center for prototyping and testing on ships and in ocean space, including fish farms. UiB is a member of the centre.
European Marine Board (EMB) (1989) Global	EMB was launched by the European Science Foundation and the European Commission's Directorate General on Research, with the purpose of identifying the 'the grand challenges' in marine and polar research.
Norwegian Marine University Consortium (NMU) (2017) National	NMU is a cooperation agreement between 11 Norwegian universities. It has membership of the European Marine Board on behalf of the member universities and facilitates cooperation with a similar university cluster in China.
European Marine Biological Resource Centre (EMBRC) (2004) Global	EMBRC is a global reference research infrastructure responding to the societal grand challenges through advanced marine biology, and it promotes basic and applied marine biological and ecological research, as well as the development of blue biotechnology. UiB coordinates the Norwegian EMBRC hub.

Note: *For more in-depth descriptions of the marine infrastructures and network in and around UiB, see the final UiB EMBRIC report (University of Bergen 2020)

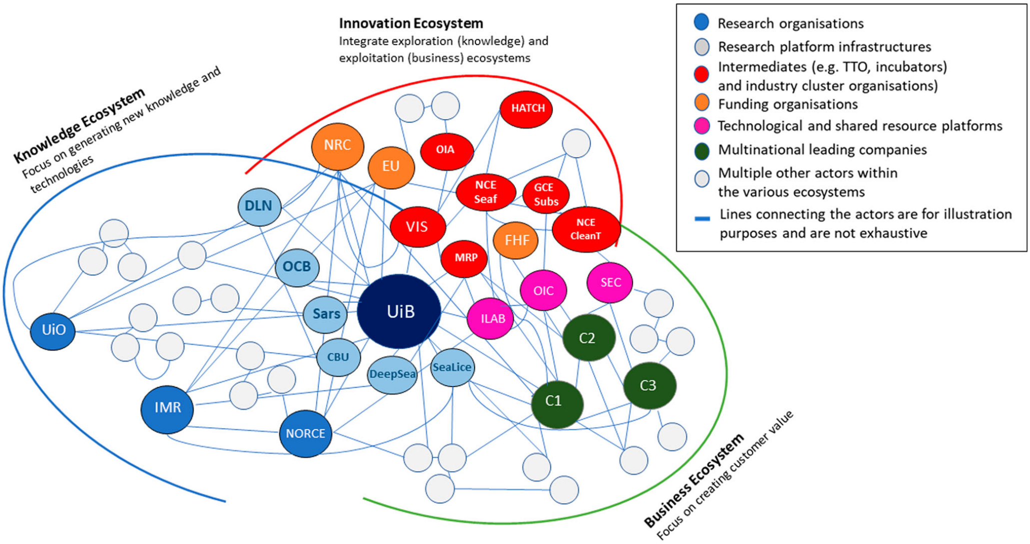

Fig. 4. Key actors (some shown abbreviated) in overlapping ecosystems in which UiB is embedded (based on Valkokari 2015, and on links identified in the study)

be important for the development of the marine innovation ecosystem in terms of funding and policy, thus demonstrating that the marine innovation ecosystem in Western Norway is a regional part of a national and global innovation ecosystem, not a genuine regional system. Further, the links demonstrate that UiB acts as a global pipeline provider through leadership in international committees, infrastructure, and networks, very often associated with sustainability and environmental issues.

For an ecosystem to perform well over time, it must co-evolve with markets and technologies (Heaton et al. 2019). Fuelled by national government and funding agencies, the marine industry in Norway is working intensively with research and development to solve the challenges it is facing, such as sea lice infections and new areas of production methods such as 'recirculating aquaculture system' (RAS) facilities. Treatment methods and medicines for various fish diseases have high priority, and UiB, very often in close collaboration with the other two major research institutions in the region, IMR and NORCE, has responded to the industry by setting up many of the shared marine infrastructure initiatives in the region. In addition, UiB provides the industry with new knowledge, technology, professional training, and a skilled workforce, which is very important for the general absorptive capacity of the actors in the region fuelling the local buzz. However, in general, the findings from our study indicate that the marine innovation ecosystem in Western Norway is quite self-organising.

We find that UiB, through its research projects and global networks and infrastructures, has links with multinational firms and organisations and with the various industry cluster organisations and intermediates, and typically acts as a global pipeline within the innovation ecosystem. Accordingly, through the dominance of regional links within the compass dimensions of 'training embodied knowledge' and 'connection with society', along with the regional dominance of many of the various other types of links, we find a strong indication of a local buzz around UiB's marine activities. However, our findings are not exclusive in this regard and the links also tell a story of more informal global connections throughout all the spheres in the research compass. In addition, UiB and the other actors mentioned in this paper are formally linked through regional industry clusters and technology platforms such as ILAB and the industrial catapults. In these technological platforms, a cost to participate is typically present. Together, the findings also imply a degree of 'global buzz' and 'local pipelines'. Therefore, our study provides an empirical insight into the mechanisms by which actors gain knowledge and expertise at different spatial scales, as illustrated in Fig. 5. The indication of the spheres in Fig. 5 is based on the case study and can vary from case to case.

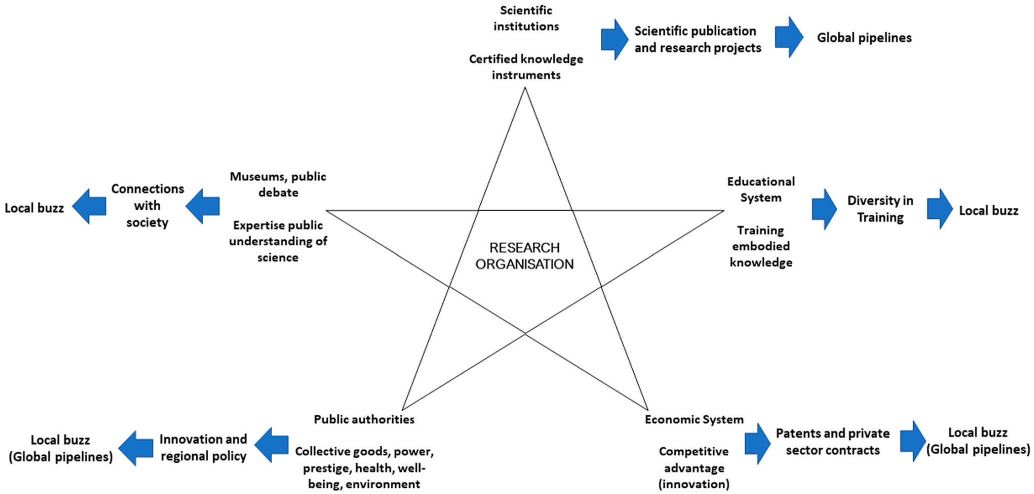

Fig. 5. A modified research compass, where the two spatial spheres of local buzz and global pipelines are connected to the data collected for the five dimensions of the compass; the indication of the spheres is based on the case study

Conclusions

In this paper we have clarified how a particular university performs its third mission activities and positions itself as an actor in an innovation ecosystem. We have operationalised and adapted an established framework – the research compass methodology – to develop and apply descriptors and indicators to characterise the variety and intensity of ecosystem linkages. By using the five dimensions of the compass, and the spheres of local buzz and global pipelines, and by identifying what data are required to inform us about these five dimensions, we have been able to create a profile – an ecosystem fingerprint – of a university. This is an important methodological contribution to the field of innovation ecosystems and can be used to evaluate the third mission of universities. We have answered the first research question on what types of links a university have within innovation ecosystems by articulating the five dimensions of the research compass to a particular context. As such, we have demonstrated that one can better understand the innovation ecosystem and how the embedded university is interacting through links to and from the various actors within the system, as both a global pipeline provider and an important contributor to the global buzz.

Moving to the second research question on how universities are performing their third mission activities, our study findings revealed a university contributing to classical third mission activities such as commercialisation projects, licence agreements, patents, and academic spin-offs and start-ups. The university also has a significant number of links to contract research, mostly with local industry along the coast, but also with some public organisations and global multinational companies. Further, our findings demonstrate a university that, partly through its owned intermediates, has been promoting cross-sectional collaboration on important infrastructure, commercialisation of research, development of new emerging technologies, training of professionals, student entrepreneurship, and research centres, thus suggesting an emerging entrepreneurial university. We also see how the university is orienting its strategy and culture towards highly international-oriented activities relating to the provision of scientific advice and the emphasis on the UN's sustainable development goals (SDGs) (United Nations n.d.). The latter is illustrated by many of the policy and society links, in addition to the participation in global networks and infrastructure. However, our links also reveal a university with a declining role in the marine innovation ecosystem, a role that might be replaced by an increasing global engagement.

Our third and final research question asked whether the various links could tell us something about the relationships and dynamics between overlapping ecosystems. Universities are complex organisations embedded in several kinds of ecosystems with different logics of action. In addition, the concept of innovation ecosystems is used ambiguously in both research and policymaking. We have found that the collected links, organised in the research compass dimensions, correspond quite closely to the business, knowledge, and innovation ecosystems. We claim that highlighting the different logics of actions and the complexity of the various ecosystems will contribute to a better understanding of the roles that the various university agencies have in innovation, commercialisation, and co-creation of value. We also claim that dividing the roles of a university between the knowledge ecosystem, innovation ecosystem, and the business ecosystem corresponds in many ways to the more traditional values of a university within research and education. This may help us to understand better, and to communicate and act according to the different roles in the various contexts for a university, both internally for policymakers and externally for other stakeholders and collaborating actors. Furthermore, we have illustrated how key actors in the different ecosystems are placed in connection to each other in the overlapping ecosystems, thus demonstrating some of the relational dynamics between those systems, as called for by Valkokari (2015). Our data also show how the marine innovation ecosystem in Western Norway has evolved historically. Especially, our data show how the number of various intermediates, industry cluster organisations, and infrastructures (artifacts) have increased over time, spanning the boundaries between the ecosystems (Fig. 4). In this regard, the intermediates and shared platforms have acted not only as local pipelines but also as facilitators for the global buzz. In this context, our study adds empirical evidence that supports the criticism of the concept of the local buzz and global pipelines as being too general and that the distinction between local and non-local relationships is too broad (Fitjar & Rodríguez-Pose 2015; Aarstad et al. 2016). However, our data also indicate a complex and self-organised nature of the innovation ecosystems characterised by an increasing number of intricate actors, especially in the regional sphere.

A better understanding of how ecosystems' function and evolve, and how universities are embedded within them, is important for university managers and other policymakers. We hope our rich case can elucidate the concepts of ecosystems in general and the innovation ecosystem in particular. The research compass methodology acknowledges that measuring the dynamics of science by codified knowledge alone is not sufficient, due to the complex nature and relationships between research organisations, industry, and society.

However, our study has some shortcomings. One of the main reasons for creating the tool for universities was the pressure to characterise their third mission. Therefore, we mapped the links to and from a university, making the university (UiB) the focal organisation of our study. Focusing on other actors in the ecosystem, such as firms and various intermediary organisations, might require different dimensions to make a useful ecosystem-linkage diagnostic tool. In addition, the rationale for why other ecosystem actors would wish to be subject to such an assessment should be clarified. Furthermore, while we conducted an in-depth study of the nature and geography of the various links a university has with other partners in research, society, and industry, our approach did not dig very deeply into the actual mechanisms behind the knowledge and technology transfer that occur through these links. We argue that our approach focused on providing a broad profile of ecosystem embedding, but we suggest that further work could focus on developing additional modules that could act as explanatory tools for the mechanisms of ecosystem embedding.

In this paper we have demonstrated an approach with which to understand the embedding of a university in an innovation ecosystem. We argue that this 'ecosystem fingerprint' is a useful means to clarify the third mission of universities through the various linkages and interdependencies with various actors ranging from firms to policymakers and civil society. We hope that our modest contribution, focusing on a single in-depth case study, provides insights into ecosystem embedding and the development of diagnostic tools to inform evaluation – in this case, evaluation of the third mission of universities.

Acknowledgements

We thank the reviewers and the editors of *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* for valuable input to the paper. We also thank our many colleagues and collaborating partners at VIS, UiB, HVL, and ESIEE/LISIS for valuable input and contributions to data collection and data analysis. In addition, the research benefited from the support of RISIS (Research Infrastructure for Science and Innovation Policy Studies) and CorText. Thanks are also due to NIFU for providing special information on PhD candidates and graduates from their databases. Finally, we acknowledge the Research Council of Norway and the Horizon 2020 instrument for funding the project on which this paper is based.

References

Aarstad, J. Kvitastein, O.A & Jakobsen, S.E. 2016. Local buzz, global pipelines, or simply too much buzz? A critical study. *Geoforum* 75, 129–113.

Adner, R. 2006. Match your innovation strategy to your innovation ecosystem. *Harvard Business Review* 84(4), 98–107.

Agrawal, A. 2001. University-to-industry knowledge transfer: Literature review and unanswered questions. *International Journal of Management Reviews* 3, 285–302.

Andersen, O., Bjørsrud, G., Hagen, I., Holter, K.M., Haave, KM, Måseidvåg, H.I. & Torgersen, G.P. 2016. *Konseptvalgutredning for lokalisering av marine FoU-virksomheter i Bergen*. Rapport til Statsbygg, Revisjonsnummer: 1.2. https://www.regjeringen.no/contentassets/cd949726c03e4ad290540a2efaa2ab2e/kvu-marin-fou-sluttrapport.pdf (accessed 24 Janaury 2022).
Asheim, B. & Gertler, M.S. 2005. The geography of innovation: Regional innovation systems. Fagerberg, J., Mowery, D.C. & Nelson, R.R. (eds) *The Oxford Handbook of Innovation*, 291–316. Oxford: Oxford University Press.
Autio, E. & Thomas, L.D.W. 2014. Innovation ecosystems: Implications for innovation management. Dodgson, M., Gann, D.M & Nelson, P. (eds) *The Oxford Handbook of Innovation Management*, 204–228. Oxford: Oxford University Press.
Bathelt, H., Malmberg, A. & Maskell, P. 2004. Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography* 28 (1), 31–36.
Benneworth, P. & Hospers, G.J. 2006. The new economic geography of old industrial regions: universities as global—local pipelines. *Environment and Planning C: Government and Policy* 25, 779–802.
Benneworth, P. & Sanderson, A. 2009. The regional engagement of universities: Building capacity in a sparse innovation environment. *Higher Education Management and Policy* 21(1), 1–18.
Benneworth, P., Pinheiro, R. & Sánchez-Barrioluengo, M. 2016. One-size- does not fits-all! New perspectives on the university in the social knowledge economy. *Science and Public Policy* 43(6), 731–735.
Blume, L., Brenner, T. & Buenstorf, G. 2017. Universities and sustainable regional development: Introduction to the special issue. *Review of Regional Research* 37, 103–109.
Bogers, M., Sims, J. & West, J. 2019. What is an ecosystem? Incorporating 25 years of ecosystem research. *Academy of Management Proceedings* 1. http://doi.org/10.2139/ssrn.3437014
Breznitz, S.M. & Feldman, P. 2012. The larger role of the university in economic development: Introduction to special issue. *Journal of Technology Transfer* 37, 135–138.
Brown, R. 2016. Mission impossible? Entrepreneurial universities and peripheral regional innovation systems. *Industry and Innovation* 23(2), 189–205.
Campbell, A., Cavalde, C., Haunold, C., Karanikic, P. & Piccaluga, A. 2020. Knowledge transfer metrics – Towards a European-wide set of harmonised indicators. https://publications.jrc.ec.europa.eu/repository/handle/JRC120716 (accessed 28 December 2021).
Chatterton, P. & Goddard, J. 2000. The response of higher education institutions to regional needs. *European Journal of Education* 35(4), 475–496.
Cockburn, I. & Henderson R. 1998. Absorptive capacity, coauthoring behaviour, and the organization of research in drug discovery. *Journal of Industrial Economics* 46(2), 157–182.
Cohen, W.M. & Levinthal, D.A. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* 35, 128–152.
Compagnucci, L. & Spigarelli, F. 2020. The third mission of the university: A systematic literature review on potentials and constraints. *Technological Forecasting & Social Change* 161: Article 120284.
Connected Places Catapult 2021. *Hubs of Innovation Report: The Role of Districts, Corridors and Quarters as Hubs of the Covid-Adjusted Innovation Economy*. https://cp.catapult.org.uk/news/hubs-of-innovation-report/ (accessed 28 December 2021).
Cooke, P. 2001. Regional innovation systems, clusters, and the knowledge economy. *Industrial and Corporate Change* 10, 945–974.
Cooke, P., Gómez Uranga, M. & Extebarria, G. 1997. Regional innovation systems: Institutional and organisational dimensions. *Research Policy* 26(4-5), 475–491.
Dodgson, M., Gann D.M. & Phillips, N. 2014. Perspectives on innovation management. Dodgson, M., Gann, D.M. & Nelson, P. (eds) *The Oxford Handbook of Innovation Management*, 3–26. Oxford: Oxford University Press.
Doloreux, D. & Gomez, I.G. 2017. A review of (almost) 20 years of regional innovation systems research. *European Planning Studies* 25(3), 371–387.
Etzkowitz, H. 2017. Innovation lodestar: The entrepreneurial university in a stellar knowledge firmament. *Technological Forecasting and Social Change* 123, 122–129.
Etzkowitz, H. & Leydersdorff, L. 2000. The dynamics of innovation: From national systems and 'mode 2' to a triple helix of university–industry–government relations. *Research Policy* 29, 109–123.
Etzkowitz, H., Schuler, E.J. & Guldbrandsen, M. 2000. The evolution of the entrepreneurial university. Jacob, M. & Hellström, T. (eds) *The Future of Knowledge Production in the Academy*, 40–60. Buckingham: SRHE and Open University Press.
Fitjar, R.D. & Rodríguez-Pose, A. 2015. Networking, context and firm-level innovation: Cooperation through the regional filter in Norway. *Geoforum* 63, 25–35.
Fløysand, A. & Jakobsen S.E. 2016. *Næringsutvikling på Vestlandet: Omstillingsevne og regional fornyelse*. Akselberg, G., Barndon, R. & Grove K. (eds.) Region og regionalisering – perspektiv og praksis, 312–343. Oslo: Novus Forlag.
Freeman, C. 1987. *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter.
Freeman, C. 1995. The 'national system of innovation' in historical perspective. *Cambridge Journal of Economics* 19(1), 5–24.
Freeman, C. 2004. Technological infrastructure and international competitiveness. *Industrial and Corporate Change* 13(3), 541–569.
Giuri, P., Munari, F., Scandura, A. & Toschi, L 2019. The strategic orientation of universities in knowledge transfer activities. *Technological Forecasting & Social Change* 138, 261–278.
Granstrand, O. & Holgersson, M. 2020. Innovation ecosystems: A conceptual review and a new definition. *Technovation* 90–91: Article 102098.
Gregersen, B., Tved Linde, L. & Guldahl Rasmussen, J. 2009. Linking between Danish universities and society. *Science and Public Policy* 36(2), 151–156.
Grimpe, C. & Hussinger, K. 2013. Formal and informal knowledge and technology transfer from academia to industry: Complementarity effects and innovation performance. *Industry and Innovation* 20(8), 683–700.

Guldbrandsen, M. & Slipesæter, S. 2007. The third mission and the entrepreneurial model. Bonaccorsi, A. & Daraio, C. (eds) *Universities and Strategic Knowledge Creation*, 112–143. Cheltenham: Edward Elgar.

Hayden, M.C., Weiß, M., Pechrigg, A. & Wutti, D. 2018. Insights into university knowledge transfer in the social sciences and humanities (SSH) and other scientific disciplines – More similarities than differences. *Frontiers in Research Metrics and Analytics*. doi: 10.3389/frma.2018.00032

Heaton, S., Siegel, D. &Teece, D.J. 2019. Universities and innovation ecosystems: A dynamic capabilities perspective. *Industrial and Corporate Change* 28, 921–939.

Herstad. S.J. & Sandven, T. 2017. *Towards Regional Innovation Systems in Norway? An Explorative Empirical Analysis*. NIFU Report 2017:8. Oslo: Nordisk institutt for studier av innovasjon, forskning og utdanning.

Høgestøl, A. & Bjørnbekk, O. 2018. *Kandidatundersøkelsen 2018 – Fra studier til jobb på Vestlandet.* ideas2evidence-rapport 08:2018. https://www.ideas2evidence.com/publications/kandidatunders%C3%B8kelsen-2018 (accessed 28 December 2021).

Jiao, H., Zhou, J., Gao, T. & Liu, X. 2016. The more interactions the better? The moderating effect of the interaction between local producers and users of knowledge on the relationship between R&D investment and regional innovation systems. *Technological Forecasting and Societal Change* 110, 13–20.

Kiørboe, T., Hagström, Å., Minshull, T., Scourse, J., Artigas, M.C., Holm, P. & Nilsson, J. 2014. *Evaluation of the Strategic Priority Area Marine Research and Education at the University of Bergen*. https://www.uib.no/sites/w3.uib.no/files/attachments/marine_report_141203_final_1.pdf (accessed 28 December 2021).

Kitagawa, F., Sánchez Barrioluengo, M. & Uyarra, E. 2016. Third mission as institutional strategies: Between isomorphic forces and heterogeneous pathways. *Science and Public Policy* 43, 736–750.

Kivimaa, P., Boon, W., Hyysalo, S. & Klerkx, L. 2019. Towards a typology of intermediaries in sustainability transitions: A systematic review and a research agenda. *Research Policy* 48 (4), 1062–1075.

Klimas, P. & Czakon, C. 2021. Species in the wild: A typology of innovation ecosystems. *Review of Managerial Science.* https://doi.org/10.1007/s11846-020-00439-4

Laredo, P. 2007. Revisiting the third mission of universities: Toward a renewed categorization of university activities? *Higher Education Policy* 20(4), 441–456.

Laredo, P. & Mustar, P. (2000). Laboratory activity profiles: An exploratory approach. *Scientometrics* 47(3), 515–539.

Lundvall, B.Å. 1985 *Product Innovation and User-Producer Interaction, Industrial Development.* Industrial Development Research Series No. 31. Ålborg Universitetsforlag.

Lundvall, B.Å. (ed.) 1992. *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning.* London: Pinter.

Mazzucato, M. & Robinson, D.K.R. 2018. Co-creating and directing innovation ecosystems? NASA's changing approach to public-private partnerships in low-earth orbit. *Technological Forecasting and Social Change* 136, 166–177.

Moore, J.F. 1993. Predators and prey: A new ecology of competition. *Harvard Business Review* 71(3), 75–86.

Musil, R. & Eder, J. 2016. Towards a location sensitive R&D policy: Local buzz, spatial concentration and specialisation as a challenge for urban planning – Empirical findings from the life sciences and ICT clusters in Vienna. *Cities* 59, 20–29.

Nelson, R.R. (ed.) 1993. *National Innovation Systems: A Comparative Analysis*. Oxford: Oxford University Press.

Norges forskningsråd 2019. *Det norske forsknings- og indikatorsystemet: Statistikk og indikatorer 2019.* https://www.forskningsradet.no/contentassets/c13c9822d47542108d768dfb4a8479c4/indikatorrapporten-2019.pdf (accessed 24 January 2022).

Oh, D., Phillips, F., Park, S. & Lee, E. 2016. Innovation ecosystems: A critical examination. *Technovation* 54, 1–6.

Pavitt, K. 2005. Innovation processes. Fagerberg, J., Mowery, D.C. & Nelson, R.R. (eds) *The Oxford Handbook of Innovation*, 86–114. Oxford: Oxford University Press.

Pawlowski, K. 2009. The 'fourth generation university' as a creator of the local and regional development. *Higher Education in Europe* 34(1), 51–64.

Perkmann, M., Tartari K., McKelveyb, M., Autioa, E., Broströmc, A., D'Ested, P., Fini, F., Geunae, A., Grimaldif, R., Hughesm, A., Krabelh, S., Kitsong, M., Llerenai, P., Lissonij, F., Salter A. & Sobreref, M. 2013. Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy* 42, 423–442.

Perkmann, M. & Walsh, K. 2007. University-industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews* 9 (4), 259–280.

Porter, M. 1990. The competitive advantage of nations. *Harvard Business Review* 68(2), 73–93.

Powell, W.W. & Grodal, S. 2005. *Networks of Innovators*. Fagerberg, J., Mowery, D.C. & Nelson, R.R. (eds) *The Oxford Handbook of Innovation*, 56–85. Oxford: Oxford University Press.

QS TopUniversites 2018 n.d. *QS World University Rankings*. https://www.topuniversities.com/university-rankings/world-university-rankings/2018 (accessed 28 December 2021)

Reichert, S. 2019. *The Role of Universities in Regional Innovation Ecosystems*. Brussels: European University Association.

Robinson, D.K.R., Schoen, A., Laurens, P., Horellou, S., Colas, P. & Larédo, P. 2016. Assessing marine biotechnology research centres in peripheral regions: Developing global and local STI indicators. Ráfols, I., Molas-Gallart, J., Castro-Martínez, E. & Woolley, R. (eds.) *Proceedings of the 21st International Conference on Science and Technology Indicators*, 575–580. http://ocs.editorial.upv.es/index.php/STI2016/STI2016/paper/viewFile/4543/2327 (accessed 14 February 2022).

Salge, T.O. & Vera, A. 2012. Benefiting from public sector innovation: The moderating role of customer and learning orientation. *Public Administration Review* 72(4), 550–559.

Sánchez-Barrioluengo, M. & Benneworth, P. 2019. Is the entrepreneurial university also regionally engaged? Analysing the influence of university's structural configuration on third mission performance. *Technological Forecasting & Social Change* 141, 206–218.

Sánchez-Barrioluengo, M., Uyarra, E. & Kitagawa, F. 2019. Understanding the evolution of the entrepreneurial university: The case of English higher education institutions. *Higher Education Quarterly* 73(4), 469–495.

Smorodinskaya, N., Russel, M.G., Katukov, D.D. & Still, K. (2017). Innovation ecosystems vs. innovation systems in terms of collaboration and co-creation of value. *Proceedings of the 50th Hawaii International Conference on System Sciences, 4–7 January 2017*. https://scholarspace.manoa.hawaii.edu/handle/10125/41798 (accessed 6 February 2022).

Strand, Ø. 2013. Industrial rights as quality indicators of the regional innovation systems in Norway. Amdam, J., Helgesen, Ø. & Søther, K.-W. (eds) *Det mangfaldige kvalitetsomgrepet*, 335–356. Fjordantologien 2013. Ålesund: forlag1.

Suominen, A., Seppänen, M. & Dedehayir, O. 2019. A bibliometrical review on innovation systems and ecosystems: A research agenda. *European Journal of Innovation Management* 22(2), 335–360.

Trippl, M., Todtling, F. & Lengauer, L. 2009. Knowledge sourcing beyond buzz and pipelines: Evidence from the Vienna software sector. *Economic Geography* 85(4), 443–462.

Tsujimoto, M., Kajikawa, Y., Tomita, J. & Matsumoto, Y. 2018. A review of the ecosystem concept—Towards coherent ecosystem design. *Technological Forecasting and Social Change* 136, 49–58.

United Nations. n.d. *Sustainable Development Goals: The 17 Goals*. https://sdgs.un.org/goals (accessed 24 January 2022).

University of Bergen 2020. *Research and Innovation within Marine biology at the University of Bergen 2010–2017: A Territorial Embedding Assessment Report*. https://www.uib.no/sites/w3.uib.no/files/attachments/matnat_tea_uib_report_2020_final_samlet_oversikt_over_var_virksomhet.pdf (accessed 13 January 2022).

University of Bergen n.d. *Knowledge that Shapes Society*. https://www.uib.no/en/strategy (accessed 28 December 2021).

Valkokari, K. 2015. Business, innovation, and knowledge ecosystems: How they differ and how to survive and thrive within them. *Technology Innovation Management Review* 5(8), 17–24.

Paper 2

Motivations for academic engagement and commercialisation: A case study of actors' collaboration in third mission activities from three European universities

Randi Elisabeth Taxt [1,2]

[1] Department of Geography, University of Bergen (UiB), Norway

[2] Vestlandets innovasjonsselskap AS (VIS), Norway

Abstract

This multiple case study explores how researchers are motivated to perform their third mission activities in terms of collaborative projects with public and private actors. The study also investigates the involvement of universities' third mission support personnel and technology transfer executives in the collaboration. The study contributes new insights into individual motivations for academic engagement and commercialisation. This is done by empirically demonstrating that commercialisation projects are based on ideas originated from novel and basic research, while academic engagement is based more on the general knowledge and capabilities of researchers and their research groups. The findings also revealed that motivations for taking on third mission activities were mainly about disseminating the results of research to wider society, rather than being driven by monetary rewards. This is demonstrated not only for the researchers, but also for the external partners, the support personnel, and technology transfer executives. The findings further imply that researchers are more satisfied with the support structure set up at their university for academic engagement projects than with the support structures for commercialisation of research, such as technology transfer offices. The findings can have implications for both policymakers and practitioners within knowledge and technology transfer.

Keywords: academic engagement, commercialisation of research, motivations, technology transfer offices, third mission

Introduction

Creating impact from research has become increasingly important in today's society and universities are encouraged by policymakers to develop a *third mission* in addition to research and education (Etzkowitz and Leydersdorff 2000; Laredo, 2007). Traditionally, the third mission of universities has been coupled to support for economic growth in society and has been evaluated based mainly on the ability to commercialise research in terms of patent and license agreements or to create academic spin-offs (Breznitz and Feldman 2012; Gulbrandsen and Slipersæter 2007). However, third mission includes all activities in a university beyond teaching and research, and in the last decade there has been a stronger focus on the transition of universities' third mission strategies towards global missions, sustainability, and green and social innovation (Benneworth et al., 2016; European University Association, 2017, McKelvey and Zaring, 2018; Reichert, 2019).

When researchers contribute to their university's third mission it is usually through either *academic engagement* or *commercialisation of research*. Commercialisation activities are defined as the exploitation of technology and knowledge for a market (OECD, 2013), whereas academic engagement is considered to mean all other knowledge and technology-related interactions between researchers and non-academic institutions (Perkmann et al., 2013). The motivations for engaging in commercialisation activities is in the literature proclaimed to be mostly monetary driven, both in the case of research organisations (Bercovitz and Feldman, 2006) and in the case of individual researchers (D'Este and Perkmann, 2011; Muscio et al., 2017; Perkmann et al., 2013). This contrasts with the motivations for academic engagement, which are reported to be more in in line with, and supportive of, the academics' own research agendas (D'Este and Perkmann, 2011; Lam, 2007, Perkmann et.al., 2013).

Most universities worldwide have established various structures to support their researchers in third mission activities, such as internal procedures, management, administrative support offices, and technology transfer offices (TTOs) (Clarysse et al., 2005; Link et al., 2015). However, many scholars seem to agree that universities have prioritised support for entrepreneurship and commercialisation activities over academic engagement (Lam, 2011; Muscio et al., 2014, 2017; Perkmann et al., 2013). Despite considerable efforts by governments, industry, and university leaders, the impacts of research have not been as high as expected (OECD, 2013, 2019; Reillon, 2017). One important theory for this lack of impact is that most researchers do not seem to be motivated by money-related and commercial motives nor by institutional obligations or incentives (D'Este and Perkmann, 2011; Iorio et al., 2017; Sormani et al., 2022). In the literature there are calls for more research on individual motivations, the importance of previous experience, career and life-cycle impacts, and contexts such as university-level and TTO support for academic engagement and commercialisation activities (Compagnucci and Spigarelli 2020; Muscio et al., 2017; Perkmann et al., 2021; Van de Burgwal et al., 2019).

The main goal of this paper is to investigate the individual motivations of various actors who engage in third mission activities by participating in academic and commercialisation projects. While researchers' motivations for researchers are covered in the literature, the motivations of other collaborative actors in third mission projects seem to have been underinvestigated. The actors in the study on which this paper is based were researchers, external partners from private and public non-academic organisations, and university support personnel and TTO executives. A further aim of this paper is to shed more light on how university support structures and TTOs collaborates in the execution of third mission activities. The study is guided by two research questions:

RQ1: How are the various actors involved in academic engagement and commercialisation motivated to engage in such activities?

RQ2: In what way are university support personnel and TTO executives involved in academic engagement and the execution of commercialisation projects?

The empirical multiple-case study presented in this paper is based on data sampling within a specific field of research from three universities in three different European countries. Researchers, public and private partners, and the involvement of university third mission support personnel and technology transfer executives are in focus in the study. From studying projects within academic engagement and commercialisation, new empirical findings concerning the motivation for and execution of third mission activities, on both individual and organisational levels, are added to the literature.

The remaining part of this paper is structured as follows: The following section starts with a brief overview of the theoretical background framing the study. Thereafter, the context and the methods for sampling and analysis of the data are presented, followed by the results. In the final section of the paper, the results and contributions are discussed in relation to theory, and the implications for practitioners and suggestions for further research are presented.

Theoretical background

Academic engagement and commercialisation

Academic engagement is increasingly considered an important part of universities' third mission and is generally defined as: 'knowledge-related collaboration by academic researches with stakeholders from non-academic organizations' (Perkmann et al., 2013: 424). Some links or channels for academic engagement are formal, such as collaborative research projects, contract research, and consulting. Other channels are more informal in character, such as providing ad hoc services and training for professionals or participation in external advisory or standardisation committees and networking with practitioners (Grimpe and Hussinger, 2013; Link et al., 2007). Commercialisation of research on the other hand can be understood as the process through which research ideas are transferred (or transformed) into products in the market, in addition to capital gains, income from licenses, and revenue from the sale of new products (Gammon, 2017; OECD, 2013). Commercialisation activities have traditionally been closely associated with the university third mission to foster economic growth and are mostly described as aimed at generating, protecting, and exploiting intellectual property (IP) (Clarysse et al., 2005; Link, et al., 2015). Academic engagement is practised more widely across disciplines and has been demonstrated as being of greater economic significance for universities and companies than commercialisation (D'Este and Perkmann, 2011; Perkmann et al., 2021). For the researchers, academic engagement is reported to be related more to the support of ongoing research (D'Este and Perkmann, 2011). Academic engagement is further linked to increases in the benefits of science to society (OECD, 2013), and is regarded as a pathway to societal progress (Muhonen et al., 2020). By contrast, commercialisation activities are usually linked to the purpose of economic reward, both for research organisations and for individual researchers (D'Este and Perkmann, 2011; Muscio, et al., 2017; Perkmann, 2013, 2021). Furthermore, academic engagement has been shown to be positively affected by researchers' characteristics, such as their previous experience of commercialisation and work outside academia, the specific scientific fields in which they work, such as life sciences and technology, their academic seniority, and their gender (Perkmann et al., 2013, 2021). Academic productivity in terms of scientific publications is further shown to go ‘hand in hand’ with both academic engagement and commercialisation, and the most productive scientific researchers are those who engage in institutional and commercialisation activities (Clarysse et al., 2011; Gulbrandsen and Thune, 2017).

Motivations for third mission activities and self-determinant theory

In the economic literature, self-determinant theory (STD) is often used when studying motivations, and two types of motivation are classified: *intrinsic* and *extrinsic* (Deci and Ryan, 1995; Gagné and Deci, 2005; Ryan and Deci, 2000). The term intrinsic motivation refers the self-determinant behaviour steered by a personal wish or an urge. By contrast, the term extrinsic motivation refers to a less self-determinant behaviour when external factors affect an individual’s choices. Compared with intrinsic motivations, extrinsic motivations can be stimulated more easily by different types of incentives.

In general, it is anticipated that most researchers have intrinsic motivations and therefore their choices of third mission channels for collaboration are determined more by their own interests and less by extrinsic motivations such as monetary or university incentives (Lam, 2011; Orazbayeva et al., 2020; Van de Burgwal et al., 2019). D’Este and Perkmann (2011) identified four main motivations for researchers to engage in industry: *commercialisation*, *learning*, *access to funding*, and *access to in-kind resources* (from industry). They point out that three of these factors are research related. The main motivations for underpinning academic engagement among academics have been found to be research funding and, to a lesser extent, academic curiosity, career development, and the need for recognition (D’Este and Perkmann, 2011; Lam, 2011; Hughes et al., 2016; Iorio et al., 2017). More recently Van De Burgwal et al. (2019) have argued that there is a fourth distinguishable category, namely motivations with a moral nature, and Orazbayeva et al. (2020) has identified social orientation as an important motivation for education-driven academic engagement.

Strong governmental or university constraints may seem to have an inverse effect on researchers’ motivations to engage in third mission activities. For example, universities with strong entrepreneurship missions or obligations to disclose inventions and use TTO services seem to cause researchers either to choose academic engagement over commercialisation or to sidestep their TTOs (Abreu and Grinevich, 2013; Clarysse et al., 2011; Van Burg et al., 2021; Zhao et al., 2020). Halilem et al. (2017) found that the level of control exerted by universities, together with high expectations and incentives for commercialisation, was resulting in decreasing academic engagement in Canada. Conversely, too high royalty rates for licensee agreements were causing researchers to choose academic engagement rather than commercialisation (Halilem et al., 2017). Industry actors on their part seem to be reluctant to collaborate when universities want to claim ownership of a patent (Taxt et al., 2022; Thursby and Thursby, 2003). However, in general, collaboration with industry seems to have led to increases in patenting by researchers, but the researchers are more often registered as co-owners of the patents with industrial companies, and also have tended to bypass their TTO in the process (Goel and Göktepe-Hultén; 2018; Lawson, 2013; Van Burg et al., 2021).

It has been shown that the effectiveness of incentives and how they are perceived does not always align in universities (Sormani et al., 2022). More, several authors have called for incentives that better reflect researchers' intrinsic motivations to take part in third mission activities (Galán-Muros et al., 2015; Lam, 2011; Sjöö and Hellström, 2019). However, it should also be considered that universities' third mission activities often conflict with traditional academic values, and it has been shown that the activities cause confusion among researchers or even an identity crisis (De la Torre et al., 2017). It is therefore important to also take academic culture into consideration when considering incentives that stimulate third mission activities (Hossinger et al., 2020; Perkmann et al., 2021).

Third mission activities and university support

Encouragement to stimulate third mission activities has come from governments and industrial actors, as well as from university managers themselves (Gulbrandsen and Slipersæter, 2007; Hayden et al., 2018; Jiao et al., 2016; Perkmann et al., 2013). A substantial increase in internal university support for entrepreneurship, innovation, and commercialisation activities and the transformation towards *entrepreneurial universities* has been reported (Etzkowitz, 2004; Etzkowitz et al., 2000; Sánchez-Barrioluengo and Benneworth, 2019). With regard to policy and organisational factors, Perkmann et al. (2021) claim that commercialisation has historically been preferred over academic engagement at university level, although the volume of activity and revenue from commercialisation projects is modest compared with university income from academic engagement (D'Este and

Perkmann, 2011; Muscio et al., 2014; Perkmann et al., 2013). The establishment of separate technology transfer offices (TTOs) to help researchers with commercialisation activities is considered an important example of such a priority by universities (Perkmann et al., 2013). TTOs are defined as either entities or separate intermediate organisations responsible for technology transfer and other activities in relation to the commercialisation of research (Link et al., 2015), and the literature highlights the importance of TTOs for commercialisation of research (Cunningham et al., 2020; Hayter, 2016; Hossinger et al., 2020). However, another stream of literature reports a general negative attitude towards the function and role of TTOs and describes them as transaction-oriented and bureaucratic structures that sometimes slow down innovation and commercialisation processes. Furthermore, TTOs are often described as not suitably equipped, to help and support academic engagement activities of a more general nature, thus leaving a gap in for such support in universities (Link et al., 2015; Hayter, 2016; Perkmann et al. 2021; Weckowska, 2017).

To cope with the emerging entrepreneurial universities, O'Kane (2018) shows that some TTOs are developing a more diverse role by probing deeper into the universities and adopting an intermediary role between them and various funding organisations. In addition, O'Kane (2018) demonstrates that TTOs increasingly engage as actors in the innovation ecosystem to attract collaborative partners and investors to commercialisation projects. However, some academics, mostly male researchers with previous commercial or industrial experience, seem to sidestep their TTO deliberately when making commercial agreements (Clarysse et al., 2011; Wu et al., 2015). Furthermore, university departments' capabilities, knowledge, and resources, in addition to support and recognition by peers and departmental leaders, have in some cases been shown to have a more positive effect on commercialisation activities than has TTO support (Hossinger et al., 2020; Leitner et al., 2021; Muscio et al., 2014; Rasmussen et al., 2014). By contrast, knowledge about what role departments and university-level support structures play in facilitating researchers' participation in academic engagement is reported as relatively scarce (Perkmann et al., 2021; Compagnucci and Spigarelli, 2020). Moreover, lack of time and resources, and lack of incentives and rewards, in addition to university inflexibility and bureaucracy, are considered important barriers to researchers' engagement in both commercialisation and academic activities (Hughes et al., 2016; Muscio et al., 2014; Sjöö and Hellström, 2019).

There are still gaps in the understanding of motivations for and effect of university-level support, policy and incentive mechanisms established to help and facilitate both academic engagement and commercialisation activities, and therefore more research is needed (Holley and Watson, 2017; Hossinger et al., 2020; Muscio et al., 2017; Perkmann et al., 2021).

Methods

Study context

The sampling of data for the study was done in connection with the Horizon 2020 project 'European Marine Biological Research Infrastructure Cluster to promote the Blue Bioeconomy' (EMBRIC[1]). The project, which aimed to accelerate scientific discoveries and innovation from marine biology, had 27 partners from 9 countries, among them universities, marine research stations, and private companies from areas along the European coastline. As part of the EMBRIC project analyses of the blue biotechnology area was performed, including a territorial embedding assessment (TEA) (Robinson et al., 2016).

Case studies from three universities involved in the EMBRIC project; the University of the Basque Country (EHU) in Spain, Sorbonne University (Sorbonne) in France, and the University of Bergen (UiB) in Norway, were selected based on third mission projects (links) identified through the data collected in the TEA method. All three universities have departments or research stations close to the sea and many relevant third mission projects were identified. The two main reason for the selection of the universities were that they had more or less finished their TEA analysis at the time when data collection started, and they are in different countries. All three are research universities with a wide selection of research themes and educational programmes. UiB had at the time defined marine research as a specific strategic area for the university as a whole and the Department of Biology (the second largest department at UiB) in particular, and from which the data were collected. At the other two universities, marine activity is restricted to their marine research stations, which are relatively small in size (Table 2). EHU has an internal TTO, as defined by Brescia et al. (2014), which also handles all the university's contract research and commercialisation activities. Sorbonne and UiB have internal research departments that handle the contract research and external TTOs – Réseau SATT,[2] a national TTO in France, and Vestlandets

[1] https://cordis.europa.eu/project/id/654008
[2] Réseau SATT

innovasjonsselskap AS (VIS),[3] a regional TTO in Bergen, Norway. Both SATT and VIS are represented as intermediate organisations in their respective regions and given responsibility for the commercialisation projects for their universities.

Data collection

The EMBRIC project data were systematically collected during 2017 and 2018, based on the TEA method developed by Robinson et al. (2016). The method is built on *activity profiling*, as described by Laredo and Mustar (2000), and has been developed as a tool to understand the role, contributions, and interrelations between universities and other ecosystem actors through the types of connections with ecosystem actors and the intensity of those connections (Robinson et al., 2016; Taxt et al., 2022). The TEA data related to five different ways (dimensions) in which universities interact with society through their third mission activities (termed links in the TEA method): (1) certified knowledge instruments (scientific publications and competition-funded projects), (2) training as embodied knowledge (courses and events for professionals), (3) competitive advantages – the innovative aspects (contract research, consulting, and commercialisation projects), (4) research and public debate (societal links), and (5) policy and society links (policy links). All data were collected for the years 2010–2016 exclusively and within the field of *marine research*, understood as research, innovation, and training within marine biology, including aquaculture, and marine biotechnology in addition to stock-assessment/management and fisheries. Representatives from the partnering academic institutions in the EMBRIC project met regularly during the project period to ensure that data from the research organisations were compiled and interpreted uniformly.[4]

Data from the third dimension, *the innovative aspects* in the TEA method were used to frame the selection of cases for this study. In total, 294 innovative projects or links were collected from the three universities and all the cases were selected among these links. A link was defined in this study as a transaction that is traceable between the parties in terms of a collaborative project, a spin-off project, a licencing agreement, a contract, or other kinds of visible economic transactions.

[3] https://www.visinnovasjon.no/en/
[4] For a more comprehensive outline of the EMBRIC project and the TEA methodology, see Taxt et al. (2022).

Case studies

To gain a more detailed understanding of the motivations for third mission activities and the collaborative patterns in those activities, a qualitative research methodology with in-depth, semi-structured interviews was used for selected cases in terms of third mission projects from the 294 innovative links collected through the EMBRIC project. The unit of analysis for the multiple-case study was therefore identified as 'an innovative link represented by a collaborative project, spin-off or contract at the university' (See Table 2 for more details about the type of link for each case). The in-depth, embedded, multiple-case study was designed as described by Yin (2018) and thus represent a rich theoretical framework. It was considered robust with regard to comparing findings across cases with differing empirical evidence. Additionally, a purposeful sampling approach was used (Harsh, 2011), in which the logic of the sampling lay in the selection of information-rich cases for in-depth studies. The collaboration in the cases selected was usually based on long-term personal contacts and trust among the partners. In addition, on request for information from the external partners, the universities reported that some of the cases were categorised as confidential. Therefore, the cases selected for this paper are highly anonymised and no connection to the various institutions are identifiable. Consequently, this has limited the potential for comparisons between the three universities.

The data material collected in the EMBRIC project did not include the identity of the individual principal investigators (PIs). Cases were therefore selected using a snowball sampling approach (Biernacki and Waldorf, 1981), whereby the collaborating partners in the EMBRIC project were actively engaged in the process of identifying possible cases. In most of the cases, the EMBRIC partners assisted in making the initial contact with the PI responsible for the project. A total of 31 cases were preselected and contact was initiated; all of those cases were identified as separate projects or contracts within their university. The final selection of cases was based on relevance and/or whether the responsible PI or collaborative partners were willing/able to meet for an interview. In total 11 cases were finally selected.

A total of 22 semi-structured interviews with 27 respondents were conducted in 2019. The PI responsible for the selected case project, the industrial/public sector partner and, if relevant, the university support personnel and TTO executives associated with the project, were interviewed. The PI was interviewed first and then assisted in contacting external collaborative partners, support staff at the university, and/or TTO executives involved in the project. A snow-ball sampling (Biernacki and Waldorf, 1981) was therefore also used in the selection of respondents. The respondents were divided in three different groups, based on their role in the project: (1) principal investigators (PIs), (2) support personnel from universities and TTOs (SPs) and (3) external collaborative partners from companies and public sector organisations (ECs). In total, 12 PIs, 9 SPs, and 6 ECs were interviewed.

The interviews were based on the following four themes defined in the interview guide:

1. What type of knowledge is the project/contract collaboration building on?
2. What is your motivation for doing this type of project and for contract collaboration?
3. What kind of support have you received from your institution/TTO, and are there any internal incentives to stimulate these kinds of activities?
4. What types of impact, knowledge, and results have resulted from the project/contract collaboration?

In addition, the respondents were asked about their background, including their previous experience of academic engagement and commercialisation, the background for the project, and about general collaboration and relations among the actors in the project. Finally, all respondents were asked about the importance of geographical proximity for their project. A separate interview guide was developed for collaborative external partners in the projects and for the TTOs, which covered the same topics. The interviews lasted 40–90 minutes and were conducted either at the individual respondent's workplace or, in some cases, at a place selected by the respondent. The interviews were tape-recorded and transcribed. In addition, the interviewer took notes during the interview. To better understand both the projects, and the individual respondents, information was also acquired by reading media articles and by studying websites and other types of documentation, such as contracts and projects descriptions that often were provided by the respondents. This information was however not included in the analysis of the data.

As the research evolved, new perspectives and new research themes emerged. When analysing the data, I continually went back and forth between the empirical data and existing research and theories. Thus, an abductive process was adopted, whereby the research process shifts back and forth between the background theory and the empirical investigation (Dubois and Gadde, 2002; Tavory and Timmermans, 2014). The recorded interviews were then coded, based on the themes and questions from the interview guide, and a first round of analysis was performed, which resulted in a rich data corpus that was then produced in a spreadsheet. The corpus consisted of quotes based on the coding for each of the three groups of respondents (PIs, ECs, and SPs). The data corpus was analysed several times and the findings organised according to five themes: (1) motivation for academic engagement and in commercialisation activities, (2) collaboration in the project, (3) attitudes peers and managers towards academic engagement and commercialisation activities, (4) mechanisms, incentives, and support structures for third mission activities, and (5) results and impact of the project. In addition, the data corpus reflected patterns of similarities and differences in academic engagement and commercialisation, respectively. The empirical findings are presented in the next section.

Results

Although the nature and context of the study did not allow for comparison between the cases, the most important findings reported here are quite consistent and not restricted to cases from a particular university. The total number of innovative links from each university within the period 2010–2016 is shown in Table 1 and a brief overview of the cases selected from those links is given in Table 2. Five of the 11 cases were from EHU, four from Sorbonne, and two from UiB.

Of the 11 cases, 5 were categorised as academic engagement, while 6 were categorised as commercialisation. Three of the cases were spin-off companies. Two of them were created before 2010, but they had ongoing research contracts or licensing agreements with their parenting university.

With regard to the characteristics of the collaboration in the projects, some general findings were made for all three groups of respondents:

1. the importance of geographical proximity was expressed as crucial for both the establishment of the project and the general collaboration
2. the level of competence of the collaborating partners was regarded as very important for both collaboration within the projects and the projects' success
3. all formal contracts and collaboration in the projects were the result of long-term personal contacts and often informal collaboration
4. industrial partners were reluctant to collaborate if the university held a patent on the technology in question

5. none of the respondents reported any incentives for cross-team collaboration or third mission activities, either from the universities or from the TTOs or partnering companies.

Table 1. Number of innovative links in the period 2010–2016 from the three universities in the study (sources: EMBRIC, Database for Higher Education (DBH), Norway, annual reports, and TEA).

University	**Number of academic staff**	**Number of Innovation links**
Roscoff Marine Station, Sorbonne University and CRNS[5]	40 (2015)	82
Research Centre for Experimental Marine Biology & Biotechnology, University of the Basque Country	70 (2016)	70
Department of Biological Sciences, University of Bergen	176 (2016)	192
Total		**294**

Table 2. The 11 cases and showing the type of innovative links (academic engagement or commercialisation) and the type of collaboration (public/private) on which, they were based.

Cases	**Type of innovative links**	**Type of collaboration**	**Public/Private**
Case1	Contract research (citizen science)*	Academic engagement	Private
Case2	Contract research	Academic engagement	Private
Case3	Contract research	Academic engagement	Private
Case4	Contract research	Academic engagement	Public
Case5	Contract research	Academic engagement	Public
Case6	Licenses agreement	Commercialisation	Private
Case7	Licenses agreement	Commercialisation	Private
Case8	Academic spin-off	Commercialisation	Private
Case9	Academic spin-off	Commercialisation	Private
Case10	Academic spin-off	Commercialisation	Private
Case11	Licenses agreement or academic spin-off	Commercialisation**	Private

*Gura (2013), **Commercial path not decided at the time of the interview

[5] Roscoff Marine Station is a shared facility between Sorbonne University and Centre National de la Recherche Scientifique (CRNS).

In the following subsections, some of the most important results relating to the three groups of respondents are presented.

Principal investigators

PIs were defined as the academic project leader for the case project. Most of the PIs interviewed had a background in contract research and other forms of collaboration with industry, and only one had a background in industry. The motivation for academic engagement and commercialisation varied among the PI respondents. For the tenured researchers, funding for their research activities was highlighted as an important motivation for their academic engagement. For the non-tenure researchers, funding for their own salary was reported as the most important motivation. None of the PIs reported that personal economic gain was their most important motivation, either for academic engagement or for commercialisation, as exemplified by one of the PIs responsible for an academic spin-off:

> I'm doing what I like. Not just being rich, you know, [rather] it's richness in your ideas and your aims and what you want to achieve. (PI4)

For the cases within academic engagement factors such as personal contacts, the general knowledge of the PIs/research group and their personal network with industry and public actors was reported as important for the establishment of a collaborative project. Specific research ideas were not reported as important for academic engagement. The possibility to have results published in academic journals was highlighted as an important prerequisite for the academic engagement projects. However, the outcome was not always as hoped:

> In this specific case, we cannot publish. However, for most of the rest of the contracts we have be able to have the results published. (PI2)

Most of the commercialisation cases had their origin in pure basic research, in which the PIs gradually, often over decades, turned their ideas into a commercial product, either in the form of a spin-off company or a licensing contract. All of the academic spin-off companies had created jobs in the region, in addition to initiating new academic engagement projects with their parent university. In the commercialisation cases, too, the urge to disseminate research ideas and inventions to wider society seemed to be a very important motivation for the PIs. In addition, the freedom from reporting and university bureaucracy was highlighted as an important driver for spin-off creation:

> I'm not working to enrich people that are richer than me, that's not my aim. However, if we want to create jobs, [...] jobs won't be created in the public institutions, [but rather] less and less, I think. So, the future for young students lies in SMEs. (PI4)

None of the PIs reported any specific institutional incentives for taking on third mission activities, but they all considered such activities important in terms of general dissemination and knowledge transfer in order to their research to reach local and wider society:

> For me it's a cultural thing, and I think it's my duty to do outreach science, to do outreach in my own language. (PI6)

A significant difference was detected among the PI respondents concerning how they experienced the support structures. In the cases categorised as academic engagement, the PIs were in general satisfied with the support they received from their institution. Moreover, they realised that setting up contracts and budgets was an area in which they needed help and they acknowledged the complementary skills of the university support staff in dealing with those matters:

> They are coordinating all the contracts. There is an online application system in which you introduce all the data, all the calculations for the budget, the person months, amount per hours, and so on. Sometimes you make mistakes, so they help you. (PI2)

However, some causes of tension were reported, such as slow bureaucracy and even arrogance, yet still the expertise of the university support staff was recognised by the PIs:

> Sometimes this help is quite hard, because they are good at doing their thing, but sometimes they speak like they are blaming you. (PI2)

In the cases categorised as commercialisation, the level of tension was much higher between the actors engaged in the projects. The PIs reported that universities were reluctant to take on any commercial activities in their organisation, such as allowing private companies access to laboratories or incubation for academic spin-off companies. Furthermore, it was claimed that both the universities and their TTOs had too high expectations about the income from the commercialisation projects, such as from licensing agreements with academic spin-offs. In most cases, the latter strategies were considered very counterproductive to the commercialisation process and left the responsible PIs and academic entrepreneurs frustrated and disappointed:

> The university wanted so much money, and it was slow at responding. They [university management] were treating us like a big pharmaceutical company, so I was telling them 'All the money I have will go to the project, and spending money to pay for the license is not very fair. I agree to pay you when we get money, but it's kind of difficult in the beginning'. (PI4)

> So, I waited three to six months just to have an appointment, with the university. They do this because they know we need the patent to create the company. However, when I refused to agree to their terms, they did not care. They just said 'In three months, you will come back and agree, because we know that you need the patent'. (PI8)

University support personnel and TTO executives

The extent to which research and innovation support personnel from the universities and the TTO executives were closely involved in the cases varied. In some of the cases, they were responsible for making contracts and maintaining licensing agreements, but for the most part they were remotely connected, with limited knowledge of the daily activities. The TTOs in general and the external TTOs only with responsibilities for commercialisation activities in particular were very often considered unnecessary and, in some cases, expensive intermediaries that did not add any value to the project:

> The TTOs is an additional layer that is not useful or, at least, if they want to be part of it [the project], they should not take so much money. (PI3)

The PIs representing university support towards third mission activities highlighted the difficulties with gaining the trust of the researchers:

> I really try to communicate with them to explain how it works, but you know, when you are not a researcher, when you don't even have a PhD, it's complicated to be listened to. (SP2)

The support personnel saw themselves as important mediators between the PIs and the TTOs in the cases when collaboration between the two parties was faltering.

In the cases involving commercially more mature spin-off companies or older spin-offs created before 2010, the TTOs were no longer involved or had only minor roles in the commercialisation process. In some of the cases, the TTO executives considered themselves important actors for moving the commercialisation activities in the right direction:

> I have confidence in saying that without the TTO, nothing would have been done. (SP1)

In other cases, the TTOs seemed more reluctant and were waiting for the researchers to respond or take a more active part in the commercialisation process. Most of the TTO executives pointed out that the researchers were very often late or even non-responsive in the deliveries agreed upon. The TTO executives also seemed very aware that many of the researchers did not have much trust in them.

Some of the cases were considered high in social impact, but with limited potential for economic return on investment. Consequently, many TTO executives found it difficult to justify working on their project, or even to get permission to from their managers to do so:

> Everyone knows that it's not viable, economically speaking. So, every year, people must sit down and decide if they want to keep losing money or not. (SP1)

In some of the potential licensing cases, the fact that the university had already patented the technology was explained as a barrier to the industry becoming interested in the technology. This often resulted in a situation in which both the PIs and the TTOs ran out of funding possibilities to develop the technology further, even when it was considered both novel and commercially promising. When asked about their motivation for working on the commercialisation of research, all SPs highlighted that they found it very meaningful to help research results become realised in society. Many of the SPs also pointed out how they enjoyed working with researchers, and how they highly appreciated having their knowledge and assistance recognised by them.

External partners

In many of the contracts within academic engagement, the universities were subcontractors with specific assignments from a company. Many of those projects were initiated based on orders from government, often based on environmental regulations. All of the academic engagement contracts with external partners, independent of sector, were based on long-term personal relationships between the ECs and the PIs, and they all expressed respect and had knowledge of the working situation for academics. They also knew very well how the researchers were incentivised in the direction of research and education, and not towards third mission activities from their institutions:

> They [the PIs] have told us that they have seen some difficulties, and some of the difficulties are that they are not measured on how much they transfer to society or how much they work with society. The measures and their salaries are based on how much they publish in science journals or how many hours is spent on research projects. So, they don't foster or incentivise research to focus on society and societal needs. (EC3)

In licenced commercialisation projects, most the interviewed external partners were clear that their motivation for participating was for other reasons than to earn money directly from the project. They considered these kinds of collaborative projects important for their business because they were based on novel ideas or were vehicles for social engagement. The research ideas or projects represented something new to the external partner's company, but without great potential for revenues. Their goal was to use the projects as important means to gain visibility and attention for their companies and they were not willing to compromise too much on the economic terms in the agreements with the universities.

In the cases within academic engagement, none of the respondents from the companies or collaborating organisations were directly exposed to either the university support personnel or the TTO executives. Instead, all contact went through the PIs. By contrast, in commercialisation projects, the external partners needed to negotiate directly with university managers, and in most cases with TTOs. Most of the external partners expressed some concern about the bureaucratic process and unrealistic expectations of future income from the university:

> For our company, it was very complex to make contracts with the university. We needed six months to build the contract and it was difficult for them to understand that we do not earn money on this project. (EC2)

The partnering companies also questioned the role of the TTO:

> The TTO doesn't bring us a lot of [...] It's not very useful for us. It's the same with all the universities we have contracts with. We always deal and talk with the researcher directly to develop, to create, to invent, to find new solutions. The TTO is in the background and comes in at the end, when we need to make the final agreements. (EC1)

The most important findings from the study are summarised in Table 3.

Table 3. The summarized most important findings from the respondents.

Respondent group	**Most important findings**
Principal investigators (PIs)	Motivations: a) Funding (tenured researchers) b) Salary (non-tenured researchers) c) To disseminate research to society, to solve a problem d) Freedom from bureaucracy (commercialisation projects) e) Satisfaction with support for academic engagement Barriers: a) Dissatisfaction with support for commercialisation activities
Support personnel from universities and TTO (SPs)	Motivations: a) To disseminate research to society, to contribute to solving a problem b) Important roles as mediators between the researchers and TTOs when problems arise (university support personnel) c) Considered themselves and their competence very important for commercialisation to happen (TTO executives) Barriers: a) Gaining the trust of PIs and other collaborative partners in the project b) Securing time or funding for working on projects considered high in social impact, but with limited potential for economical return on investment
External collaborative partners (ECs)	Motivations: a) Considered collaborative projects important for their business because they represented something new to their company, not because of the income potential from the project b) Regarded the projects as vehicles for social engagement Barriers: a) Lack of incentives for PIs to work with third mission projects b) Issues regarding the role of the TTO in the project

Discussion and practical implications

Motivations for academic engagement and commercialisation

The findings from this study add new perspectives on researchers' motivations to engage in third mission activities and especially their motivations for academic engagement and commercialisation. Empirically, the findings from the multiple case study demonstrate that commercialisation projects within marine sciences are based on long-term, novel, and basic research. The academic engagement projects, however, seemed to be based more on the general knowledge and the experimental capabilities of the research group to meet the needs of the private and public partners. These findings to some extent contrast with those of D'Este and Perkmann (2011) and other researchers (Muscio et al., 2017; Perkmann et al., 2013, 2021), who makes the point that academic engagement is closer to the researchers' own research than to commercialisation projects. There is considerable consensus in the literature that commercialisation activities are driven by monetary rewards, both at the university level and among individual researchers (Bercovitz and Feldman, 2006; D'Este and Perkmann, 2011). However, none of the PI respondents in the study reported economic rewards as important for starting a commercialisation project. Rather, they stated a wish, or even an urge, to realise their research ideas, often as a solution for existing problems in society, and that this was their most important motivation for becoming involved in the commercialisation process. This finding is in line with the work of Lam (2011), who found that the great majority of the scientists are motivated more by research and an academic career also in their commercialisation activities, rather than by monetary rewards.

Non-commercial motivations for entering into commercial agreements with universities were also expressed by many of the collaborative partners, who reported they were motivated by social engagement and a wish to 'give something back to society'. These findings are in line with those from more recent research showing how a moral or social orientation can motivate researchers (Orazbayeva, et al., 2020; Van de Burgwal et al., 2019), but this has not been documented in the literature for other groups of actors involved in third mission activities. Therefore, these findings must be considered a novel contribution from this study.

By contrast, many of the academic engagement projects were driven by economic motivations in terms of funding for the research group, including academics' salaries. This was especially highlighted by the non-tenured researchers, who were dependent on the projects in order to continue in their university position. But they did not necessarily express a wish to continue the activity if they managed to obtain a tenured position. Although funding is an important motivation for academic engagement (D'Este and Perkmann, 2011), the aforementioned finding in many ways stands in contrasts to existing literature highlighting academic engagement as being much closer to researchers' own research agenda than to commercialisation (D'Este and Perkmann, 2011; Muscio et al., 2017).

As academic engagement projects are dominant in both volume and income, they are considered in the literature as being of greater economic significance than commercialisation projects, both for universities and the collaborating companies (Bercovitz and Feldman, 2006; Hughes et al., 2016; Perkmann et al. 2021). Furthermore, Perkmann et al. (2021) argue that commercialisation support has traditionally been favoured over support structures for academic engagement, such as the establishment of TTOs. All three universities in this study have set up professional internal support structures for projects categorised as academic engagement. The universities have also established or have access to a TTO. While the researchers seemed quite content with their internal support for academic engagement activities, they were less satisfied with the help and support they received from the TTO. Moreover, the study findings demonstrated that in several of the commercial cases the university managers counteracted the commercialisation process. Furthermore, the counteraction seemed to be related to a lack of capabilities, experience, and sometimes to disproportionately high-income expectations, both in the case of the universities and in the case of the TTOs. In addition, the economic burden of having to pay a TTO as a partner in the project caused dissatisfaction among the PIs, as well as the partnering companies, and the university leaders, especially in the cases that involved an external TTO. For their part, the TTOs seemed reluctant to invest too many resources in projects for which the return on investment was considered low.

The third mission of universities has been shown in transition from a money-driven policy structure towards a more socially engaged and sustainability-driven university mission (Compagnucci and Spigarelli, 2020; McKelvey and Zaring, 2018; Perkmann et al., 2021). In the early phases of the commercialisation process, when the commercial risk is very high, few actors are willing to help or capable of helping researchers in their innovation and commercialisation activities. Moreover, the competence, willingness, and capabilities for university support structures, including TTOs, have been found crucial for early-stage commercialisation projects (Galán-Muros et al., 2015; Rasmussen et al., 2014). However, in the studied cases reported in this paper, TTO funding and rewards caused a lot of tension, especially in cases where the social impact was considered high, but the economic rewards were low. In addition, the study revealed that the initial motivations for both academic engagement and commercialisation activities seemed to be more coincidental and tended to reflect social engagement among researchers, rather than motivated by monetary rewards (Orazbayeva et al., 2020; Van de Burgwal et al., 2019). This observation may also mirror the described transition of the third mission of universities. TTOs are considered both as important components and as necessary intermediaries for realising the impacts of research from universities (Cunningham et al., 2020; Hayter, 2016). Therefore, the role, missions, competence, and funding structures for TTOs should ideally be aligned with the evolving third mission of universities. However, the findings presented in this study imply that both universities and TTOs need to put in considerable effort and make changes to achieve such alignment.

Practical implications and advice

The findings have some practical implications. Universities may consider giving researchers more freedom to choose between the academic engagement and commercialisation paths, as also supported by Lam (2011). Policymakers, university managers, or support structures such as TTOs should consider academic engagement and commercialisation activities equally important parts of the third mission. It follows that more universities should consider broadening the role and tasks of their TTOs. To achieve this, a more seamless inclusion of the TTO activities in the university third mission projects could be mediated. This in turn might result in a beneficiary effect of drawing on important competence from the TTOs, as well as facilitating a culture for both academic engagement and commercialisation within the universities. In addition, different funding mechanisms for the TTOs could be considered, preventing the quest for financing for their activities prior to collaboration in the projects. Furthermore, universities should reconsider their incentive for third mission activities, including avoiding too high expectations of income from the commercialisation projects. Finally, in line with several other scholars (Halilem et al., 2017; Lam, 2011; Sormani et al., 2022), it is argued universities should in general balance their obligations and incentives and align them better with researchers' intrinsic motivations.

Limitations and suggestions for further research

The research presented in this paper had some limitations, but these limitations may also give directions for further studies. Based on the context and nature of the cases, a snowball sampling approach was used in the data collection, leaving the sample non-representative and biased toward certain group of cases (innovative links) and respondents. Furthermore, a significant comparison either between the three universities or between the specific national or regional characteristics they operate in relation to was possible. Moreover, the third mission activities were compared in terms of contract research, citizen science projects, and commercialisation projects, but did not include academic engagement activities, such as competition-funded research projects with private or public partners. Therefore, further studies should aim for a broader representative comparison of incentives and support structures for academic engagement and commercialisation. In addition, the role of department levels and university support for both academic engagement and commercialisation activities needs to be further explored. A good place to start could be to conduct a parametric study based on the main findings from this study, in addition to other results from the EMBRIC project. Finally, the role and funding structure for TTO support in relation to the transition of the third mission of universities should be included in future research agendas.

Acknowledgements

I want to acknowledge VIS, UiB, EHU and Sorbonne University for the collaboration and willingness to share relevant cases for this study. A special thanks to Pierre Colas at the Roscoff Marine Station and Ibon Cancio at the Research Centre for Experimental Marine Biology & Biotechnology, University of the Basque Country for their help and assistance during my data collection at their institutions. I will further express my deepest gratitude to all the respondents for their time and contributions. In addition, I want to thank my supervisor Knut Hidle at UiB for his valuable input to this paper and the Referees for their effort and very constructive comments. Finally, this study could not have been conducted without financial support from The Research Council of Norway and the Horizon 2020 funding programme.

References

Abreu, M and Grinevich V (2013) The nature of academic entrepreneurship in the UK: Widening the focus on entrepreneurial activities. *Research Policy* 42(2): 408–422.

Benneworth P, Pinheiro R and Sánchez-Barrioluengo M (2016) One size does not fit all! New perspectives on the university in the social knowledge economy. *Science and Public Policy* 43(6): 731–735.

Bercovitz J and Feldman M (2006) Entrepreneurial universities and technology transfer: A conceptual framework for understanding knowledge-based economic development. *Journal of Technology Transfer* 31: 175–188.

Biernacki P and Waldorf D (1981) Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research* 10(2): 141–163.

Brescia F, Colombo G and Landoni P (2014) Organizational structures of knowledge transfer offices: An analysis of the world's top-ranked universities. *Journal of Technology Transfer* 41(1): 132–151.

Breznitz, SM and Feldman P (2012) The larger role of the university in economic development: Introduction to special issue. *Journal of Technology Transfer* 37, 135–138.

Clarysse B, Wright M, Lockett A, Van de Velde E and Vohora A (2005) Spinning out new ventures: A typology of incubation strategies from European research institutions. *Journal of Business Venturing* 20: 183–216.

Clarysse B, Tartari V and Salter A (2011) The impact of entrepreneurial capacity, experience and organizational support on academic entrepreneurship. *Research Policy* 40(8): 1084–1093.

Compagnucci L and Spigarelli F (2020) The third mission of the university: A systematic literature review on potentials and constraints. *Technological Forecasting & Social Change.* 161: Article 120284.

Cunningham JA, Harney B and Fitzgerald C (2020) *Effective Technology Transfer Offices. A Business Model Framework.* Newcastle upon Tyne: Springer.

Deci, EL and Ryan RM (1985) *Intrinsic Motivation and Self-Determination in Human Behavior.* New York: Plenum.

D'Este P and Perkmann M (2011) Why do academics engage with industry? The entrepreneurial university and individual motivations. *Journal of Technology Transfer* 36: 316–339.

De la Torre EM, Agasisti T and Perez-Esparrells C (2017) The relevance of knowledge transfer for universities' efficiency scores: An empirical approximation on the Spanish public higher education system. *Research Evaluation* 26(3): 211–229.

Dubois A and Gadde LE (2002) Systematic combining: An abductive approach to case research. *Journal of Business Research* 55(7): 553–560.

Etzkowitz H (2004). The evolution of the entrepreneurial university. *International Journal of Technological Globalization* 1: 64–77.

Etzkowitz H and Leydersdorff L (2000) The dynamics of innovation: From national systems and 'mode 2' to a triple helix of university–industry–government relations. *Research Policy* 29: 109–123.

Etzkowitz H, Schuler EJ and Guldbrandsen M (2000) The evolution of the entrepreneurial university. In: Jacob M and Hellström T (eds) *The Future of Knowledge Production in the Academy*. Buckingham: SRHE and Open University Press, pp. 40–60.

European University Association (2017) EUA's response to the renewed EU agenda for higher education. Available at: https://eua.eu/resources/publications/415:eua%E2%80%99s-response-to-the-renewed-eu-agenda-for-higher-education.html (accessed 28 February 2023).

Gagné M and Deci EL (2005) Self-determination theory and work motivation. *Journal of Organizational Behavior* 26(4): 331–362.

Galán-Muros V, Sijde P, Groenwegen P and Baaken T (2015) Nurture over nature: How do European universities support their collaboration with businesses? *Journal of Technology Transfer* 42: 184–205.

Gammon, J (2017) What is research commercialisation? Architecture. Available at: https://sourceable.net/what-is-research-commercialisation/ (accessed 23 February 2023).

Goel, RK and Göktepe-Hultén, D (2018) What drives academic patentees to bypass TTOs? Evidence from a large public research organization. *Journal of Technology Transfer* 43: 240–258.

Grimpe C and Hussinger K (2013) Formal and informal knowledge and technology transfer from academia to industry: Complementarity effects and innovation performance. *Industry and Innovation* 20(8): 683–700.

Gulbrandsen M and Slipersæter S (2007) The third mission and the entrepreneurial model. In: Bonaccorsi A and Daraio C (eds) *Universities and Strategic Knowledge Creation.* Cheltenham: Edward Elgar, pp. 112–143.

Gulbrandsen M and Thune T (2017) The effects of non-academic work experience on external interaction and research performance. *Journal of Technology Transfer* 42: 795–813.

Gura T (2013). Citizen science: Amateur experts. *Nature* 496: 259–261.

Halilem N, Amara N, Olmos-Peñuela N and Mohiuddin M (2017) 'To own, or not to own?' A multilevel analysis of intellectual property right policies on academic entrepreneurship. *Research Policy* 46(8): 1479–1489.

Harsh S (2011) Purposeful sampling in qualitative research synthesis. *Qualitative Research Journal* 11(2): 63–75.

Hayden MC, Weiß M, Pechrigg A and Wutti D (2018) Insights into university knowledge transfer in the social sciences and humanities (SSH) and other scientific disciplines – More similarities than differences. *Frontiers in Research Metrics and Analytics* 3. doi: 10.3389/frma.2018.00032.

Hayter H (2016) A trajectory of early-stage spinoff success: The role of knowledge intermediaries within an entrepreneurial university ecosystem. *Small Business Economics* 47: 633–656.

Holley AC and Watson J (2017). Academic entrepreneurial behavior: Birds of more than one feather. *Technovation* 64–65: 50–57.

Hossinger SM, Chen X and Werner A (2020) Drivers, barriers and success factors of academic spin-offs: A systematic literature review. *Management Review*70: 97–134.

Hughes A, Lawson C, Salter A, Kitson M, Bullock, A and Hughes RB (2016) The changing state of knowledge exchange: UK academic interactions with external organisations 2005–2015. Available at:

https://eprints.lancs.ac.uk/id/eprint/145906/1/NCUB_The_Changing_State_of_Knowledge_Exchange_Feb16_WEB.pdf (accessed 3 March 2023).

Iorio R, Labory S and Rentocchini F. (2017) The importance of pro-social behavior for the breadth and depth of knowledge transfer activities: An analysis of Italian academic scientists. *Research Policy* 46(2): 497–509.

Jiao H, Zhou J, Gao T and Liu X.(2016) The more interactions the better? The moderating effect of the interaction between local producers and users of knowledge on the relationship between R&D investment and regional innovation systems. *Technological Forecasting and Societal Change* 110: 13–20.

Lam A (2007) Knowledge networks and careers: Academic scientists in industry–university links. *Journal of Management Studies* 44(6): 993–1016.

Lam A (2011) What motivates academic scientists to engage in research commercialization: ‘Gold’, ‘ribbon’ or ‘puzzle’? *Research Policy* 40(10): 1354–1368.

Laredo P (2007) Revisiting the third mission of universities: Toward a renewed categorization of university activities? *Higher Education Policy* 20(4): 441–456.

Laredo P and Mustar P (2000) Laboratory activity profiles: An exploratory approach. *Scientometrics* 47(3): 515–539.

Lawson C (2013) Academic patenting: the importance of industry support. *Journal of Technology Transfer* 38: 509–535.

Leitner K-H, Bergner S and Rybniecek R (2021) The role of heads of departments in the commercialization of university research. *Journal of Business Economics* 91: 353–378.

Link AN, Siegel DS and Bozeman B (2007) An empirical analysis of the propensity of academics to engage in informal university technology transfer. *Industrial and Corporate Change* 16: 641–655.

Link AN, Siegel DS and Wright M (2015) *The Chicago Handbook of University Technology Transfer and Academic Entrepreneurship:* Chicago, IL: University of Chicago Press.

McKelvey M and Zaring O (2018). Co-delivery of social innovations: Exploring the university’s role in academic engagement with society. *Industry and Innovation* 25: 594–611.

Muhonen R, Benneworth P and Olmos-Peñuela J (2020) From productive interactions to impact pathways: Understanding the key dimensions in developing SSH research societal impact. *Research Evaluation* 29(1): 34–47.

Muscio A, Quaglione D and Vallanti G (2014) Perceived obstacles to university-industry collaboration: Results from a qualitative survey of Italian academic departments. *Industry and Innovation* 21(5): 410–429.

Muscio A, Ramaciotti L and Rizzo U (2017) The complex relationship between academic engagement and research output: Evidence from Italy. *Science and Public Policy* 44(2): 235–245.

OECD (2013) *Commercialising Public Research. New Trends and Strategies*. Available at: https://ec.europa.eu/futurium/en/system/files/ged/oecd_9213031e.pdf (accessed 15 March 2020).

OECD (2019) University-industry collaboration: New evidence and policy options. Available at: https://dokumen.pub/university-industry-collaboration-new-evidence-and-policy-options-9789264637344-9264637346-9789264778375-9264778373.html (accessed 7 August 2020).

O'Kane C (2018) 'Technology transfer executives' backwards integrations: An examination of interactions between university technology transfer executives and principal investigators. *Technovation* 76–77: 64–77.

Orazbayeva B, Davey T, Plewa C and Galán-Muros V (2020) Engagement of academics in education-driven university-business cooperation: A motivation-based perspective. *Studies in Higher Education* 45(8): 1723–1736.

Perkmann M, Tartari K, McKelvey, M, Autioa E, Broström A, D'Este P, Fini F, Geuna A, Grimaldi R, Hughes A, Krabel S, Kitson M, Llerena P, Lissoni F, Salter A and Sobrero M (2013). Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy* 42, 423–442.

Perkmann M, Salandra R, Tartari V, McKelvey M and Hughes A (2021) Academic engagement: A review of the literature 2011–2019. *Research Policy* 50(1): Article 104114.

Rasmussen E, Mosey S and Wright M (2014) The influence of university departments on the evolution of entrepreneurial competencies in spin-off ventures. *Research Policy* 43(1): 92–106.

Reichert S (2019) The role of universities in regional innovation ecosystems. Available at: https://eua.eu/resources/publications/819:the-role-of-universities-in-regional-innovation-ecosystems.html (accessed 23 January 2022).

Reillon V (2017) EU framework Programmes for research and innovation. Evolution and key data from FP1 to Horizon 2020 in view of FP9. *European Union*. Available at: Briefing European Parliamentary Research Service (europa.eu) (accessed 05.20.2023).

Robinson DKR, Schoen A, Laurens P, Horellou S, Colas P and Laredo P (2016) Assessing marine biotechnology research centres in peripheral regions: Developing global and local STI indicators. In: *21st International conference on science and technology indicators*, Valencia, Spain, 14–16 September 2016. Available at: http://ocs.editorial.upv.es/index.php/STI2016/STI2016/paper/viewFile/4543/2327 (accessed February 2022).

Ryan RM and Deci EL (2000) Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology* 25: 54–67.

Sánchez-Barrioluengo M and Benneworth P (2019) Is the entrepreneurial university also regionally engaged? Analysing the influence of university's structural configuration on third mission performance. *Technological Forecasting & Social Change* 141: 206–218.

Sjöö K and Hellström T (2019) University-industry collaboration: A literature review and synthesis. *Industry and Higher Education* 33(4): 275–285.

Sormani E, Baaken T and Van der Sijde P (2022) What sparks academic engagement with society? A comparison of incentives appealing to motives. *Industry and Higher Education* 36(1): 19–36.

Taxt RE, Robinson DKR, Schoen A and Fløysand A (2022) The embedding of universities in innovation ecosystems: The case of marine research at the University of Bergen. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* 76(1): 42–60.

Tavory I and Timmermans S (2014) *Abductive Analysis: Theorizing Qualitative Research*. Chicago, IL: University of Chicago Press.

Thursby JG and Thursby MC (2003) Industry/university licensing: Characteristics, concerns and issues from the perspective of the buyer. *Journal of Technology Transfer* 28(3–4): 207–213.

Van Burg E, Du J and Kers JG (2021) When do academics patent outside their university. An in-depth case study. *Technovation* 4(6): 731–735.

van de Burgwal LHM, Hendrikse R and Claassen E (2019) Aiming for impact: Differential effect of motivational drivers on effort and performance in knowledge valorisation. *Science and Public Policy* 46(5): 747–762.

Weckowska D (2015) Learning in university technology transfer offices: Transaction-focused and relations-focused approaches to commercialization of academic research. *Technovation* 41–42: 62–74.

Wu Y, Welch EW and Huang W (2015) Commercialization of university inventions: Individual and institutional factors affecting licensing of university patents. *Technovation* 36–37: 12–25.

Yin RK (2018) *Case Study Research and Applications*. Thousands Oaks, CA: SAGE.

Zhao Z, Broström A and Cai J (2020) Promoting academic engagement: University context and individual characteristics. *Journal of Technology Transfer* 44: 304–337.

Paper 3

Paper 4

Graphic design: Communication Division, UiB / Print: Skipnes Kommunikasjon AS

UNIVERSITAS BERGENSIS

uib.no

ISBN: 9788230866191 (print)
9788230847428 (PDF)