



Høgskulen
på Vestlandet

MASTER'S THESIS

Technology transfer and academic entrepreneurship. A comparison between VIS (Bergen) and InnovUS (Stellenbosch)

Christer Lerøen Sørensen

Master in Innovation and Entrepreneurship

Faculty of Engineering and Natural Sciences (FIN)

Supervisor: Inger Beate Pettersen

31.05.22

I confirm that the work is self-prepared and that references/source references to all sources used in the work are provided, cf. Regulation relating to academic studies and examinations at the Western Norway University of Applied Sciences (HVL), § 12-1.

Abstract

This study examines academic spin-off projects in one BRICS country, South Africa, at Stellenbosch University (SU), and one developed country, Norway, at Western Norway University of Applied Sciences (HVL). It compares university-industry connections in the entrepreneurial ecosystems. Further, it looks at university entrepreneurial cultures and support and how these may influence academic spin-offs and early development paths. This study adopts a qualitative multiple case study approach based on in-depth interviews with academic entrepreneurs and key informants associated with the technology transfer office. Both technology transfer offices had adopted a relational approach to the commercialization process where the TTO executives work together with various actors in the entrepreneurial ecosystem during the development of the spin-off. Academic entrepreneurs (PhD students and postdocs) affiliated with Stellenbosch University rely more on the university's reputational networks. Innovus is an internal division of the university; it has the mandate and aims to target young academic entrepreneurs engaged in its research projects. In Bergen, the academic entrepreneurs are predominantly established researchers with more expansive networks. In Stellenbosch, the underlying motivation of academic entrepreneurship is creating new businesses and SMEs to restrain inequalities in the country. In Bergen, the motivation relates more to the green transition. Furthermore, as the entrepreneurial ecosystem in Stellenbosch is nascent, the TTO concentrates on building a knowledge region to attract actors. By contrast, the entrepreneurial ecosystem in Bergen is well established, with many actors interacting, and the TTO does not need to take a comprehensive role in building the ecosystem.

The originality of this research is that it compares spin-off projects in one developed country and one less researched but rapidly developing (BRICS) country.

Keywords:

Academic entrepreneurship, the entrepreneurial university, entrepreneurial ecosystem, networks, technology transfer, social capital, human capital, Norway, South Africa, case-study

Sammendrag

Denne studien undersøker akademiske spin-off prosjekter i ett BRICS-land, Sør-Afrika, ved Stellenbosch University (SU), og ett utviklet land, Norge, ved Høgskolen på Vestlandet (HVL). Studien sammenligner universitet-industri forbindelser i det entreprenørielle økosystemet. Videre ser studien på universitetets entreprenørskapskultur og hvilken innvirkning den har på akademisk entreprenørskap. Forskningsmetoden er en kvalitativ multippel casestudie basert på dybdeintervjuer med akademiske entreprenører og nøkkelinformanter tilknyttet TTOen. Begge TTOene har en relasjonell tilnærming til kommersialiseringsprosessen der TTO-lederne samarbeider med ulike aktører i det entreprenørielle økosystem gjennom spin-off perioden. Akademiske entreprenører (PhD studenter og postdocs) tilknyttet Stellenbosch University er mer avhengige av universitetets omdømmenettverk. Innovus som er en intern divisjon av Stellenbosch Universitet, har mandat til, og rekrutterer unge akademiske entreprenører engasjert i universitetets forskningsprosjekter. I Bergen er de akademiske entreprenørene i hovedsak etablerte forskere med bredere nettverk. I Stellenbosch er den underliggende motivasjonen for akademisk entreprenørskap å skape små og mellomstore bedrifter for å begrense ulikheter i landet. I Bergen er motivasjonen mer relatert til det grønne skiftet. Ettersom det entreprenørielle økosystemet i Stellenbosch er under utvikling konsentrerer TTOen seg om å bygge en kunnskapsregion for å tiltrekke seg ulike aktører. I Bergen er økosystemet etablert med flere ulike aktører og TTOen tar ikke en like omfattende rolle i å bygge økosystemet. Nyhetsbidraget med denne studien er at den sammenligner teknologioverføring og akademisk entreprenørskap i to ulike land inkludert ett BRICS land der akademisk entreprenørskap er lite forsket på.

Preface

This thesis marks the end of a two-year Master in Innovation and Entrepreneurship offered by Western Norway University of Applied Sciences (HVL), Campus Bergen.

I want to use this opportunity to express my gratitude to my supervisor and professor, Inger Beate Pettersen. She has given me invaluable guidance, feedback, and motivational conversations over the last six months.

I would further like to thank the respondents for their willingness to participate in my research, including VIS and Innovus, and their valuable contribution during the interviews.

I would also like to thank Intpart, professor Inger Beate Pettersen, HVL, and SU for facilitating and organizing the comparative thesis project and enabling us to travel to Stellenbosch to conduct all interviews in person.

List of Contents

Abstract	1
Keywords:	2
Sammendrag	2
Preface	3
1. Introduction	1
2. Theoretical framework	4
2.1 Academic entrepreneurship, and academic entrepreneurs' capabilities	4
2.1.3 The importance of entrepreneurial culture in universities for spin-off establishment	7
2.1.4 PhD and postdoc students pursuing academic entrepreneurship	7
2.1.5 Factors influencing the university's spin-off performance.....	8
2.2 Academic entrepreneurs and Entrepreneurial Ecosystems	9
2.2.1 Venture capital and university-managed funds	10
2.2.2 University-industry links (UILs)	11
2.2.3 Entrepreneurial ecosystem dynamics in South Africa.....	12
3. Methodology and research design	15
3.1 Choice of research design and methodology	15
3.2 Data collection and key informants	16
3.2.1 Semi-structured interviews	16
3.2.1 Observations at VIS	18
3.3 Sample and research context.....	19
3.2.1 Presentation of the TTOs, VIS and INNOVUS.....	21
3.3 Criteria for judging the quality of research design	23
3.3.1 Conceptual validity	23
3.3.2 Intern validity (credibility)	23
3.3.3 External validity (transferability)	23
3.3.4 Reliability (dependability)	23
3.5 Privacy and ethical reflections	24

4. Analysis	25
4.1 VIS -Technology Transfer office in Western Norway.....	25
4.1.1 Alpha, academic entrepreneur VIS A.....	29
4.1.2 Beta, academic entrepreneur VIS B	31
4.2 INNOVUS, Technology Transfer Office at Stellenbosch University	35
4.2.1 Gamma, academic entrepreneur Innovus A	39
4.2.2 Delta, academic entrepreneur Innovus B.....	41
5. Cross-case analysis and discussion	45
5.1 Relational-focused commercialization approach– adopted at VIS and Innovus	45
5.2 Academic entrepreneurs: professors and postdocs?.....	46
5.3 Academic entrepreneurs’ capabilities and various relations with the university	48
5.4 Building and maintaining the entrepreneurial ecosystem	49
6. Limitations and future research	51
References	52
Appendix	57
Appendix 1: Interview guide academic entrepreneurs	57
Appendix 2 Interview guide TTO executive.....	60
Appendix 3 Consent form	61

Acronyms

ASO	Academic Spin-off
BRICS	Brazil, Russia, India, China, and South Africa
EE	Entrepreneurial Ecosystem
TTO	Technology Transfer Office
AE	Academic Entrepreneur
TE	TTO Executive
VC	Venture Capital
UFs	Private Equity Funds
EVS	External Venture Capital
UIL	University-Industry Links

GEI	Global Entrepreneurship Index
GCI	Global Competitiveness Index
IEF	Index Economic Freedom (IEF)
LPI	Legatum Prosperity Index
SME	Small and Medium-sized Enterprises
CEO	Chief Executive Officer

List of figures

Figure 1: Conceptual framework of social networks influences on academic entrepreneurs' social capital

Figure 2: Transformation of entrepreneurial ecosystems

Figure 3: Conceptual model of entrepreneurial ecosystem dynamics in emerging economies

Figure 4: Embedded multiple case study

List of tables

Table 1: Primary data collection

Table 2: List of meetings in Stellenbosch

1. Introduction

Radical innovations are essential not only for the positive economic impact they typically create but also because they fundamentally change the behavior of consumers, often in ways that improve their lives (Wright et al., 2007). Societies and economies need radical innovations, and academic spin-offs (ASOs) and research-based innovations are essential in creating new technologies and products to develop new industries and businesses, vital for regional growth and renewal.

Commercialization of research-based innovations saw a significant increase with the US Bayh Dole Act legislated in 1980. In addition, the law created substantial incentives for universities to look for the commercialization of research applications (Debackere & Veugelers, 2004). Technology Transfer Offices (TTOs) typically serve as a mediator between providers of innovation (university researchers) and those who can help to commercialize them (investors, entrepreneurs, and firms) (Siegel et al., 2007). Many researchers see entrepreneurship as an essential part of their faculty responsibilities. In universities with a strong entrepreneurial culture, researchers are more optimistic about commercializing and developing new technologies based on their discoveries (Hayter, 2011). University support and incentives are necessary for the success of entrepreneurship activity. Human capital contains the stock of knowledge and skills within individuals, and it can be developed over time and transferred between individuals (Becker, 1964, cited in Wright et al., 2007). Although academic entrepreneurs may have human capital, they can lack some expertise and networks related to the market and commercialization.

Many studies of academic entrepreneurship have focused on individual characteristics (Stam, 2015), and less on how they relate to their surroundings. Academic spin-offs need to engage with the broader entrepreneurial ecosystem to succeed with commercialization. Spiegel and Harrison (2017) argue that resources and networks are two essential elements vital for developing entrepreneurial ecosystems. Networks can be described as social ties between actors, and resources acquired through networks can be described as human, physical, and financial. Academic entrepreneurs' internal capabilities are critical to exploiting social networks. Furthermore, creating and taking advantage of networks is crucial for academic spin-off performance (Pettersen & Tobiassen, 2012), and partnerships with industry are vital for

academic spin-offs (ASO) to provide access to complementary assets (Mathisen & Rasmussen, 2019). Conversely, a lack of networks with commercial actors can constrain growth (Pettersen & Tobiassen, 2012). Academic spin-offs typically possess high academic competence and solid academic networks, yet little business expertise and limited networks outside the academic sphere (Mathisen & Rasmussen, 2019; Urban & Chantson, 2017).

The literature on academic entrepreneurship is extensive and has grown significantly over the last decade. However, previous research on academic entrepreneurship has predominantly focused on drivers and success factors at the micro and meso levels. However, there is a lack of research on central barriers and the factors that influence the development of ASOs at the meso and especially macro levels (Hossinger et al., 2019). Furthermore, there is little research on the interaction among different actors in ecosystems (Hayter et al., 2018). In addition, there is also a lack of research on ASO projects in rapidly developing countries (Hossinger et al., 2019; Hayter et al., 2018). Most studies have focused on faculty as academic entrepreneurs and modest literature on the roles of students and postdocs as academic entrepreneurs (Boh et al., 2016; Rasmussen and Wright, 2015; Pirnay et al., 2003 et, Hayter et al., 2018). However, little research examines the role of PhD students and postdoc entrepreneurs in establishing new ASOs and student-supervisor relations (Hayter et al., 2018).

This study looks at the connection between university entrepreneurial cultures and support and how these may influence early development paths. It will bridge micro-level phenomena to the ecosystem characteristics by combining two theoretical frameworks: academic entrepreneurs' capabilities and entrepreneurial ecosystems. Furthermore, I aim to compare ASO projects in one rapidly developing country (BRICS country, South Africa) and one developed country (Norway). Specifically, I will study ASOs at the University of Stellenbosch and Western Norway University of Applied Sciences. Based on various cultural and regional outlooks, academic entrepreneurs could be motivated to start their businesses for various reasons. An internship inspired the background for choosing this topic during spring 2021 and a part-time position (since fall 2021), both at VIS Nyskapingsparken. In the internship and the part-time position, I contributed to academic spin-off projects from research communities at Western Norway of Applied Sciences, which increased my interest in understanding academic entrepreneurship. With this thematic background, I formulate the following research questions:

RQ1: How do the academic entrepreneurs perceive the entrepreneurial culture in their universities?

RQ2: What characterizes the academic entrepreneurs' capabilities and networks across cases/countries? How are they used/exploited in the commercialization of spin-off projects?

RQ3: What capabilities and networks do the academic entrepreneurs seek and exploit in the regional entrepreneurial ecosystems?

2. Theoretical framework

This chapter explains the research fields and theoretical perspectives that will be the basis for answering the study's overall research questions and sub-problems.

2.1 Academic entrepreneurship, and academic entrepreneurs' capabilities

Academic entrepreneurship is a process of commercialization, transforming knowledge created at universities into products, processes, and organizations through academic spin-offs and their contribution to innovation and economic development (Ray, 2013).

Academic entrepreneurs face unique challenges associated with the commercialization of their research. They need to acquire social skills that increase social capital and expand social networks (Buskirk, 2017). Davidson and Honic (2003) describe entrepreneurship *as a dual process of discovering and exploiting opportunities* where social- and human capital are essential factors. *Social capital* can be defined as the resources a person can acquire using networks beyond one's own. Social capital results from building relationships that help to facilitate and keep a shared goal. *Social networks* are the framework created by personal, professional, and business relations and may act as a mechanism for improving academic entrepreneurs' social capital by compensating for their social skill shortages. Social networks provide academic entrepreneurs with the resources necessary for commercializing their research (Buskirk, 2017). Bonding social capital is strong relations within a group or community while bridging social capital can be described as weak ties to external networks e.g., industry actors (Davidson & Honic, 2003).

Strong and weak network ties gain access to necessary information and resources that can increase academic entrepreneurs' social skills and increase their social capital. As academic entrepreneurs develop their social networks, they continue to develop social skills, which enhances their social capital. The figure below illustrates the continuous process of how social networks impacts academic entrepreneurs' social capital:

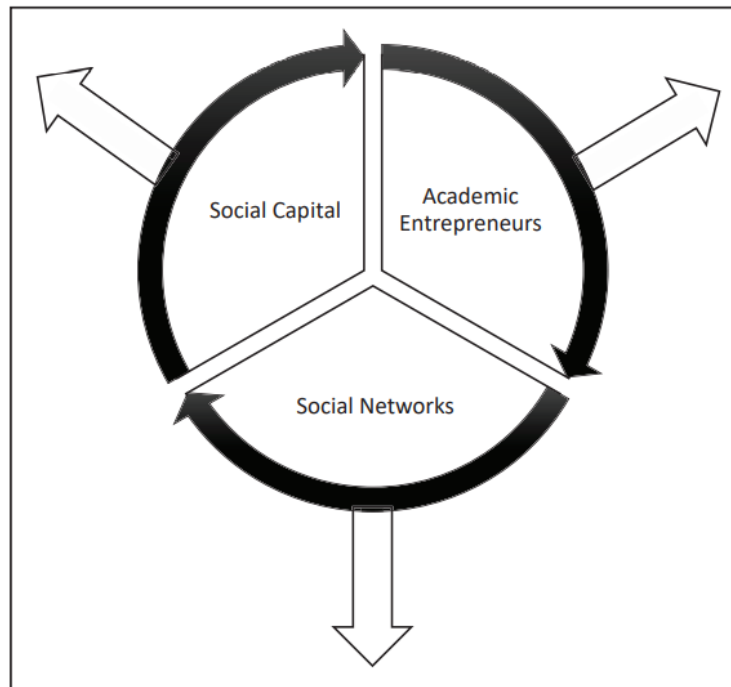


Figure 1: Conceptual framework of social networks influences on academic entrepreneurs' social capital (Buskirk, 2017).

Entrepreneurial networks span organizations, firms, and other people who help them set up the firm (Hansen, 1995 cited in Greve & Salaff, 2003). Further, these networks to commercial actors develop over time and usually in the first couple of years after business establishment (Davidson & Honic, 2003). According to Mosey and Wright, (2007) the presence of one type of capital may reduce the dependence on or need for others. Researchers who are highly linked in the academic community, have more social capital, publications, and government grants, tend to pursue academic engagement (Urban & Chantson, 2017). Mosey and Wright, (2007) propose that academic entrepreneurs that have previous business ownership experience are more effective in developing network ties to industry actors.

Human capital consists of knowledge and skills within individuals. Human capital can be developed over time and transferred between individuals. (Becker, 1964, cited in Wright et al., 2007). General human capital includes age, career status, and experience variables. Entrepreneurship-specific human capital variables have higher explanatory power regarding entrepreneurial opportunity exploration and exploitation. Mosey and Wright, (2007) argue that a specific combination of human capital is crucial for founding a start-up. Founders' human capital could enhance their ability to attract external investment and improve the ASO survival

rate. Prior commercial and entrepreneurial experience, prior industrial work experience, and a balanced skillset will improve academics' entrepreneurial opportunity identification capability and increase the likelihood of pursuing these opportunities (Mosey & Wright, 2007; Hossinger et al., 2019). Conversely, academics who are risk and stress averse or fearful of failure are less likely to start their own business. (Hossinger et al., 2019).

Research has shown that the social capital of ASOs beyond academia is confined (Mosey & Wright, 2007). One barrier to attracting commercial actors (investors, stakeholders) is that these actors do not see ASOs as commercial ventures but as academic individuals. ASOs tend to remain close to their university and exploit networks provided by the institution. Hence, they tend to pursue commercial ties after establishing the ASO (Davidsson & Honig, 2003). Human capital can be increased by making use of additional sources of human capital, e.g., TTOs (Cleyn et al., 2011). Cleyn et al., (2011) study shows the value of social and human capital on the success of early-stage ASOs. It demonstrated the importance of heterogeneity in ASO teams at the top management. Inventing a new technology and developing a market fit requires expertise hardly to be found in a single person. This is further prevalent in ASOs which are predominately technology-dominated. Furthermore, one can argue that these teams may lack prior entrepreneurial experience; thus, heterogeneous teams have been shown to develop more varied network ties with various actors.

2.1.2 Network Theory

Identity-based networks can describe personal or social ties with other actors that can motivate or influence economic actions. These networks are path-dependent, easy to access, and include work experience and education. However, these ties tend to be smaller and less diverse than calculative networks; they are less likely to possess the scope of resources required during the ASO's early growth. As the ASO grows, the network change and becomes more calculative. Calculative networks are pursuing networks beyond previously established ones. This includes customers, collaborators, and research institutions. These are characterized by a majority of weak ties that are more market-like than socially ingrained. They are often less redundant and better able to bridge structural holes (Hite & Hesterly, 2001). Network capabilities are the organization's ability to develop, use and maintain a relationship with external partners, e.g., stakeholders and research institutions. Entrepreneurial orientation refers to self-direction in pursuing opportunities (Weerawarden & Mort, 2006). The study shows that network

capabilities positively influence ASO performance. Entrepreneurial orientation and financial growth were shown to be more contextually dependent.

2.1.3 The importance of entrepreneurial culture in universities for spin-off establishment

Traditionally, one could understand that universities' mission consists of research and teaching. However, "entrepreneurial university" describes a third mission: social and economic development. In addition, universities take a more active role in commercializing their knowledge through academic spin-offs, contributing to regional growth and an innovation-driven environment (Grimaldi et al., 2011; Perkman et al., 2013). The local environment where the spin-off process is initiated appears to significantly influence the development path of nascent ventures (Rasmussen et al., 2014). The influencing factors include university characteristics, research orientation, and university support mechanisms (Hossinger et al., 2019). Support mechanisms such as incubation services, financial support, and entrepreneurial education programs are critical drivers for ASO performance. Thus, universities with great scientific productivity, innovation, and resource integration capabilities demonstrate excellent entrepreneurial performance (Hossinger et al., 2019). As for early growth ASOs and pre-founding, the parent institution and its network play a vital role by providing legitimacy, credibility, and reputation in international markets (Pettersen & Tobiassen, 2012). In addition, the university's status signals a positive commercial potential for investors (Gomes Gras et al., 2008). In contrast, a lack of department supports to stimulate an entrepreneurial culture constrains the development of spin-offs, especially in the early-stage formation process (Mathisen & Rasmussen, 2019; Hossinger et al., 2019). Success stories about other academic entrepreneurs can create positive mindsets toward entrepreneurship. In addition, a strong culture can improve the eagerness of entrepreneurs and other actors to engage in the risks associated with innovative entrepreneurship (Spiegel & Harrison, 2017).

2.1.4 PhD and postdoc students pursuing academic entrepreneurship

As mentioned in section 2.1.3, university culture and entrepreneurship programs can positively influence students' entrepreneurial motivations and minds (Boh et al., 2016; Pittaway and Cope 2007). Boh et al. (2016) found that among 47 ASO in their sample, graduate students and postdocs were involved in 36, with at least 11 spinoffs established with no faculty involvement. The study revealed that both faculty and students are involved in the early phases of the ASO

but that the role of faculty decreases over time. The study also demonstrated that while PhD students and postdocs may lack business expertise and experience, they are confident enough to drive the transition phase from public to private funding with appropriate university support. Postdocs were highlighted as highly motivated and knowledgeable about the technology.

A study by Hayter, (2016) demonstrates that graduate students play a significant role in the early stages of spin-off development in roles as CEOs and co-founders. They also contribute with technical expertise as they are normally involved in the faculty's academic research. Additional study findings highlighted how professors introduced networks and expertise to the spin-off. The study demonstrates that graduate students serve as a catalyst for spin-off establishments by developing initial spin-off ideas and investigating mechanisms associated with the firm establishment. The research also highlighted the influence of other students and faculty with entrepreneurial mindsets and various entrepreneurship support programs provided by the institution. These programs help link graduate students to entities outside the university with access to resources crucial to spin-off success. A study by Hayter et al., (2021) argue that postdocs are generally younger than most faculty and have therefore spent less time developing their scientific identity potentially making them more easily persuaded to commercialization-focused entrepreneurial identity development.

2.1.5 Factors influencing the university's spin-off performance

Research by O'Shea et al. (2005) emphasizes why some universities are more successful than others in creating ASOs. The research compared the number of ASOs created compared to other research institutions. The data collection included 141 U.S universities. These included the Massachusetts Institute of Technology (MIT), which, from 1980 to 2001, generated over 200 ASOs. The most important finding is that universities have various resource stocks available based on their previous history and the success rate of established ASOs. These findings support path dependences, prior developments impact current implementation. Secondly, the quality of the university (expertise and knowledge of academic personnel) was shown to be a crucial factor. The third factor was related to the number of financial resources allocated to ASOs and that universities benefit from industry-university collaborations. This was prominent for funding for federal science and engineering. The fourth finding underlines that the number of resources invested in TTOs personnel increases ASOs activity and that larger TTOs are more likely to produce ASOs.

2.2 Academic entrepreneurs and Entrepreneurial Ecosystems

Entrepreneurial Ecosystems (EE) is a dynamic and interactive system that entails a set of entrepreneurial actors (both potential and existing), organizations (firms, venture capitalists, business angels, banks), and institutions (universities, public sector agencies, and financial bodies) in an entrepreneurship context. (Pittz & Hertz, 2018; Shwetzzer et al., 2019). One can define EE as a set of unified entrepreneurial actors in the ecosystem that formally and informally connect and govern the local dynamic entrepreneurial environment (Shwetzzer et al., 2019). Therefore, one can argue that academic spin-offs relate to resources in the geographical context rather than exist merely within firms or individual spin-offs (Stam & Spiegel, 2017).

Spiegel and Harrison, (2017) suggest a process-based view of ecosystems to understand their role in supporting new venture creation. This framework explains the evolution and transformation of entrepreneurial ecosystems and builds a typology of various ecosystem structures. Essential entrepreneurial resources are often tied up in social networks, such as risk investors, talented workers, and mentorship from experienced entrepreneurs. Academic entrepreneurs' internal capabilities will affect their ability to draw on these resources. The functionality of an ecosystem is determined by the ability of entrepreneurs to access the flow of resources. However, it is challenging to acquire these resources if the academic entrepreneurs are not trusted inside the community. Ecosystems can be seen as ongoing processes through which entrepreneurs acquire knowledge, resources, and support, increasing their competitive advantage and ability to scale up. As the ecosystem strengthens through entrepreneurial success, new resources are generated through firm exits, new organizations and new resources are drawn from outside the region in the form of in-migration and inbound investment (Spiegel & Harrison, 2017).

Conversely, poorly performing ecosystems lack dense social networks that allow entrepreneurs to access vital resources, posing challenges for human capital and academic, technological entrepreneurship. (Wright, 2007, Spiegel & Harrison, 2017). EE in emerging or transition economies is often cited as resource-poor lacking venture capitalists and solid public support for high-growth academic technology scale-ups (Spiegel & Harrison, 2017). Figure 2 below illustrates *three processes of resource creation, resource recycling, and the flow of resources between actors such as high-growth firms, anchor firms, universities, and in addition to other regions that drive the evolution and transformation of EE* (Spiegel & Harrison, 2017 p 161).

Universities` interactions and collaborations with the industry can stimulate new firm creations, such as academic spin-offs.

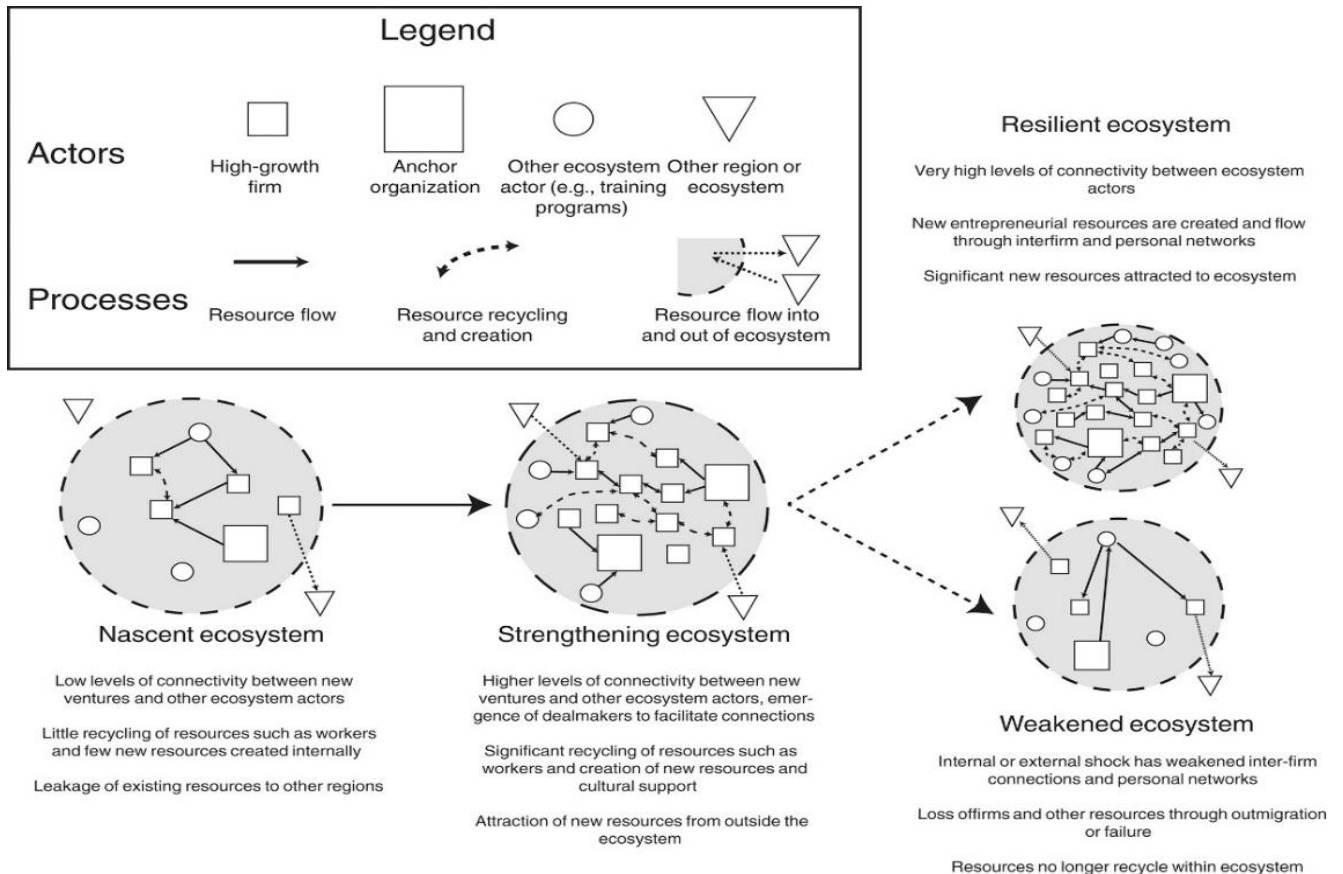


Figure 2 Transformation of entrepreneurial ecosystems (Spiegel & Harrison, 2017 p 162)

2.2.1 Venture capital and university-managed funds

A study by Croce et al., (2013) analyzes the creation and management of venture capital (VC) and private equity funds at the university level (UFs). Universities usually enter venture capital and private equity markets through their TTOs academic spin-offs. Therefore, UFs investment aim is mostly internal by financing projects and technologies developed inside the university. UFs in the EU tend to focus on financing early-stage spin-offs. The study emphasizes that prominent universities are more inclined to have successful UFs. UFs are successful as

providers of financial resources through their ability to find customized co-investors and to implement expansion strategies that allow them to spread out risk across diverse industries.

Knockaert et al., (2010); Zhou et al. cited in Hossinger et al., (2019) argue that one of the main challenges with ASOs is attracting external venture capital (EVC). Usually, EVCs have distinct preferences regarding investments; thus, it is challenging for EVCs to make correct investment choices because of the diversity of ASOs. Applying for funding is often time-consuming because of bureaucratic formalities. Compared to VC funding, the structure of public funding programs may also negatively affect the commercial performance of ASOs. ASOs with EVC support demonstrate a higher success rate than non-venture capital-backed spin-offs (Hossinger et al., 2019).

2.2.2 University-industry links (UILs)

Research partnerships between universities and industry are crucial components of an innovation ecosystem (Bramwell et al., 2012). Prominent research universities seek UILs to enhance their innovation networks and acquire and maintain a strategic position in the knowledge market (Debackere & Veuglers, 2005). However, one of the main challenges to university-industry collaboration is conflicting views of the purpose of research. Firms are interested in developing new products and services, while researchers tend to publish topics their peers view as exciting and valuable. The industry tends to see the long-term orientation of university research, potential conflicts over intellectual property, and rules and regulations imposed by universities or governments as the key barriers to collaboration (Bramwell et al., 2012). Bramwell et al., (2012) discuss “organizational cultural differences” as a significant problem complicating university-industry collaborations. For example, managers often complain that universities operate on extended timelines and demonstrate little regard for the urgent business deadline, which is a barrier, especially to small entrepreneurial firms unused to such arrangements. A university that can exploit the complementarities between teaching, basic research and applied research will thus be a strong player in the knowledge market (Debackere & Veuglers, 2005). Rasmussen, (2006) argue that government initiatives can encourage ‘bottom-up’ institutional innovation by providing resources for direct use in commercialization projects or to develop professional expertise in technology transfer in the university sector.

External factors influencing the development of university-industry partnerships include macro-economic and macro-institutional factors. This includes the Bayh-Dole Act or national policies to support Triple Helix's approaches to commercialization. Internal factors include

entrepreneurial activity within the university, institutional technology-transfer policies, and technology-transfer organization. University culture also affects its technology transfer capacity, and studies highlight the importance of the university's mission statement, the research and commercialization activities of employees and the administration's attitude towards commercialization. These factors significantly influence the nature of university-industry knowledge flows and ultimately affect the health and sustainability of the innovation ecosystem (Debackere & Veuglers, 2005).

2.2.3 Entrepreneurial ecosystem dynamics in South Africa

BRICS is an acronym that refers to five major emerging economies (Brazil, Russia, India, China, and South Africa) (Rosenberg, 2018). Several entrepreneurship economic growth-related measures, including Global Entrepreneurship Index (GEI), Global Competitiveness Index (GCI), Index Economic Freedom (IEF), and Legatum Prosperity Index (LPI) are used to compare the countries' entrepreneurial ecosystem. GEI shows country-level entrepreneurship (attitudes, abilities, and aspirations) and combines individual data with contextual institutional factors. LPI, IEF, and GEI put South Africa's entrepreneurial ecosystem in a favorable position as compared to Brazil and India. However, it is further argued that the ongoing recession, the dominance of large firms, inadequate infrastructure, dual economy, and corruption have been hampering South Africa's EE. The study also shows that the SA EE bottlenecks include start-up skills, networks, technology absorption, human capital, and risk capital pillars. The South African economy has grown slowly, and World Bank projected 1.7% growth in 2020. The unemployment rate climbed to 27,6 % in 2019. Large firms highly dominate the economy of South Africa, and it accounts for 90 % of total business. As the large firms' domination has built up connections with customers, it challenges small firms to enter the market unless being invested substantial capital (Bate, 2021).

More generally, Cao and Shi (2020) argue several key barriers for entrepreneurs in emerging economies: institutional voids (national), resource insufficiencies (regional) and structural gaps (regional). Networks in emerging economies tend to depend heavily on informal rather than formal ones, partially due to the lack of supporting organizations and weak formal institutions. Informal interactions help entrepreneurs cultivate critical resources and contact informal resource holders when they have limited ability to leverage formal institutions. Firms often partner with foreign entrants for international knowledge. Entrepreneurs are almost all self-

motivated/necessity-driven or encouraged by families and friends to engage in entrepreneurial careers rather than other peer encouragement from other entrepreneurs. Public incubators rely heavily on government funding (Cao & Shi, 2020).

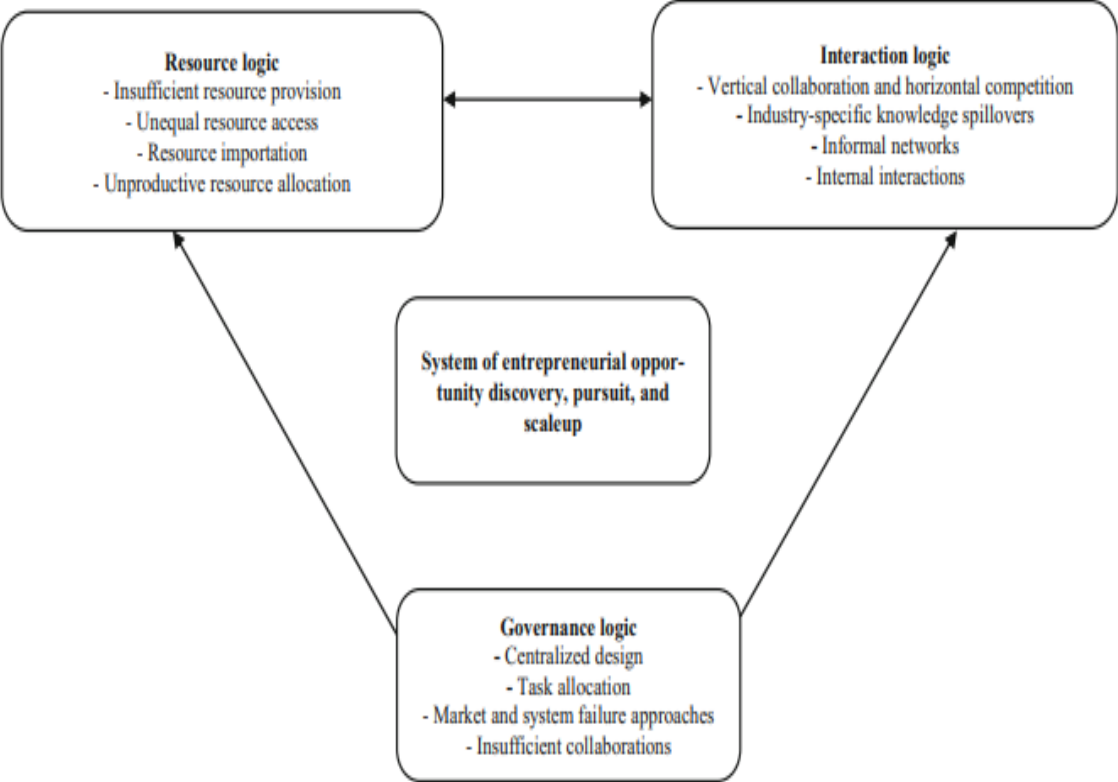


Figure 3 Conceptual model of entrepreneurial ecosystem dynamics in emerging economies (Cao & Shi, 2020 p 104)

There is fewer and unequal resource access offered to entrepreneurs in emerging economies. Because of this, entrepreneurial entry tends to be of poorer quality in a context characterized by institutional voids and biased toward necessity rather than opportunity-driven entry. The financial resource gap has been one of the most critical factors contributing to start-up failures in many emerging economies. This is due to a lack of private investments and substantial public resources in emerging countries—high reliance on networks with key resource providers, mainly governments supported (Reynolds et al., 2002; Melaas & Zhang 2016; Cao & Shi, 2020). In addition, a lack of knowledge represents a considerable challenge for entrepreneurs and new ventures. Entrepreneurs relying heavily on government subsidies tend to show a low level of growth potential and are likely to engage in corrupt activities. The successful

collaboration of structural agents such as the Triple Helix positively impacts entrepreneurial innovations not only in advanced economies but also in emerging economies (Cao & Shi, 2020).

3. Methodology and research design

This section presents the research methodology I will use in the thesis, which is comparative multiple case study research.

3.1 Choice of research design and methodology

Within the context of the philosophy of science, this study is characterized by social constructionism. Social constructionism aims to increase the general understanding of the situation, and the observer is part of what is observed. (Easterby-Smith, 2018). According to (Yin, 2018), a research design can be exploratory, descriptive, and explanatory. The exploratory design provides insight and creates understanding, and it is about understanding and interpreting the phenomenon in question in the best possible way.

This study aims to increase the understanding and knowledge of academic entrepreneurs' capabilities and networks during a commercialization process in two different contexts. To answer the research questions, I have chosen a qualitative methodology. Qualitative data are information gathered in a non-numeric form (Easterby-Smith, 2018). Qualitative research tends to be more *explorative* and entails open-ended rather than pre-coded queries and responses. Furthermore, *qualitative interviews* are directed conversations evolving around questions and answers about a specific subject. They are based on questions that follow a particular purpose, usually an in-depth exploration of a particular topic (Easterby-Smith, 2018).

The research follows an abductive approach. A deductive study is based on theory and tests this on an empirical phenomenon. Inductive reasoning is based on empirical data and observations of a phenomenon. An abductive approach gets inspiration from empirical data and combines induction and deduction (Jacobsen, 2015). I have worked closely with academic entrepreneurs and TTO executives through my practice and a part-time position at VIS and have had the opportunity to engage in spin-off projects and observe and interact with the actors involved. More specifically, I have interacted with different actors in the ecosystem, e.g., academic entrepreneurs and potential external collaborators and gained insight into challenges they experience related to early phase commercialization. Based on this ad-hoc observation of TTOs and academic spin-offs, I took inspiration and acquired knowledge to define some research themes and questions.

The research is also a case study. Case study research is an empirical method that examines a contemporary phenomenon in depth and its natural context, especially when the boundary between the phenomenon and the context is unclear. Case study methods are helpful when the research questions seek to explain some current circumstance, e.g., "how" or "why" some social phenomenon works. A case study approach is recommended as a research method when (Yin, 2018):

- The phenomenon one wants to study is contemporary.
- There is little to no control over human behavior.
- It is possible to observe the phenomenon directly.
- It is possible to interview people involved in the phenomenon.

The researchers' type of problem will influence the research design (Yin, 2018). The research question is *how do academic entrepreneurs perceive the entrepreneurial culture in their universities?* The phenomenon is possible to observe directly, and it exists today. In keeping with the theoretical development aims, I have conducted a multiple case study research. Multiple case studies normally provide a more substantial base for theory building than single case studies. Case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes. In doing case study research the goal will be to expand and generalize theories (analytic generalization) (Yin, 2018).

3.2 Data collection and key informants

Yin (2018) identifies six sources of evidence and source of data: documents, archival records, interviews, direct observations, participant observations and, physical artifacts. Case studies with more than one source of evidence are generally of higher quality than those that only have one source. Interviews, observations, and documents are the most common sources of information (Campbell, 2015).

3.2.1 Semi-structured interviews

The study has used in-depth qualitative interviews to explore the research question. In-depth interviews can help the researcher answer questions "why" and "how" and can help acquire knowledge of individual opinions and attitudes regarding a particular topic. In interviews, the researcher interacts with the research object, develops, creates data together in a community, shares reflections, and brings out the interviewee's perspective and experiences. Challenges and the ability to conduct good interviews are improvisations, follow-up questions, knowledge of the context, preparation, and confidentiality (Easterby-Smith, 2018).

I have conducted *semi-structured* interviews with an interview guide to collect data. Semi-structured interviews are based on a list of questions that can be addressed in a more flexible approach (Easterby-Smith, 2018). I have conducted face-to-face physical interviews since this type of interviewing enables researchers to get in-depth insight and build trust and relations. Additional value is that it allows observation of the environments that provide supplemental information, e.g., ad-hoc observations. It also provides greater tolerance for conducting more extended interviews (Easterby-Smith, 2018).

To gain knowledge of the TTOs I used a TTO executive as a *Key informant*. A Key informant is a person who has a general overview of a project and can speak out on behalf of several people. For example, it is a good idea to utilize a key informant at the beginning of a research project to get an overview of the challenges of the various projects (Yin, 2018). The TTO executive functioned as a key informant because of his extensive experience with the TTO and ASOs.

I designed two interview guides, one for the academic entrepreneurs and one for the TTO executives - a total of 6 interviews. The themes for the academic entrepreneurs involved network building in the pre-commercial phase. This included pre-founding and early development stages, how the research project started, and how the project has evolved. In addition, I aimed to explore their network strategies, capabilities, and how they perceived the entrepreneurial culture in the universities. As for the TTO key informant, the goal was to get comprehensive information about the projects and his/her experience with early-stage commercialization projects in general.

I conducted both individual and *group interviews* with academic entrepreneurs/researchers. Group interviews can give insight and opinions that may lead to exciting discussions. Furthermore, it can provide a more profound understanding and reflection (Easterby-Smith, 2018). The academic entrepreneurs may have different responsibilities in the projects, and their perceptions and experience may differ as to their ambitions of the spin-off.

Table 1 below presents the informants. Interviews with these constitute the primary data collection:

Table 1: Primary data collection

Name	Role/position	Data collection	When	Were
Bergen				
TE VIS	TTO Key informant	Semi-structured interview	April	VIS
Alpha	Associate Professor	Semi-structured interview	February	TEAMS
Beta	Professor	Semi-structured interview	February	VIS
Stellenbosch				
TE Innovus	TTO Key informant	Semi-structured interview	March	INNOVUS
Gamma	Postdoc	Semi-structured interview	March	INNOVUS
Delta	Postdoc	Semi-structured interview	March	INNOVUS

3.2.1 Observations at VIS

Referring to my part-time position at VIS during the master project, observations can be helpful for data collection in case studies. Participant observation is a particular method of observation in which you are not just a passive observer. Instead, you may assume various roles and participate in the studied actions within a fieldwork situation. A unique opportunity is the ability to perceive reality from the viewpoint of someone "inside" a case rather than external to it (Yin, 2018). Being an insider can facilitate the establishment of trust but can at the same time imply role conflict; since critical distance is vital to perform research. Summing up my observations at VIS, they provided me with insider knowledge of the commercialization processes, academic entrepreneurship, and the role of TTO executives and actors in the entrepreneurial ecosystem.

In addition, during my data collection in Stellenbosch, South Africa I participated in various meetings and seminars about the SA ecosystem and meetings with TTO Innovus. The list of meetings in SA and topics are presented in table 2:

Table 2: List of meetings in Stellenbosch

What	With whom	When	Where
Ecosystem Seminar	Brandon Paschal, Ecosystem expert	11.03.2022	Stellenbosch
Meeting with Innovus	Anita Nel, Chief Director: Innovation and Commercialization at SU	14.03.2022	Innovus, Stellenbosch
Innovus – Medical portfolio discussion	Nolene Singh, Technology Transfer Manager	11.03.2022	The LaunchLab, Stellenbosch
Agriculture meeting, research portfolio	Agri Innovation	14.03.2022	The LaunchLab, Stellenbosch

3.3 Sample and research context

In Bergen, Norway, VIS operates as an external entity of the University of Bergen (UiB) and Western Norway University of Applied Science (HVL), among other research institute owners. Bergen is known for its well-developed industry sector, mainly maritime, aquaculture and subsea. Innovus is a division of Stellenbosch University, South Africa. The university is amongst South Africa`s leading institutions based on research outputs (Stellenbosch, 2021).

The comparative case study included a purposeful selection of 4 ASO projects to examine early phase development, challenges, resources, and barriers. It consisted of two ASO projects from HVL in Bergen and two ASOs from SU, South Africa. The research aimed to select four projects with similar traits and define the following criteria: the academic spin-off projects are 1) in the early phase of technology development and 2) in the segment of renewable/green technologies. Furthermore, the technologies are medium-advanced/complex technologies. However, the case selection introduced significant cultural disparities and contextual effects, as the academic spin-offs are placed in different university milieus (HVL and SU) and regional entrepreneurial ecosystems (the Bergen region and Stellenbosch region). According to their roles, two informants on each project are included: the academic entrepreneur and the TTO executive responsible for the project. See figure 3 below, an illustration of the two cases:

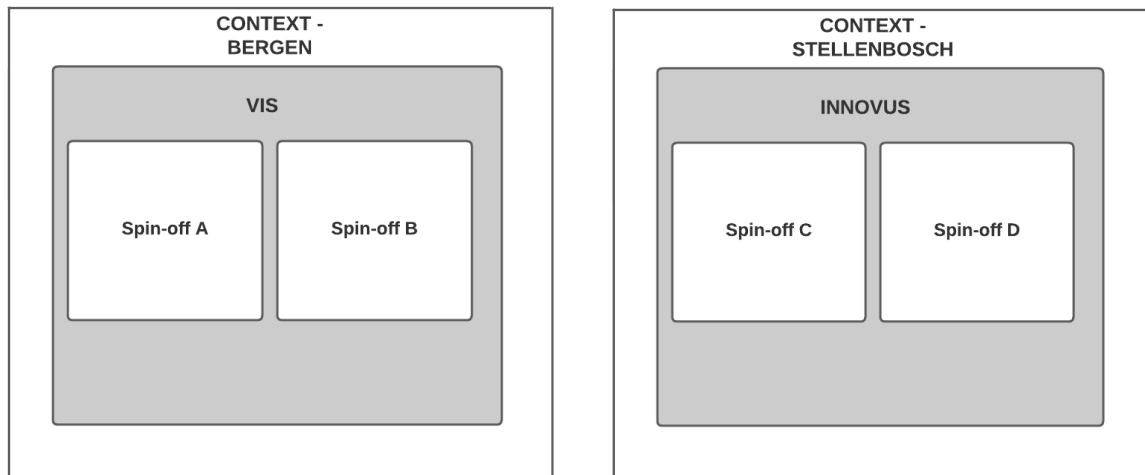


Figure 3 Embedded multiple case study

Figure 3 illustrates the case selection with embedded units of analysis in two unique contexts. An embedded case study contains several subunits for analysis (Yin, 2018). First, I wanted to explore similar and contrasting results. For example, a case with many similar traits may differ in other variables, e.g., cultural, and geographical differences - theoretical replication. The projects may face similar challenges because researchers/academic entrepreneurs face similar problems (publish or perish, incentives and lack of capabilities). However, at the same time since the context (both university and ecosystem are different) – they will also have distinctive possibilities and challenges. Academic entrepreneurs can have different motivations to pursue entrepreneurial activities individually. Individuals in Western societies define themselves in terms of their actions and, at the same time, are bound to societal norms (Urban & Chantson, 2017). Looking at Wright, (2007) and Spiegel and Harrison`s, (2017) understanding of ecosystems, poorly functioning ecosystems hinder entrepreneurs from accessing critical resources, posing human capital and academic entrepreneurship challenges. South Africa is categorized poorly in terms of start-ups skill, networking, and human capital pillars (Bate, 2021).

The master thesis also draws upon a recent master thesis by Iversen and Nessler, (2020) and a paper by Taxt et al., (2022) about VIS conducted at VIS, which includes qualitative data on the organization and the cradle to grave approach.

To investigate the academic spin-offs, I asked them to explain the history of their spin-off and how the project had evolved from the idea phase to the current situation. I asked about their background, family, education, and research. Topics were technology development, motivation, perceived opportunities, and barriers. The interviews lasted 40-90 min. All interviews were recorded after consent from the informants. Data collection was based on two interview guides, one for TTO executives (see Appendix 1) and one for academic entrepreneurs (see Appendix 2). After transcribing the interviews, work began on the analysis. The interviews were coded and analyzed based on the themes from the interview guide. The next step was to find patterns and connections between the categorized findings.

3.2.1 Presentation of the TTOs, VIS and INNOVUS

This section presents the TTOs, VIS and Innovus

Vestlandets Innovasjonsselskap (VIS)

Vestlandets Innovasjonsselskap AS (VIS) is a TTO established in 2004 to secure innovation and commercialization of research results on behalf of its owners. VIS is owned by the research milieus in Bergen: University of Bergen (UiB), Helse Bergen, Western University of Applied Sciences (HVL), Norwegian School of Economics (NHH), SIVA, and Institute of Marine Research. VIS acts as a mediator for providers of innovation (research milieus) and commercial actors (businesses, entrepreneurs, and investors). VIS has 36 employees, including 14 at *VIS research innovation* and ten at *VIS startup*. VIS startup includes startup-and-growth programs and incubation services. The second division is VIS research innovation. VIS contributes with expertise to evaluate the idea's social and commercial potential, idea protection, financing, and commercialization. The scope of ideas comes from the owners and research partners- from different faculties and departments, including ideas from students (Iversen & Nessler, 2020). VIS has guided 622 startups through its incubation facilities. Furthermore, they have started 100 startup companies The project portfolio in VIS is divided into three different disciplines – health, ocean and energy, and finance and media technology (VIS, 2021). From 2012 to 2020, an average of 50% of incoming ideas were within medicine and life science (Taxt et al., 2022).

VIS has a CEO as chief executive, followed by a vice president director. Further, the personnel are organized into eight teams. Five of these teams are thematically aligned project divisions.

The teams are set up as follows: Team Health, Team Technology, Team Societal Challenges, Team Marin, and Team start/scale-up. In addition, investment/appointments, project support, and communication teams support the other teams and their projects. All teams have a project leader and several TTO executives (Iversen & Nessler, 2020).

InnovUS, Stellenbosch University

Innovus is a division of Stellenbosch University responsible for technology transfer, entrepreneurial support and development, and innovation. The Technology Transfer Office manages the University's innovation and intellectual property portfolio by seeking relevant intellectual protection for the universities intellectual property portfolios, such as patents, trademarks, design and other forms of protection. The organization consists of one technology transfer director, five TTO executives, a team of administrative people, and a spin-out coordinator. Innovus have partnerships with key service providers. e.g., startup commercial attorneys and financial outsourcing service companies. In addition, they have two patent firms they collaborate with. US Enterprises (Pty) Ltd is a wholly owned subsidiary of the University and provides the platform for industry interaction through equity holding in the university start-up group of companies. From 1998-to 2021, Innovus spun out 28 companies and 82 licenses since 2017 (Innovus, 2022).

Innovus has a strong connection with the business incubator, LaunchLab with two unities; University StartupLab and Climate Lab. University StartupLab helps students, faculty and researcher transform research into startups. LaunchLab has programs for different stages in the commercialization process. The first stage is *the mentor and facilitator stage* and involves customers – and market discoveries to ensure whether the technology is feasible. The next stage is business viability and then technology feasibility programs. The rationale behind these entrepreneurship programs is to create an environment where like-minded entrepreneurs can come together to share experiences and offer advice (Innovus, 2022).

3.3 Criteria for judging the quality of research design

3.3.1 Conceptual validity

Validity defines the measure of the accuracy of the collected data material (Easterby-Smith et al., 2018). My part-time position in VIS has helped me gain knowledge about the research topic and better formulate the questions with depth and range. A further distinction is made between internal and external validity.

3.3.2 Intern validity (credibility)

According to Yin (2018), internal validity will describe the extent to which the results are valid for the sample and phenomenon being investigated and concerns whether the results are perceived as accurate. It is vital to have high validity in qualitative studies, as it gives validity and applicability to the data collected to answer the research questions (Easterby-Smith, 2018). Methods to strengthen credibility in research are reading relevant literature, using several sources of data collection, i. e triangulation, and using key informants during the research (Yin, 2018). Another important aspect is to avoid verifying but also trying to falsify findings. Regarding my association with VIS, I needed to be able to put down predetermined perceptions and beliefs that could have influenced the validity of the research. I have tried to decrease this issue by collecting data with an open mind and allowing the informants to speak freely, without leading questions and interrupting them.

3.3.3 External validity (transferability)

External validity implies whether the findings from a case study can be generalized to other situations, i.e., to a larger population that was not part of the original study (Yin 2018). One challenge of this study is that the sample is limited, making it difficult to generalize for the entire population. One approach to increase external validity is to articulate the research questions into "how" and "why" questions to attain a theoretical generalization. One of the study's strengths is that I have asked the same questions to respondents both in Norway and South Africa. This approach provides an indicator of what are more general factors and what are more contextual-specific elements.

3.3.4 Reliability (dependability)

Reliability from the viewpoint of constructionists involves whether other researchers will find similar patterns in other contexts and settings and whether the presentation of the data is

credible (Easterby-Smith et al., 2018). Replication may be challenging to achieve in qualitative research, as qualitative interviews are often situational and co-creation of data. Therefore, it is not easy to carry out the same methods and attain the same results in other settings. I have used a semi-structured interview guide as the primary data source. A reliability issue is that I could not carry out a longitudinal study and asked the interviewees about past events. This retrospective approach may have had an impact on my results (memory bias). The goal is, therefore, to obtain transparency in the research process. This was obtained by defining criteria for the cases, planning for data collection and documentation, and later transcribing the interviews (Yin, 2018). My experience and knowledge through my job at VIS have given me a different kind of insight into the organization and the selection criterion compared to others who do not have this insight into research innovation.

3.5 Privacy and ethical reflections

Before I started collecting data, I reported the study to the Norwegian Centre for Research Data (NSD) so that the study was carried out following the Privacy Act. Furthermore, I have adhered to applicable regulations for the processing of personal data and the EU General Data Protection Regulation (GDPR) throughout the research process.

Before the interviews, informants signed a consent form (Appendix 3), which informed them about the purpose of the research, the informants' right to withdraw from the research, and a confidentiality agreement.

4. Analysis

This chapter analyzes the empirical findings. First, it presents the findings of the ASOs affiliated with VIS. Then, it will present the findings of the ASOs affiliated with Innovus.

4.1 VIS -Technology Transfer office in Western Norway

VIS's primary mission is to collect ideas from the research milieus intending to establish companies, produce jobs and contribute to society's value creation and development. Annually VIS evaluates about 100 ideas from the research milieus. The initial selection process begins with TTO personnel having a prerequisite for evaluating the idea's potential. The ideas may have developed through inventors' industry experience, from discoveries in laboratories and research to needs and opportunities in society and markets. Next, TTO personnel utilize their networks to make necessary checkoffs about customers and market needs and technological feasibility:

Den som er ute og henter inn ideer har i utgangspunktet en forutsetning for å vurdere ideer innenfor den teknologien, markedet eller industrien. Hva er behovene innenfor et spesielt område (Key informant TTO VIS).

A common strategy for the TTO is that one TTO manager takes overall responsibility for a project/ASO throughout the project's life span, i.e., a "cradle to grave" approach, also shown in Taxt et al., (2022). This approach aims to keep track of the project's history and ensure continuity. In addition, the TTO executives use relevant internal expertise when needed and acquire expertise from external actors, also shown in Taxt et al., (2022):

Det fungerer bedre for å holde historien i prosjektene, at det er en sentral person som på en måte har hele historien. De som jobber på prosjektene, har ikke all kompetanse. Når vi kommer inn i en fase der vi samarbeider med industri og går ut og finner en industripartner, så er det noen som har større nettverk (...) Når vi skal gjøre exit-enten det er lisens forhandlinger eller opprette et selskap så er det noen som har mer erfaring med det - også tar vi det vi trenger underveis (Key informant TTO VIS).

Building relationships with the research communities

Building relations towards academic entrepreneurs and research milieus is vital for the TTO. This is also shown in Iversen and Nessler (2020) and Taxt et al., (2022). First, it is vital to build

trust at the project's start and maintain the relationship throughout its lifetime. The relations include close collaboration and a high role of interdependency between the academic entrepreneur and the TE, as explained in Taxt et al., (2022).

It is emphasized that one of the most valuable aspects of successful commercialization is encouraging the researcher and making them understand that there is value in their research beyond publishing. The key informant explained the value of the university supporting academic entrepreneurship and that there are several research opportunities:

Universitetet har mange gode muligheter til å få kommersialisert mye mer, men da tror jeg faktisk at universitetet må inn og så må de anerkjenne de ansatte som jobber med kommersialisering og på lik linje med de som produserer artikler (Key informant TTO VIS).

One of the main challenges associated with the commercialization of research is that Universities have no direct incentives to commercialize. The main incentives for universities are research, publications, and teaching; hence, researchers are not encouraged to initiate and participate in commercial activities. Therefore, knowledge about commercialization should be integrated from the beginning of higher education, preferably stimulating, and informing students already at the bachelor's level. Although the university offers entrepreneurship courses and there are possibilities for PhD students to apply for verification funds, the key informant underlined that commercialization programs are not fully implemented:

Et problem er at de som tar doktorgrad i dag, de ønsker primært å forske. Det er ikke lagt godt nok opp muligheter for en PhD student til å være innovative og være entreprenørielle. Det er i hovedsak rettet mot forskning (Key informant TTO VIS).

Therefore, the Norwegian organization for TTOs has made efforts to influence universities' incentives to include commercial activities, thereby making universities more "entrepreneurial":

En ting som TTO Norge har jobbet med de siste årene er å få institusjonene til å lage tellekanter på kommersialisering. At kommersialisering for eksempel skal gi like mye poeng som en publisert artikkel (Key informant TTO VIS).

The path to commercialization might not be apparent to researchers. The TTO has a responsibility to make awareness about their offerings and to make sure the researchers know about their possibilities and encourage them that the best alternative could be to commercialize the technology. According to the key informant, one barrier for the TTO to reach and inform about their offerings to the university is that the university has its department where the researchers make the first contact:

Sånn som jeg har forstått det, så skal ikke vi gjøre noe veldig utadrettet virksomhet der. Selvfølgelig skal vi pleie kontakt med de forskerne vi har, men første kontakt skal gå via der (Key informant TTO VIS).

However, there has been an increasing trend over the last couple of years regarding entrepreneurial activities in universities. Nevertheless, the key informant explains that academic entrepreneurs have varied capabilities; some have extensive entrepreneurial and industry competence while others have minimal entrepreneurial and industry experience. Usually, academic entrepreneurs are often more interested in basic research and publishing and are less interested in commercial applications of their research inventions, also shown in Iversen and Nessler, (2020). Therefore, TTO executives focus on developing academic entrepreneurs' understanding of the commercialization process to compensate for their lack of capabilities:

Alle som jobber som forsker har evne til å ta til seg ny kunnskap, enten det er innenfor sitt eget fagområde eller innenfor noe helt annet. Hvis de er motivert og interessert, klarer vi å få det til (...) Drive litt voksenopplæring og forklarer hvordan vi gjør ting. Hvordan vi utvikler i forhold til det industrien trenger (...) (Key informant TTO VIS).

The key informant explains that even though commercial insight is not crucial, it is a significant advantage for developing an ASO:

I prosjekter der vi jobber med forskere som har en kommersiell forståelse så skjønner de at her må vi utvikle noe som er i retning av det industrien eller kundegruppen trenger (Key informant TTO VIS).

Network building and linkages to the entrepreneurial ecosystem

Another vital role for the TTO is to bridge academic spin-offs with relevant industry partners (and other actors). Therefore, TTO personnel need to continuously establish, maintain, and expand their industry networks as networking helps provide the right resources for the ASO projects, also shown in Iversen and Nessler (2020). Building linkages to industry actors includes acquiring pilot customers for the pre-commercial stage, industry partners for full-scale technology development, and investors to fund the scaling of the project. One important aspect is that at least one project team member understands how the industry works. More, TTO executives should build competence and networks in relevant areas. It was highlighted that it is essential for a TTO executive to build trust within the academic communities and understand their situation and "world" as well as the business world:

Vi skal være bindeleddet, så vi må forstå forskeren og deres situasjon og hvordan deres system fungerer, samtidig som vi må forstå hvordan industrien fungerer (Key informant, VIS).

Collaboration with industry partners is essential to develop early-stage technologies, e.g., building real-life prototypes to fit market needs. VIS is also engaged in funding early-stage technology, e.g., through the FORNY program, which aims to fund early-stage ASOs. FORNY, the Research Council of Norway, is aimed at commercialization projects from the research communities and is highlighted as necessary for providing speed and momentum in the ASO projects. In FORNY applications, it is required to include industry partners and pilot customers. TTO executives invest a substantial amount of time building these industry relationships, and it is common to establish contacts by attending various conferences and events. These events can occur nationally and internationally as many of the ASOs possess technologies applicable to various market segments and target customers worldwide:

Vi har alltid brukt mye tid på å være ute på møtepunkter for industrien. Det er et lurt sted å være for å bygge nettverk, treffe folk igjen, snakke med folk, holde folk oppdatert. Av samme grunnen reiser jeg stort sett hvert år til Houston på Offshore Technology Conference. Også bruker jeg en del tid på å være ute i industrien og. Det kan være klynger som arrangerer frokostmøter eller andre samlinger. Det er kanskje den viktigste måten å opprettholde kontakt med industrien på. Det å være ute og treffe folk der de er (Key informant, VIS).

The key informant emphasized that university-industry collaborative projects can be challenging as shown in prior research (e.g., Bramwell et al., 2012). The industry often works with deadlines, and it can be time-consuming to be granted a milestone project (FORNY) precisely because of bureaucracy regarding the applications. The key informant emphasizes that the industry may not understand these procedures. In addition, technology development can take time because the researchers have teaching obligations, and they cannot fully engage in a project. There may be challenges related to progress in the projects, as researchers often must balance the role of both employees at the university and as commercial players. In addition, the industry has a framework and schedule. However, being motivated and interested are highlighted as essential criteria for developing a project:

Det som går på fremdrift. Industrien vil alltid ha det så fort som mulig (...) Det er jo ting som skal utvikles og hvis du da har en veldig introvert forsker og en veldig ekstrovert leder. Det i seg selv er jo utfordrende å være midt mellom der. Så tid er noe som er vanskelig å forstå. Forskerne trenger kompetansen som VIS tilbyr (Key informant TTO VIS).

4.1.1 Alpha, academic entrepreneur VIS A

The idea behind the technology originates in 2015. The team consists of two associate professors. One of the academic entrepreneurs pursued a career in the industry for over 20 years before working at the university. The motivation behind the idea and the decision to try to commercialize the technology gradually evolved over the years. The academic entrepreneur explained that one of the reasons was the transition toward the green shift. As he became affiliated with the university, he saw an opportunity to fulfill his vision.

Quote from the inventor behind Alpha:

"Jeg har laget denne teknologien som har sluppet ut denne klimagassen, nå ønsker jeg å bidra til å rense fremtidige utslipp, og gjøre [XX machines] til et bærekraftig alternativ også for fremtiden" (Academic entrepreneur, VIS A).

The idea and early-stage technology were further tested in a lab in the industry a few years later through so-called validation tests of the prototype. The technology was first tested on a small scale; then, after contact with the TTO, funding was provided by the NRF to do a milestone-based verification project (proof of concept). As a result, the research group increased its expertise in applying the technology. The TTO filed a patent application.

Previous industry connections from the researcher's network were essential for granting the first milestone project on public funding:

Selskapet var en veldig viktig medspiller for å få det første milepæl prosjektet som vi fikk. Vi fikk 500 000 da (Key informant, TTO VIS).

The company offered a support letter about the feasibility of the technology in the NRF application, which VIS wrote. The academic entrepreneur highlighted the role of the TTO personnel as a coordinator during this process:

Koordinering og systematikken i fremdriften har jo VIS vært veldig flinke. VIS er veldig dyktig på dette med offentlig finansiering. Det å kunne formulere søknader, det er klart vi ikke hadde greid uten VIS (Academic entrepreneur, VIS A).

The researchers' contact with VIS was through the university. In 2018, the research team engaged a master's student to perform master's thesis research with valuable measurements for developing and validating the project. In parallel with the master's thesis, VIS submitted a patent application to protect the technology. As the academic entrepreneur had extensive industry experience, it was easy to exploit networks when needed. The academic entrepreneur benefitted from both business and more applied (hands-on) experience:

Nå er jeg jo litt bortskjemt, jeg kommer rett fra institutt og fra industrien og har jobbet på utviklingsavdelingen der. Og har alltid vært vant til å ha et verksted rundt meg. Det har vært viktig for meg, men det har jo samtidig også gitt meg en viss breddekompetanse (...) Som innovatør så har jeg vel kanskje der hatt en bredere bakgrunn og det har jo hjulpet da selvfølgelig (Academic entrepreneur, VIS A).

In addition to the competence of the research team, other types of expertise have been necessary to develop the technology. For example, several people affiliated with the university have contributed with cross-disciplinary expertise, such as lab technicians and other experts doing various simulations. The academic entrepreneur highlighted the benefits of having a university as a collaborator:

Det praktiske uten tvil. Universitetet er mer fleksibel i forhold til industrien. Så lenge produktideene er såpass umodne som der er - så må du gjerne ha den friheten både på mannskapsiden og ikke minst på utstyrssiden som typisk et Universitet har. Og særlig viktig dette med bachelorstudenter (...) en del av de er rimelig praktisk anlagt og synes det er gøy med måleutstyr (...) Så det er klart at et uavhengig institutt er fenomenalt. Det har jo vist seg at så lenge vi ikke har de praktiske begrensningene har vi til tider jobbet veldig godt (Academic entrepreneur, VIS A).

Throughout the milestone project, the academic entrepreneurs maintained contact with an industry partner with the aim to run a full-scale project together to validate the technology in a natural environment:

De er i hvert fall såpass interessert at der har vi tilbud om å få låne en test fasilitet (...) Men det har vært betydelige praktiske hindringer på universitetet (Academic entrepreneur, VIS A).

The ASO has also acquired external actors and infrastructure in the project, e.g., personnel from universities abroad, where various technology validation tests have been carried out. In addition, cooperation has been initiated with commercial actors, equipment manufacturers, and subcontractors. Although the university has been helpful with human resources and technical expertise, the academic entrepreneur highlighted some challenges. Practical obstacles have stood in the way of progress in the project, and the academic entrepreneur believes they should have been more active. The academic entrepreneur explains that the university has chosen to focus more on "future-oriented" technologies, and this strategy has delayed the development of the project:

På toppnivå, altså fakultetet for (ingeniørutdanningen) har vært helt likegyldige. Fullstendig. På et tidlig tidspunkt var de ikke interessert i å støtte oss fra fakultetssiden. Men ett hakk lenger ned (ingeniør avdeling) der ideen kom fra - har de bidratt med noen tekniske fasiliteter, lab og litt manpower. Men det har vært så lenge det ikke gikk utover andre ting. (...) Vi har kjøpt flere studentoppgaver (...) og det har jo vært nyttig (...) Spesielt bacheloroppgaver fordi det er så mye praktisk kjøring og målinger (Academic entrepreneur, VIS A).

4.1.2 Beta, academic entrepreneur VIS B

The ASO consisting of three researchers, two professors and one post-doc have since 2015 developed the technology within the engineering department at the university. The idea arose

ten years ago as the academic entrepreneur detected an article of interest and saw a gap in the existing literature. As a result, several theoretical models were developed and are still further developed in collaboration with researchers from another regional research institution. The post-doc who joined the team has been carrying out different experiments. These models have then been utilized to design a laboratory-scale prototype built in collaboration with the engineering department - with research funding from the university. According to the academic entrepreneurs, the motivation behind commercializing the idea/technology is to develop renewable energy technologies that are better adapted to the Nordic climate:

(We) are primarily interested in developing a commercial application of the technology. (...) It would be nice to improve the current technology. To make it economically beneficial (...) A spin-off is an absolutely mandatory kind of aim for this development. (...) I am mostly interested in the development of the technology-but not in the extraction of the highest possible profits. So, maybe the spin-off could just be sold out by the university later” (Academic entrepreneur, VIS B).

Networks and capabilities

The academic entrepreneur emphasized that networks were essential for developing the technology and accessing potential stakeholders. It was vital that when moving forward with the project and having plans to scale up, it could be a challenge to find the right actors, especially if lacking commercial and business competence:

Norway has a very special market. Here you need to know people- so we need some help, someone on the team regarding social connections (Academic entrepreneur, VIS B).

Nevertheless, the research team has used their networks from professional acquaintances to contact relevant companies that could help with the commercial application:

We got a couple of companies abroad that potentially are looking into the technology and could help us with sales (...) But all of this cost us something (Academic entrepreneur, VIS B).

Additional funding was provided by the NRF to do a milestone-based qualification project. The academic entrepreneur explains how VIS got involved in the project:

Initially, I didn't know what VIS was (...) I was targeted on Facebook by an announcement from VIS. (...) By that time I had a completely different idea, and this idea was transformed into what we have now (Academic entrepreneur, VIS B).

The academic entrepreneurs saw a market opportunity and have adopted the original idea to something that they believe will fit the market in Norway. VIS has utilized its networks to contact relevant industry actors for support in applying for funding to develop the technology for market fit. In addition, VIS has helped with the economic part of the application and has conducted market investigation activities:

Forskeren hadde ikke et like stort nettverk som vi kunne spille på. Men vi gjorde noen undersøkelser og kom over noen aktuelle selskap. Industriaktører å samarbeide med. Og egentlig litt tilfeldig at vi kom i kontakt med (selskap) fordi jeg så en artikkel på LinkedIn-at de [satset på denne teknologien]. Også hadde det seg sånn at et en annen som jeg har jobbet en del med, han jobber tett opp mot dette [selskapet], og så brukte jeg han som en døråpner inn mot dem og jeg fikk dialog med daglig leder (Key informant, TTO VIS).

Both the TTO executive and the academic entrepreneurs contributed to acquiring relevant actors in the process:

Vi har flere interesserte industripartnere i prosjektet. Begge de to sistnevnte var det forsker som opprettet dialog med og brukte sin kompetanse og delvis sitt nettverk der. Men vi delte på det. Forskeren gjorde noe, og jeg gjorde noe. Og vi kom i dialog med industrien (Key informant, TTO VIS).

The short-time aim was to test the application on a larger scale prototype in collaboration with an industry partner. A significant milestone in the qualification application was to get positive interest from potential customers and a partner signed for the first full-scale trials. Although the ASO has gained interest among industry actors, the academic entrepreneurs underscore that the industry often wants to invest in large-scale prototypes close to industrial application and more petite in development projects. Thus, for early-stage ASOs, it can be challenging to acquire investment to develop the technology further. Further aims are to extend networks towards industry clusters specialized in this technology field. In addition, several firms have expressed interest in collaborating toward commercialization and becoming partners for a larger

verification project. Therefore, the long-time envision is licensing agreements with national and international firms. Also, establishing an ASO with a partner to develop and commercialize the technology is viable.

The university's entrepreneurial culture

The academic entrepreneur explained that the entrepreneurship culture had changed gradually over the past five years. First, the university uses intranet where the TTO occasionally makes announcements for researchers. As a result, the services of the technology transfer office are more visible today. In addition, successful researchers and trainee professors are offered external research time, and the academic entrepreneur ejected external funds and used this money for equipment for the prototype. As the university does not yet have a well-established entrepreneurial vision, the academic entrepreneur underscores bureaucracy and lack of well-defined methods as a barrier for the university to compete with other major universities and private companies:

We need a team that describes and supports the development of spin-offs. Because the most successful universities, mainly NTNU, they have this routine, they have a very well-defined method (...) They support spin-offs. I think we have to meet the same criteria (...) We have to get a routine that makes everything automatically if you have a good idea (Academic entrepreneur, VIS B).

4.2 INNOVUS, Technology Transfer Office at Stellenbosch University

The TTO follows a “cradle to grave” approach where the TTO executives follow the project through the whole process. Their chief director implemented the rationale behind this approach as she had a philosophy that it was important to learn and grow into areas where you can add value. The approach implies the process of idea conceptualization through securing intellectual property rights (IPR), obtaining funding, and helping to create the ASO company. The TTO executives are involved in all those phases. The TTO key informant highlights that the rationale behind the approach is to obtain value through the technology development process, meaning to collaborate closely with academic entrepreneurs and other actors in the EE. In this way, it is easier to understand better what changes could be made and evaluate the continuousness of the value given the technology development:

We tend to get very hands-on in the commercial process. We feel that it is important to understand every aspect of it. If I am also involved in managing the IP (...) I can keep an eye on how the technology is developing. We feel that if we are involved in all of those aspects, we can add much more value to the whole process (Key informant, TTO Innovus).

Innovus focuses on knowledge and competence enhancement in the organization and is the TTO in South Africa with the most registered technology transfer professionals (RTTP). RTTP implies competencies and signals that the individual has demonstrated core competencies required to work in technology/knowledge transfer and has the experience to add value based on a recognized track record. On the other hand, it was, however, implied that it was difficult to find people with the skillset mainly because of their portfolio size. Innovus is the first TTO in South Africa that focus more on establishing ASOs rather than licensing. The key informant accentuates that it is vital to create job opportunities in the region to avoid economic disparities:

If we just ship our IP out through licenses, it is kind of taking our natural resources, sending it to another country for value to be added, and then buying it back, at a high cost (Key informant, TTO Innovus).

Building relationships with the researcher communities

The key informant underlined that communication internally with the university was vital for building trust towards students (master's, PhD, and postdocs) and researchers. The Boyle Dole

Act mandates the university to identify research inventions with potential for innovation/commercialization. This mandate can cause internal friction as many researchers are not driven by commercial value but identify themselves more as researchers than entrepreneurs. Therefore, one of the crucial roles of a TTO executive is to translate between the academic world and industry:

That is one of the big communication struggles that we try to overcome is communicating the value that we add (...) This IP is owned by the university, and we want to work with you and get as much impact out of this as possible and there is a small difference, but it is also important. (...) They (researchers) are driven by and working on stuff that they love. They want to make an impact. They do not want it to be money-making schemes (Key informant, TTO Innovus).

Innovus used 30 percent of its time directly interacting and building relationships with researchers and students involved in research projects at the university. The aim is to build trust within the communities through personal relationships and informal contact. One of the main challenges highlighted is reaching out to students pursuing masters and PhDs. They focus on picking up on the possible value of their research early. Various marketing approaches were used to communicate the importance of research-based innovation within the university. One of the strategies was an awareness program aimed at masters and PhD students. *The Translational Fellows Program* (TFP) is a sponsored fellowship program where the objective is to enable students to pursue an entrepreneurial career upon graduation while developing entrepreneurial and commercial skillsets. The program provides a stipend and commercial support from Innovus, including market validation, business development, and access to funding:

We started the Translational Fellows Program. It is predominantly PhD graduates that instead of directly going off and working somewhere, we get reappointed as postdoctoral fellows for another year, but the outputs are not more articles and investment in research, the output is business cases [that can be commercialized] (Key informant, TTO Innovus).

Innovus also arrange entrepreneurship bootcamps once a year, open to all students. Pitching, mentoring, and business cases are part of these events. Students learn and can participate in various courses such as Big Data, Design Thinking, Lean Startup and entrepreneurial

development techniques. The motivation is to drive the entrepreneurial culture among students. In addition to reaching out to students, TTO leaders focus on building trust with established researchers and research communities.

The aim is to get awareness about the onboarding boarding program because we want them to be made aware as soon as they arrive at the university (Key informant, TTO Innovus).

One of the instruments is to build relationships and conduct personal visits to the research departments. The key informant emphasized the importance of being open and inform about the role of Innovus and, at the same time, building networks. For example, one important activity was to regularly look at their faculty websites to see if there are any new ongoing research projects. One of the considerations one must endeavor for pursuing academic entrepreneurship is whether the researchers or students want to become entrepreneurs or CEOs. A part of the TTO executives' role is to guide them. The researchers (professors) rarely want to leave the university and invest entirely in a company. Hence, they are involved, but not full-time, because they want to continue to be researchers:

One of the things we look for is that there is a champion, somebody that is willing to commit. That is normally not the professor, because they need to mark tests and perform research and publishing. (...) Besides, we have a pool of retired CEOs that are willing to work in these companies and once they raise funding, they pay themselves salaries as a surrogate entrepreneur. (Key informant, TTO Innovus).

Thus, not surprisingly, the key informant highlights passion, openness, and resilience as essential traits for a researcher pursuing academic entrepreneurship. Throughout the years there has been a positive change in the entrepreneurial culture at the university. One of the main reasons for this shift is that the region needs to create jobs. The university has implemented various student entrepreneurship programs where they get all universities together once a year to share learnings:

It is definitely changing. Nationally, there is a big drive to get entrepreneurship more integrated into the culture of universities. The reason being, we need people not only their jobs, but to create jobs (Key informant, TTO Innovus).

Connection with industry actors

The key informant underlined their vision of creating a knowledge region, and through Innovus, they build a knowledge region to attract multinationals, and through Launchlab, they maintain their networks. Informal networking opportunities are highlighted as important. Creating a critical mass of spinouts around the university would attract more entrepreneurs, funders, and multinationals to the region. In addition, they needed connections with Venture Capital (VCs) and mentors whom they invited to work with the companies. *The Stellenbosch network* is a cross-sector and interdisciplinary nonprofit organization that connects industry, government, society, and academia. For example, LaunchLab events and industry breakfast events once a year. The aim is to share ideas and encourage collaboration and partnership to support inclusive economic growth.

We attend those events, we attend the LaunchLab events (...) industry breakfast (...) Meet people that we think might be interested in our technologies, we think might be interested in our companies try to get them involved with the Launchlab (...) We need to engage with people before we will get into the companies. That also involves angel investors (Key informant, TTO Innovus).

University funds and linkage to investors

The key informant explains that business angels are pretty prevalent in the Western Cape region. However, since the government contribution to research funds has decreased, researchers need to utilize their networks for capital. Usually, the TTO has some local investment initially. International investors are not that prevalent. The *University of Technology fund* (UTF) is a private investment fund specifically focused on commercializing technology, intellectual property, and research from South African Universities. Their region's largest companies started the *South African SME* fund inspired by the University of Oxford's fund. They give TTO discretion to use money, and the TTO uses that to invest in high-risk early-stage projects across the country. One of the challenges in South Africa is that many SMEs are not captured or registered and are not part of the formal economy. The key informant underscored bureaucracy and regulatory approval as the main barriers to establishing SMEs. In addition, over the last couple of decades, R&D departments and South African companies have shrunk considerably:

We need to start small companies because, like most places in the world, we believe that if we start SMEs, they will create jobs, they will have a big multiplier effect (Key informant, TTO Innovus).

4.2.1 Gamma, academic entrepreneur Innovus A

The idea behind the technology/ASO originated within the university based on an ongoing research project/group with about 5 to 10 researchers. The idea developed further during the academic entrepreneur's PhD and postgraduate studies, and today he is the company's CEO. The research group saw a gap in the practical application of the technology that could be implemented in various market segments. The academic entrepreneur became motivated to pursue commercialization after working with his supervisor, a professor who is also an academic entrepreneur:

That stood out for me because he did research and with his research, he helped a lot of people in our country and many trust him because he has done valid research. That whole thing is super attractive to me. I want to be like that (...) Definitely a role model and mentor. (...) Also want to have that type of impact (Academic entrepreneur, Innovus A).

The academic entrepreneur had some previous corporate work experience. Even though he worked on important corporate projects, the academic entrepreneur wanted to pursue another path:

The work environment was so restrictive (...) want to be very flexible with my time and have a big impact (Academic entrepreneur, Innovus A).

When developing the technology, the academic entrepreneur saw the possibilities and benefits the idea could have on society:

I know that I cannot do that just by research, my research needs to translate into the other spheres in our country (...) and we could change their infrastructure, we could save them energy (Academic entrepreneur, Innovus A).

The ASO consisted of members with both engineering and economic backgrounds. Having an experienced and interdisciplinary team has helped the ASO to access and maintain essential networks and business opportunities. For example, the supervisor served as a door opener with

the networks he had. The professor had also acquired trust within the community because of previous research:

He played a big role with the networks that he had (...) There are a lot of people that come through to the links of the professors (Academic entrepreneur, Innovus A).

Networks provided by the university

The academic entrepreneur had proactively sought to identify potential customers based on the broad networks provided by his supervisor. In addition, the university was perceived as a credible organization among its stakeholders and was a fruitful environment for accessing the resources needed. The academic entrepreneur could exploit the reputational networks to get in contact with relevant industrial companies and potential investors:

The university has a lot of networks (...) The companies see the university as a credible organization. If I pitch up at a place and I would like to work with them, and I say, I am from the university, it opens up the whole door (Academic entrepreneur, Innovus A).

Innovus has been important for legally starting the company, primarily helping with finances and legal issues through external networks. In addition, Launchlab offered support to the startup by helping the startup better define its business. However, to further expand and commercialize has been trying:

In terms of manpower, or the number of people working on the project, I think that's where we lack a lot (...) It's just me doing everything. That can't work if I want to have a huge impact in South Africa. (Academic entrepreneur, Innovus A).

Future aims for Gamma

Initially, the ASO had one paying customer. Later, the ASO participated in a larger project for the government. During this project, the ASO received funding from The University Technology Fund. Participating in this significant project proved valuable for the ASO, as they had the opportunity to showcase to companies how much they could save and the value of the project. The academic entrepreneur underlined that the short-term aim is to provide service to small companies. Although it is potentially risky to get approvals for the technology and secure

finance, the long-term strategy is to expand to other provinces and target broader segments and larger commercial companies:

I think if we get more and try to get more clients and build a client base, we can definitely employ other people. We are doing public sector now, but we can expand to the commercial sector, the residential sector, and also the industrial sector (Academic entrepreneur, Innovus A).

The university's entrepreneurial culture

The academic entrepreneur explained that some professors at the university, especially in engineering, who had industrial backgrounds, have started several spin-off companies. Several of them had done this in association with masters and PhD students. The academic entrepreneur highlighted the entrepreneurial culture at Stellenbosch University and that the university has provided both technical and human resources:

I just need to ask them if I can use their labs, they've always said yes. And I needed to do a whole bunch of tests and I use the equipment (Academic entrepreneur, Innovus A).

The academic entrepreneur envisioned future aims that he would serve as a mentor for others who wanted to pursue the commercialization of research based on his own experience.

4.2.2 Delta, academic entrepreneur Innovus B

The idea developed during the academic entrepreneur's master's degree as the research group identified a gap within existing research regarding the Fourth Industrial Revolution. With encouragement and guidance from his mentors, a PhD student and a professor at Stellenbosch University, he continued developing the architecture through his PhD research, and as of today, he is the company's CEO. The team identified a knowledge gap during the technology development, saw a market opportunity, and believed the technology would solve several challenges. Innovus helped the ASO on securing rights for the technology. The first part of the research was done in the laboratory as the PhD project was both theoretical and applied:

I think our research group does not like to have things very theoretical. I cannot think of any post-grad that did something where it was not done in a lab or tested in a factory (Academic entrepreneur, Innovus B).

The primary motivation to commercialize the idea came from his own beliefs that he wanted to make something valuable for society:

I have a deep passion, for advancing technology as a species. I would want to see us live on multiple planets (...) It'll make the world so much better living, it'll make things efficient. From hospitals to manufacturing, to mining, and farming. And I think this concept will revolutionize us as species (Academic entrepreneur, Innovus B).

The research team and networks

In the initial period the ASO received considerable support from the university, both network resources and legitimacy. The academic entrepreneur's supervisor had many years of industry experience. The ASO benefitted from the supervisor's network resources in investigating the technology's feasibility within the South African business landscape. In the early stages, they collaborated with a company to further develop the technology. The network resources also helped the ASO get in contact with a pilot customer. Later, they did a case study in a real manufacturing environment. Being part of a prominent research institution enhanced the team's credibility among industry actors:

Stellenbosch is a very respected university in South Africa. So, the culture is not to ask a university to come and help them with a research topic or to extend their knowledge. They respect the university enough that they just wait for the student to come (Academic entrepreneur Innovus B).

Prior experience and acquired entrepreneurial capabilities

The academic entrepreneur described himself as a technical person, not an academic, and in addition, he had limited entrepreneurial experiences. His first real venture was when he designed a product to solve the drought problem. Through his work on an actual industry problem, he contacted a supplier and raised capital, and that proved to be a useful learning experience:

I didn't know anything about product-market fit and what the base distribution channels are. I just managed to get a supplier and designs going and funded capital. So that was a big learning experience (Academic entrepreneur, Innovus B).

Still, the academic entrepreneur emphasizes that he did not have much business or entrepreneurial experience:

I'm very new to this entrepreneur thing, I was an introvert programming engineer, making games and stuff, I didn't know how to communicate business (Academic entrepreneur, Innovus B).

Challenges to partner with the industry in early technology phases and pilot customer roles

The university has excellent legitimacy among industry actors, yet the academic entrepreneur stressed that there should be more collaborations between academia and industry. The academic entrepreneur highlighted that the main barrier between academia and the industry is the different mindsets. The industry struggles with how to communicate with academia:

They [industry] are really good at it (...) playing this fast get ahead game. I think that they view academics as these slow to do methodical for them to make use of (...) its two different mindsets (Academic entrepreneur, Innovus B).

In addition, one of the most significant barriers for the researcher is the translation of the technology into a value proposition for a customer:

One of the biggest challenges is trying to describe what we are doing (...) and show its value (...) we have a tool that solves so many problems-, we have to choose a specific implementation and apply it. (...) I am very new to this entrepreneur thing (...) So I do not know how to communicate business (Academic entrepreneur, Innovus B).

One of the things highlighted in the interview is that research-based projects lack long-term government support/funding and potential industry partners. The academic entrepreneur explained that many excellent solutions and ideas exist in South Africa – yet capabilities and resources to commercialize are lacking (Bate, 2021). Several bottlenecks are restraining economic growth in South Africa. One of them is the vast majority of large companies and bureaucratic corporations, which count for almost 90 percent. In addition, there are barriers related to funding. The academic entrepreneur explained that while there are problems to solve, insufficient funding exists to support them. For example, the University Technology Fund is government-sponsored, but the competition is high. The academic entrepreneur further explained that large companies cannot justify investing money to sponsor research projects that they cannot utilize. The combination of lack of funding and large bureaucratic organizations

impedes the level of innovation in South Africa, and the academic entrepreneur underlined this problem:

It's sort of a double-edged sword is that you need the big companies with the money to sponsor these kinds of research topics, but they're not the ones that implement the study [difficult to implement new technology in large bureaucratic companies] (Academic entrepreneur, Innovus B).

The university's entrepreneurial culture

The academic entrepreneur has experienced a change in the entrepreneurial culture at the university over the past five years, especially with the establishment of LaunchLab. The academic entrepreneur emphasized that the university is trying to encourage students to think commercially instead of just taking a degree and then getting a job at some of the large companies. The academic entrepreneur believes that the university is following an "MIT" inspiration, as MIT has a reputation for excellent commercial output. The university has for the last five years promoted startups and built awareness about how students (masters, PhDs and postdocs) can submit early-phase ideas. As a result, large European companies have sponsored several master's projects. The ASO has benefitted from using university facilities, e.g., human resources and technical support, in developing the technology. In addition, the academic entrepreneur highlighted the role of the LaunchLab programs in which both students and external parties can participate.

Future aims for Delta

The ASO aimed to recruit master's students from the research group. The benefit of this was to be able to onboard the students immediately after graduation as opposed to employing people from outside. The academic entrepreneur envisioned how the technology would benefit society in the future:

The venture in about 10 years from now. I don't want to sell this idea to somebody who's going to absorb it and then just go on an old stack. I want this to be the default (Academic entrepreneur, Innovus B).

5. Cross-case analysis and discussion

This section addresses the differences and similarities across the TTOs and ASOs

5.1 Relational-focused commercialization approach– adopted at VIS and Innovus

This study reveals that both TTOs had adopted a "cradle to grave" approach where the TTO executives follow the project through the entire process from the early idea phase to the exit/establishment of a company. For Innovus, this approach was implemented by the TTO's CEO in the tech transfer division, as she had a clear idea and vision of the benefits of this approach from early on. The rationale behind this practice is quite similar for both TTOs. For VIS, this practice emerged through learning over time and resulted from a continuous learning process in the organization. This approach recognizes that the innovation process develops as an interactive process where actors in the EE collaborate to match research and market demands. This study provides insights into how TTO executives utilize networks in both spheres, internally with the universities and externally with actors in the EE. The empirical findings support Taxt et al., (2022) study that through a relational approach, the TTO executives are developing a more varied role, which involves that the TTO executive during the commercialization process of ASOs must interact with a variety of actors in the EE.

Previous scholars on TTOs have traditionally focused on a transactional, linear practice that involves licensing and patenting. However, the empirical findings from this study suggest that for the TTOs, it was vital to create ASOs and contribute to regional growth. The mutual learning and co-creation of knowledge with other actors were essential prerequisites for accessing resources, specialized networks, and capabilities (Iversen & Nessler, 2020; Taxt et al., 2022). In addition, existing networks must be maintained, as established relationships provide easier access to necessary resources and expand the networks (Iversen & Nessler, 2020). Therefore, this relational practice supports the notion that this co-creating knowledge and commitment practice is vital in creating ASOs (Taxt et al., 2022).

This study adds to existing research by including contextual factors by comparing commercialization practices in two unique contexts.

It was essential for the academic entrepreneurs affiliated with SU who lacked capabilities to access and exploit social networks during ASOs establishment. This study shows that Innovus, through this relational approach, had relations with other actors that could provide necessary resources to the ASOs (Taxt et al., 2022). Technology transfer is influenced by context, as demonstrated in Spiegel & Harrison's (2017) process-based view of EE. In this process-based view, relations between EE actors affect how an EE will develop. Therefore, this study supports previous research that a relations-oriented practice may be advantageous over a more conventional transactional-focused approach during an ASOs' commercialization process.

Furthermore, the research shows that competence building within the organization was necessary. Typically, ASOs projects go through an extensive and complex process, from ideas to the creation of ASOs. A TTO executive responsible for a commercialization project should have knowledge about commercialization. In addition, the TTO executives develop the ASO through their networks and acquire human and social capital that academic entrepreneurs may be lacking (Iversen & Nessler, 2020). Obtaining the prerequisite skills, both Innovus and VIS emphasized building competence and had RTTPs professionals executives in the organization. This was highlighted because some researchers have commercial understanding, while others may lack this competence as some researchers are most interested in basic research. Both TTOs shared similarities in their translation views between the research communities and the industry. Furthermore, both TTOs emphasized communication internally with the university. It was essential to build trust within the research communities and maintain connections towards the researchers and students.

5.2 Academic entrepreneurs: professors and postdocs?

Innovus used various approaches to attract and create awareness of their various entrepreneurial programs among students. As Innovus was an internal division at Stellenbosch University, the TTO had the mandate to engage and interact directly with the university's students. Moreover, Innovus collaborated closely with LaunchLab and invested one-third of its time interacting with students (Pittaway and Cope, 2007; Hayter, 2016; Boh, et al., 2016). Summarizing the findings from the analysis, Innovus actively targeted masters and PhD students involved in research projects to engage in academic entrepreneurship. The aim was to help them translate their

technology/research. They started a *translational fellows program* to get PhDs reappointed as post-doctoral fellows for one year after graduation. The gaining was to raise investment and create a spin-off. They intended to guide them to become the company's CEOs. Finally, Innovus had a program aimed at more established researchers and interacted in informal sessions to spread awareness about their offerings, but their main target was young PhDs and postdocs.

This study reveals that Innovus had adopted a strategy to invest resources in targeting PhD students and postdocs. These findings support scholars understanding that PhD students and postdocs are typically younger and have spent less time developing their scientific identity, possibly making them more amenable to commercialization-focused entrepreneurial identity development (Hayter et al., 2021). Findings from this study further show that the motivation of academic entrepreneurs is vital for successful commercialization. The academic entrepreneurs affiliated with SU highlighted motivation and passion as personal drivers in accord with the findings of Boh et al., (2016). For example, the academic entrepreneurs at SU did not possess any significant previous business or entrepreneurial experience; they were confident enough to pursue academic entrepreneurship with proper university support. The empirical findings suggest that Innovus' aim in targeting PhD students and postdocs is related to having motivated academic entrepreneurs to establish ASOs.

Academic entrepreneurs who are professors often balance the role of researchers and entrepreneurs (hybrid entrepreneurs), implying role conflicts. Often preoccupied with obligatory duties such as teaching, professors often do not want to become CEOs or have little interest in the commercialization part.

VIS is not an internal division of the university (HVL) but acts on behalf of it. VIS had not recently been active in targeting the research communities about their services. The university has a division that communicates VISs offering to the research communities and wants to approach HVL researchers before directing them to VIS directly. Another resemblance was that both TTOs stressed that universities should adopt early awareness programs for students pursuing academic entrepreneurship. This should be applied early on, preferably beginning at the bachelor's level.

5.3 Academic entrepreneurs' capabilities and various relations with the university

This study provides insights into how academic entrepreneurs use their capabilities and networks and/or exploit the reputational networks provided by their university. Developing research-based technology and acquiring the necessary resources for the ASOs require various capabilities, e.g., human and social capital (Buskirk, 2017). These resources include funding, approaching pilot customers, industry collaborators, and various stakeholders crucial to avoid liability of newness. However, acquiring the vital resources for developing the technology can be challenging for the academic entrepreneur. Academic entrepreneurs may lack the requisite skills, social networks, business expertise, and limited networks outside the academic sphere (Siegel & Wright, 2015; Mathisen & Rasmussen, 2019; Urban & Chantson, 2017). Academic entrepreneurial intent may be influenced by university characteristics, entrepreneurial orientations, and various support mechanisms (Hossinger et al., 2019). Furthermore, according to Hossinger et al., (2019), this study supports a favorable university entrepreneurial environment that can encourage academics to engage in entrepreneurial activities such as ASO creation.

The academic entrepreneurs affiliated with Stellenbosch University had various relations with the university regarding their engagement in commercial activities. Because they were young, they did not have an extensive industry or entrepreneurial background. Initially, they profited from friends and family social networks (Hite & Hesterly, 2001; Davidson & Honig, 2003). The university served as a door opener for the two academic entrepreneurs in contact with industry and market actors relevant to the ASO project (reputational networks). It was common to take advantage of the relations with professors they had worked with as students. These professors had both industry and prior entrepreneurial experience and had high reputations as researchers. The fact that universities and researchers can act as reputational networks in markets for ASOs is demonstrated in previous research (e.g., Bramswell et al., 2012; Pettersen & Tobiassen 2012; Avnimelech & Feldman 2015 and Hossinger et al., 2019). This study suggests that these reputational networks could also explain why the AEs, at a later stage, as the ASO grew, proactively sought new network resources (Hite & Hesterly, 2001).

The Norwegian academic entrepreneurs benefitted quite similarly from already established network resources from previous work and educational background during the technology development (calculative networks Hite & Hesterly, 2001). Alpha, having extensive industry experience and acquiring necessary resources through weak ties to other professionals, e.g., industry actors, proved valuable in developing the technology (Hite & Hesterly, 2001; Mosey & Wright, 2007; Davidson & Honic, 2003). Both academic entrepreneurs, especially Beta, benefitted from the networks provided by the TTO. The Norwegian ASOs affiliated with HVL did not experience a strong entrepreneurship culture at their university or any incentive efforts to encourage researchers to commercialize their research inventions. The lack of entrepreneurial focus and practical issues had impeded the development of the ASOs. (Hossinger et al., 2019; Mathisen & Rasmussen, 2019). However, HVL has just recently been developing as a research institution. The academic entrepreneurs at SU had extensive contact with their previous research groups and had access to using infrastructure and labs to develop the technology further. These connections proved valuable. In addition, all four ASOs highlighted that access to human resources at the university was important. The affiliation with the university provided Alpha and Beta with labs and access to research students who contributed with technical expertise. Research students (PhD and postdocs) were part of the university's research group (Hayter, 2016).

5.4 Building and maintaining the entrepreneurial ecosystem

Both TTOs emphasized that building networks with external actors in the entrepreneurial ecosystems were crucial in developing and commercializing ASOs. For both. VIS emphasized building industry networks for early-stage technology projects through FORNY applications. Most ASOs needed industry partners to develop and test real-scale prototypes and function as pilot customers. Establishing companies and creating jobs was important for both TTOs, yet the underlying motivation differed slightly. Creating jobs and new industries in Norway was primarily part of the drive and transition toward the green shift. Besides, in the Bergen region, the entrepreneurial ecosystem has already many actors interacting, e.g., the industry clusters (GCE Ocean technologies, NCE Maritime CleanTech, NOSCA, Ocean Hyway Cluster) established incubators and Connect Vest, an organization responsible for connecting early-stage entrepreneurs and informal investors/business angles. Hence, VIS does not need to take a similar role in building the ecosystem as Innovus did but must interact with already established actors in the existing industry clusters and ecosystem (Spiegel & Harrison, 2017).

For Innovus, as part of the context, and with high unemployment rates, it was essential to create startups and, in the long term, more SMEs to add value to the region by creating job opportunities and contributing to economic growth, as explained in Bate (2021). Large firms highly dominate the businesses of South Africa, and SMEs are essential for innovation and the creation of new businesses. Therefore, Innovus focused more on establishing companies, and ASOs rather than licensing research-based ideas, among other factors to contribute to job creation and solving social problems. Innovus especially emphasized building what the key informant called a knowledge region. By this concept, the key informant envisioned building a knowledge region (critical mass of ASOs in the region) that could attract academic entrepreneurs, VCs and business angels, and multinationals to the region. Debackere and Veuglers (2005) also explain the concept of knowledge regions. This study suggests that resource creation and recycling are essential mechanisms for strengthening an EE. When successful ASOs exit EE, resources are recycled and can be used by academic entrepreneurs (Spiegel & Harrison, 2017).

This study also has practical implications. First, a relational approach to commercialization where the TEs work with various actors in EE through the ASOs lifetime can be advantageous in providing value to the ASOs. This study shows that the TTOs provide social networks to ASOs who may lack the necessary capabilities. Second, research institutions should better facilitate career paths for PhD students and postdocs who want to commercialize their inventions. Last, research institutions should feel the responsibility to support AEs, and adopt a culture that stimulates entrepreneurial activities. The research shows that universities providing legitimacy, networks and credibility to ASOs are more inclined to produce spin-offs (Hossinger et al., 2019).

6. Limitations and future research

One of the limitations of this study is that it considers only two cases/regions; the external validity is limited, thus limiting its generalizability to a broader population of ASO projects. In addition, it only focuses on one university in each country, thus not generalizable to other universities in the same context/region. However, the aim was to understand better the capabilities and networks of academic entrepreneurs in a less-studied context. Therefore, the objective was not to generalize but to compare different contexts.

Future research may pay more importance to generalizability, e.g., a quantitative study on PhD and postdoc entrepreneurship. In addition, a future study could include other actors in ASOs, like industry collaborators, investors and professors. More, conducting a comparative study examining other universities in Western Cape and other fields and industries like medicine and life science. Last, a longitudinal study emphasizing life science ASOs projects at Innovus and VIS could be valuable to compare contextual factors.

References

- Bate, F.A. (2021). A comparative analysis on the entrepreneurial ecosystem of BRICS club countries: practical emphasis on South Africa *SN Business & Economics* 1(10)
DOI: 10.1007/s43546-021-00120-2
- Boh, W.F., De-Haan, U. & Strom, R. University technology transfer through entrepreneurship: faculty and students in spinoffs. *J Technol Transf* 41, 661–669 (2016). <https://doi.org/10.1007/s10961-015-9399-6>.
- Becker, G.S. (1964). *Human capital: A theoretical and empirical analysis, with special reference to education* Chicago: University of Chicago Press.
- Buskirk, S. C. (2017). Social Networks: Mechanisms for Building Academic Entrepreneurs' Social Capital. *Journal of Entrepreneurship and Management*, 6(3), 1–16.
- Bramwell A., Wolfe D, & Hepburn N. (2012). *Growing Innovation Ecosystems: University-Industry Knowledge Transfer and Regional Economic Development in Canada*. Program on Globalization and Regional Innovation Systems. University of Toronto. Available <https://hdl.handle.net/1807/80099>.
- Dabackere, K. & Veugulers, R. (2005). The role of academic technology transfer organizations in improving industry science links 34(3), 321-342.
- Davidsson, P. & Honig, B. (2003). The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing*, 18(3), 301-331.
[https://doi.org/10.1016/S0883-9026\(02\)00097-6](https://doi.org/10.1016/S0883-9026(02)00097-6)
- Campell S. (2015). *Conducting Qualitative Research* (ascls.org) Retrieved 17.12.2021
- Cao Z. & Shi X., (2020). A systematic literature review of entrepreneurial ecosystems in advanced and emerging economies. *Small Business Economics* 57, 75-110 (2021).
- Cleyn, S, Braet, J & Klofsten, M. (2011). How do human and social capital contribute to the early development of academic spin-off ventures? *Frontiers of entrepreneurship research* 31 (17)
- Croce, A., Martí, J. & Murtinu, S. (2013). The Impact of Venture Capital on the Productivity Growth of European Entrepreneurial Firms: 'Screening' or 'Value Added' Effect?. *Journal of Business Venturing*. 28. 489–510. 10.1016/j.jbusvent.2012.06.001.
- Easterby-Smith, M., Thorpe, R., Jackson, P. R., & Jaspersen, L. J. (2018). *Management & Business Research* (6th ed.). SAGE Publications.

- Gómez Gras JM, Galiana Lapera D R, Solves IM, Verdú Jover AJ & Azuar JS (2008) An empirical approach to the organisational determinants of spin-off creation in European universities. *Int Entrep Manag J* 4(2):187–198
- Greve A. Salaff J, W. (2003). *Social Networks and Entrepreneurship*. SAGE journal <https://doi.org/10.1111/1540-8520.00029>
- Grimaldi, R., Kenney, M., Siegel D.S. & Wright, M. (2011). 30 years after Bayh–Dole: Reassessing academic entrepreneurship, *Research Policy*, 40(8),1045-1057.
- Hansen, E.L. (1995). Entrepreneurial network and new organization growth. *Entrepreneurship: Theory & Practice*, 19(4), 7–19.
- Hayter, C.S. (2011). In search of the profit-maximizing actor: motivations and definitions of success from nascent academic entrepreneurs. *J Technology Transfer* 36(3):340–352
- Hayter, C.S., Lubynsky, R. & Maroulis, S. (2016). Who is the academic entrepreneur? The role of graduate students in the development of university spinoffs. *J Technol Transf* 42, 1237–1254. <https://doi.org/10.1007/s10961-016-9470-y>
- Hayter, C.S., Fischer, B. & Rasmussen, E. (2021) Becoming an academic entrepreneur: how scientists develop an entrepreneurial identity. *Small Bus Econ*. <https://doi.org/10.1007/s11187-021-00585-3>
- Hayter. C.S., Nelson J.A, Zayed S. & O`Connor A.C. (2018). Conceptualizing academic entrepreneurship ecosystems: a review, analysis and extension of the literature. *The Journal of Technology Transfer* 42(6284) <https://link.springer.com/article/10.1007/s10961-018-9657-5>
- Hite, J.M. & Hesterly, W.S. (2001). The evolution of firm networks: from emergence to early growth of the firm. *Strat. Mgmt. J.*, 22: 275-286. <https://doi.org/10.1002/smj.156>
- Hossinger, S.M., Chen, X. & Werner, A. (2020). Drivers, barriers and success factors of academic spin-offs: a systematic literature review, *Managment Review*,70, 97–134 [online]. Available at: doi.org/10.1007/s11301-019-00161-w
- Innovus (2022) Retrieved from Making Stellenbosch University Innovation Matter (innovus.co.za)
- Iversen, K.P & Nessler, K.Z. (2020) TTO innovasjonslederes bidrag i akademiske spin-off prosjekter og team.[Masteroppgave]. Høgskolen på Vestlandet.
- Jacobsen, D. I. (2015). *Hvordan gjennomføre undersøkelser?: innføring i samfunnsvitenskapelig metode*, Oslo, Cappelen Damm akademisk.
- Knockaert M, Clarysse B. & Wright M (2010) The extent and nature of heterogeneity of venture capital selection behaviour in new technology-based firms. *R&D Manag* 40(4):357–371

- Mathisen T. M. & Rasmussen E. (2019). The development, growth, and performance of university spin-offs: a critical review. *The Journal of Technology Transfer* 44(6) <https://link.springer.com/article/10.1007/s10961-018-09714-9>
- Melaas, A. & Zhang, F. (2016). *National Innovation Systems in the United States and China*. The Center for International Environment and Resource Policy, 36
- Mosey, S. & Wright, M. (2007). From Human Capital to Social Capital: A Longitudinal Study of Technology-Based Academic Entrepreneurs. *Entrepreneurship Theory and Practice*, 31(6), 909-935. <https://doi.org/10.1111/j.1540-6520.2007.00203.x>
- O'Shea, R. P., Allen, T. J., Chevalier, A. & Roche, F. (2005). Entrepreneurial orientation, technology transfer and spinoff performance of US universities. *Research Policy*, 34, 994-1009.
- Pettersen, I.B. & Tobiassen, A, E Are born globals really born globals? The case of academic spin-offs with long development periods. (2012). *Journal of international entrepreneurship* 10 (2), 117-141. Available <http://dx.doi.org/10.1007/s10843-012-0086-5>.
- 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, & Sobrerof., 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. & Hughes, A. (2021). Academic engagement: A review of the literature 2011-2019, *Research Policy*, 50(1) [online]. Available at: doi.org/10.1016/j.respol.2020.104114.
- Pittz, T. G. & Hertz, G. (2018). A relational perspective on entrepreneurial ecosystems: the role and sustenance of the entrepreneurship center, *Journal of Enterprising Communities: People and Places in the Global Economy*, 12(2), 220-231.
- Pirnay, F., Surlumont, B., Nlemvo, F., 2003. Toward a typology of university spin-offs. *Small Business Economics* 21, 355–369.
- Pittaway, L. & Cope, J. (2007) 'Entrepreneurship Education: A Systematic Review of the Evidence', *International Small Business Journal*, 25(5), pp. 479–510. doi: 10.1177/0266242607080656.
- 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. [10.1016/j.respol.2013.06.007](https://doi.org/10.1016/j.respol.2013.06.007).

- Rasmussen E (2006). Spin-off venture creation in a university context-An entrepreneurial process view. Spin-off venture creation in a university context-An entrepreneurial process view (researchgate.net) Retrieved 20.12.2021
- Reynolds, P. D., Bygrave, W. D., Autio, E., Cox, L. W. & Hay, M. (2002). Global entrepreneurship monitor executive report 2002, Kauffman Center for Entrepreneurial Leadership. Kansas City, MO: Ewing Marion Kauffman Foundation
- Ray, J. (2013). Academic Entrepreneurship. SpringerLink Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship. Retrieved 21.12.2021
- Rosenberg M. (2018). BRIC/BRICS Defined. ThoughtCo. The Definition of BRIC and BRICS (thoughtco.com) Retrieved 17.12.2021
- Siegel, D. S., Veuguliers, R. & Wright, M. (2007). Technology transfer offices and commercialization of university intellectual property: performance and policy implications. *Oxford Review of Economic Policy*, 23, 640-660.
- Spiegel, B. & Harrison, R. (2018). Toward a process theory of entrepreneurial ecosystems. *Strategic Entrepreneurship Journal* Available <https://doi.org/10.1002/SEJ.1268>
- Shwetter, C., Maritz, A. & Nguyen, Q. (2019). Entrepreneurial ecosystems: A holistic and dynamic approach, *Journal of Industry-University Collaboration*, 1 (2), 79-95.
- Stam E (2015). Entrepreneurial ecosystems and regional policy: A sympathetic Critique. *European Planning Studies* 12(9) DOI: 10.1080/09654313.2015.1061484
- Taxt, R. E, Høvig, Ø.R, Pettersen, I.B. (2022) The relational dynamics in the extended teams of academic spin-offs: a Norwegian case-study. Accepted for publications
- Yin, R. K. (2018). Case study research and applications: design and methods (6th ed.). SAGE Publications.
- Wright, M., Hmieleski K.M., Siegel S. D. & Ensley D.M. (2007). The role of human capital in technological entrepreneurship, *Entrepreneurship: Theory and Practice* 31(6), 791-806 Available at: <https://doi.org/10.1111%2Fj.1540-6520.2007.00202.x>
- Urban,B. & Chantson J. (2017). Academic entrepreneurship in South Africa: testing for entrepreneurial intentions *The Journal of Technology Transfer* 44, 948-980 DOI 10.1007/s10961-017-9639-z
- University of Stellenbosch Discover Stellenbosch University (sun.ac.za) Retrieved 19.12.21
- VIS. (2022). Om oss. Hentet fra <https://www.visinnovasjon.no/om-oss/>
- Weerawardena, J & Sullivan M, G. (2006). Investigating Social Entrepreneurship: A Multidimensional Model. *Journal of World Business*. 41. 21-35. 10.1016/j.jwb.2005.09.001

Zhou Y, Xu G, Su J, Minshall T (2011) Barriers to entrepreneurial growth: an empirical study on university spin-offs in China. *J Sci Technol Policy China* 2(3):277–294

Appendix

Appendix 1: Interview guide academic entrepreneurs

Research Topics:

- 1) *Entrepreneurship culture/incentives at universities*
- 2) *Academic entrepreneurs' capabilities and networks relevant to the commercialization of academic spin-off/technological projects*
- 3) *How has the TTO contributed to the development of the project (competence, network)*
- 4) *Cooperation with industry partners and research environment to develop the project*

1) General information

- General information about the purpose of the project and the topics to be discussed
- Information about audio recording and transcription
- Information about confidentiality and anonymity
- Does the respondent have any questions before the start of the interview?

2) Introduction

- What is your scientific field?
- What is your prior research and work experience(s)?
- How long have you been working at this university?
- Do you have any previous industry and/or entrepreneurial experience with spin-offs?

3) Background: Idea/technology (academic spin-off)

- Can you describe the project/technology-from early idea to technology testing?
- Who is part of your research team? (PhD, Post.doc) - different roles?
- What is the main driver behind the idea to commercialize the technology?
 - Motivation? (Develop superior technologies useful to the industry/society)
 - To develop new technology to enhance -sustainability/enable the green shift?
- What is your short and long-term ambition with the spin-off project?
 - Do you plan on creating a company?
- Have there been any significant changes/new developments in the project/technology through the project period?
- How do you balance between the entrepreneurial role and the researcher role? (Researcher identity-entrepreneurial identity)

4) Capabilities – academic entrepreneur and the team involved (research knowledge, industry, and market knowledge)

- What type of research/engineering knowledge is this project built on?
 - Interdisciplinary natural science and engineering competence?
 - Commercialization competence: knowledge of markets/industry, market segments, customer knowledge-industry needs e.g., pilot customers
 - Does the project suffer from specific resource shortages, e.g., lack of competence, lack of networks, lack of pilot customers, and so on?
- Do you rely on networks and knowledge present at the region/national level, and/or internationally? (Beyond the team, TTO)
 - What type of actors? (Industry experts, technology suppliers, (pilot) customers, research institutes/Universities)
 - Are you engaged in technology collaboration, open innovation with other firms/organizations)?

5) Networks

- What types of networks do you consider important in the early stage of the project?
 - What kind of actors (industry, researchers, experts, other firms, etc.)?
- What do these networks provide of essential resources: technology knowledge, market knowledge, internationalization, and other?
- Did you possess these networks from your earlier career? Or did you proactively seek them during the project period?
- How is the communication with potential collaborators from the industry?
 - Have there been any challenges?

6) University entrepreneurial culture/incentives

- How does the university contribute to the development of the project?
- How would you characterize the entrepreneurial culture at the university?
 - How does the department /university support your commercialization project? (Test facilities, use of labs, human resources, research projects-PhDs)
 - Are there any incentives for this kind of project? If so, which?
 - What are the main barriers for academics to engage in such a project at your university? (e.g., publish or perish)
- How has the entrepreneurial culture at the university changed since you started working there?

7) TTO as a facilitator

- When was the first contact with your TTO? At what stage in the project?

- How has your TTO contributed to the project? Give examples of areas, tasks? (Patenting, applications, funding, networks, and other resources, competencies)
- How has the contact and involvement with your TTO evolved during the project period? (From idea to development phase)
- Are you satisfied with the competence your TTO has provided for your project?

8) Extra:

Is there anything else you would like to add that we have not covered in this interview

Appendix 2 Interview guide TTO executive

1) General information

- General information about the purpose of the project and the topics to be discussed
- Information about audio recording and transcription
- Information about confidentiality and anonymity
- Does the respondent have any questions before the start of the interview?

2) TTO function

- How is the TTO organized? (Ownership, purpose, how it is financed)
- Can you talk about the general spin-off process?
 - What are the selection criteria for projects in the TTO?
 - What are the most important milestones in the early development phases?
 - How do you allocate funding for the project? (Internal/external, NRF, Others)

3) Academic entrepreneurs and capabilities

- What competencies do the researchers provide in the projects? (research/technology, technical prototyping/testing, commercial and market knowledge)
- What are the most important factors for the successful development of spin-offs? (Development phase)
- What are the main barriers? What are the main resource and knowledge shortages? (Lack of capabilities)
- What competencies do TTO provide in these projects? (Commercialization, market knowledge, patents)

4) Networks to industry partners and collaboration

- How did you get in contact with the industry partners collaborating in this project? What networks were used? (Researchers, TTOs?)
- Why was this specific industry firm chosen for the project?
- What criteria are set by the industry partner? Do they have any requirements? (Time deadlines, proofs-of-concept, development criteria)
- What do you see as being the main challenge regarding collaborations between researchers (academia) and industry? (Time issues, understanding of technology, patents, market)
 - Research VS commercialization
- How to maintain contact with industry actors over time

Are you interested in taking part in the research project

Academic entrepreneurs' capabilities and networks when commercializing research-based green technologies?

This is an inquiry about participation in a research project where the main purpose is to investigate academic entrepreneurs' capabilities and networks when commercializing research-based green technologies. In this letter, I will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

The purpose of this master's thesis is to explore the capabilities and networks of academic entrepreneurs and how these are being used during the commercialization process of the spin-off project. The study aims to look at the entrepreneurial culture at the university and entrepreneurial ecosystem, and how these contribute to the process, including industry collaborators. The project is part of my master's thesis in innovation and entrepreneurship.

Who is responsible for the research project?

Western Norway University of Applied Sciences is the institution responsible for the project.

Why are you being asked to participate?

The selection for the data collection is based on informants who are connected to early-stage spin-off projects such as academic entrepreneurs/researchers, TTO executives responsible for the project, and industry collaborators.

What does participation involve for you?

If you choose to participate in the projects, it means that you participate in an interview that will take approx. 1,5 hours of your time. If you allow this, audio recordings and notes from the interview will be taken. Then the audio recording will be transcribed. This transcript can, if desired, be sent to you afterward so that you can have the opportunity to read through it for approval.

Participation is voluntary

Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made

anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

I will only use your personal data for the purpose(s) specified in this information letter. I will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

At Western Norway University of Applied Sciences, me, and supervisor Inger Beate Pettersen will have access to the information.

In accordance with the guidelines at Western Norway University of Applied Sciences, the data material will be securely stored on my private PCs, and we will ensure that no unauthorized persons have access to the information.

What will happen to your personal data at the end of the research project?

The information is anonymized when the project is completed / the assignment is approved, which according to the plan is June 2022. At the end of the project, audio recordings will be deleted.

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and

send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent.

Based on an agreement with Western Norway University of Applied Sciences, Data Protection Services has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?

If you have questions about the project or want to exercise your rights, contact:

- Professor Inger Beate Pettersen, Western Norway University of Applied Sciences, supervisor/Project coordinator, e-mail: Inger.Beate.Pettersen@hvl.no
- Christer Lerøen Sørensen, student, 141323@stud.hvl.no Tlf.: 941 99 90
- Our Data Protection Officer at Western Norway University of Applied Sciences: Trine Anikken Larsen, Trine.Anikken.Larsen@hvl.no
- Data Protection Services, by email: personvertjenester@nsd.no or by telephone: +47 53 21 15 00.

Best regards,

Project Leader

Student

Consent form

I have received and understood information about the project *Academic entrepreneurs' capabilities and networks when commercializing research-based green technologies?* and have been given the opportunity to ask questions. I give consent:

- To participate in an interview
- That audio recording of the interview is made

I give consent for my personal data to be processed until the end date of the project,

