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Ein Transformationsinstrument für den Übergang zu einer unternehmerischen Universität

Fallstudie: Die Rolle der TU Wien in einem wachsenden technologieorientierten Spin-off-Umfeld

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Alexandra Negoescu   Christian Huemer

A transformational tool to guide the transition towards an entrepreneurial university

Case Study: The role of TU Wien in a growing tech-oriented spin-off environment

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Kurzfassung

Außerhalb der Kernaufgaben Bildung und Forschung wird heute von Universitäten erwartet, dass sie zum lokalen Wirtschaftswachstum beitragen, indem sie das lokale unternehmerische Ökosystem gestalten und beim Aufbau unterstützen [Sci21]. Die Studie erforscht die komplexe Dynamik akademischer unternehmerischer Ökosysteme und untersucht ihre Komponenten, Interaktionen und zugrunde liegenden Mechanismen. Die Studie zielt darauf ab, durch die Untersuchung von Modellen und Faktoren, die zu ihrer Effizienz beitragen, verwertbare Erkenntnisse über den effektiven Aufbau und die Optimierung dieser Ökosysteme zu gewinnen. Die Universität kann sicherstellen, dass diese Anreize erfüllt werden, indem sie die Anreize versteht, die eine stärkere Spin-off-Aktivität auf Universitätsebene auslösen. Durch ein besseres Verständnis der Schwächen und Stärken des Ökosystems können neue Lösungen zur Förderung des unternehmerischen Verhaltens an Hochschulen entwickelt werden. Ziel ist es, durch ein neu entwickeltes Rahmenwerk zur Förderung wissenschaftlich-unternehmerischer Aktivitäten strategische Leitlinien und Schlüsselprinzipien für die Kultivierung eines wirkungsvollen akademischen unternehmerischen Umfelds anzubieten. Die TU Wien, bekannt für ihre exzellente Forschung und ihr Motto "Technology for People", benötigt einen Rahmen, der die entscheidenden Komponenten und Überlegungen für den Aufbau eines effektiven akademischen unternehmerischen Ökosystems zusammenfasst. Daher wird der Rahmen an der TU Wien getestet, um seine Eignung für den Transformationsprozess zu beurteilen. Der vorgeschlagene Rahmen kombiniert Konzepte aus wichtigen Theorien. Während die Umwelttheorie die Interaktionen zwischen den Subsystemen betont, ergänzt die Einbettungstheorie diese, indem sie die Auswirkungen des Ökosystems auf die Gründung neuer Unternehmen in die Diskussion einbringt. Die ressourcenbasierte Sichtweise (RBV) unterstreicht die Bedeutung der verschiedenen Ressourcen, über die Universitäten verfügen, von finanziellen Ressourcen über technologische Fähigkeiten bis hin zu Humankapital und organisatorischem Vermögen, während sich die kompetenzbasierte Sichtweise (CBV) auf die Förderung der unternehmerischen Fähigkeiten von Einzelpersonen konzentriert und sicherstellt, dass die künftigen Sciencepreneure eine Reihe persönlicher Fähigkeiten entwickeln, um Deep-Tech-Innovationen effektiv durchzuführen. Es zielt darauf ab, die Beschränkungen bestehender Rahmenwerke zu überwinden und die vielschichtige Natur des universitären Unternehmertums zu berücksichtigen. Der Rahmen soll als umfassender Leitfaden dienen, der die wichtigsten Aspekte aus der Literatur umfasst, um einen ganzheitlichen Ansatz für die Gestaltung und Förderung dieser Ökosysteme für Erfolg zu ermöglichen.

Abstract

Outside the core missions of education and academic research, universities are today expected to contribute to local economic growth by shaping and assisting with building the local entrepreneurial ecosystem \cite{AcademicEntrepreneurship}.

The study explores the complex dynamics of academic entrepreneurial ecosystems, examining their components, interactions, and underlying mechanisms. This study seeks to uncover actionable insights on effectively constructing and optimizing these ecosystems by investigating models and factors contributing to their efficiency. The university can ensure these incentives are met by understanding the incentives that trigger a stronger spin-off activity at the university level. New solutions for fostering entrepreneurial behavior at higher education institutions can be further developed due to a better understanding of the ecosystem's weaknesses and strengths. The goal is to offer strategic guidance and key principles for cultivating a vibrant and impactful academic entrepreneurial environment through a newly developed framework for facilitating sciencepreneurial activity.

With a reputation for research excellence and the motto \say{Technology for People}, TU Wien requires a framework that encapsulates its crucial components and considerations for constructing effective academic entrepreneurial ecosystems. Therefore, the framework will be tested on the TU Wien sciencepreneurial environment to assess its suitability in its transformational process. The framework proposed combines concepts from major theories. While the environment theory emphasizes the interactions between subsystems, embeddedness theory complements it by bringing into the discussion the effect of the ecosystem on new venture creation. The Resource-Based View (RBV) underscores the importance of various resources possessed by universities, from financial resources to technological capabilities, human capital, and organizational assets, while the competency-based view (CBV) concentrates on nurturing the entrepreneurial capabilities of individuals and making sure the future sciencepreneurs will develop an array of personal skills for effectively running deep-tech innovations. It aims to overcome the limitations of existing frameworks and consider the multifaceted nature of university entrepreneurship. The framework should serve as a comprehensive guide, encompassing key facets from the literature to facilitate a holistic approach to designing and nurturing these ecosystems for optimal success.

Contents

CHAPTER 1

Introduction

"In the intermingling of science and technology, scientific entrepreneurship is being brought to a high temperature. Educators, scientists, artists, writers, innovators and entrepreneurs are the athletes of social progress fuelled by sustainable and environmentally friendly economic development in the current period of revolutionary change. They all aim to strengthen the four pillars of sustainability."[For23]

The UN's Agenda 2030, aiming for a just and sustainable future, tackles significant global challenges like climate change, poverty, and educational disparities. Overcoming these challenges involves creating sustainable practices aligned with the Earth's resources. The synergy between science and scientific entrepreneurship has the capacity to foster innovation and positive change. Entrepreneurial scientists and scientific entrepreneurs play an important role in envisioning novel methods, products, and services, influencing our lifestyles positively[For23].

The interpretation of words is subjective and unique to each reader. Exploring the human facets of 'Science' and 'Entrepreneurship,' Piero's[For23] imaginative perspective prompts reflection on the two words: "scientist" and "entrepreneur", highlighting their creative and practical contributions and the convergence of these significant realms. Definitions of entrepreneurship differ considerably from scholar to scholar. There are, however, some generalities among academics in defining the nature of entrepreneurship. They agree that entrepreneurship is an activity that requires an innovative blending of various resources to create state-of-the-art goods/services/processes or creative ways of organizing markets or even raw materials[Abr13]. Most commonly, the definition of entrepreneurship focuses on the activity of founding a new business, with Infoscipedia, the largest database of Information Science and Technology Terms and Definitions defining entrepreneurship as

> "*the capacity and willingness to develop, organize and manage a business venture along with any of its risks to make a profit*"[Inf22]

In today's technology-driven world, new technology-based companies are vital to the development of entrepreneurial ecosystems, high-tech clusters and their economic growth, job creation, and generating competitive advantage[Sch34][Gri90][Rob91][Aut97]. We are now living in an era where a start-up can be easily set up with a fraction of the costs needed in previous years, and the technological revolution has resulted in a significant reduction in the cost of product development. Studies worldwide consistently connect entrepreneurship, especially fast-growing ventures, with rapid job generation, increased GDP, and long-term improvements in productivity[Ise10]. In this context, the two most important generators of technology-based companies are corporate spin-offs and academic spin-offs[Oak95], with the latter being seen as a traditional source of new technology discovery[Jaf89]. With the extension of the traditional university's primary missions of education and research with a third one (academic entrepreneurship), universities need to adjust to the external expectations and social needs for bringing university inventions to society and, though encouraging the generation of spin-offs, take on a more active role in the regional and national economic growth[Etz01]. Considering the growing pressure to become the incubators for the national capacity[Gra15], universities are focusing on improving and complementing their entrepreneurial and innovation capacity. H. Etzkowitz considers that the definition of academic entrepreneurship should not be resumed to aspects related to the commercialization of research via spin-offs or patenting and licensing. He introduces a new concept of an entrepreneurial university characterized through "*the development of organizational mechanisms to move commercializable research across institutional borders and [. . .] the integration of academic and non-academic elements in a common framework*"[Etz03]. As a result, the term "*academic entrepreneur*"[Sha04] respectively "*sciencepreneur*"[Sha23] have been introduced to describe the university scientists engaging in research commercialization.

To better dive into the research topic, the term "spin-off" needs first to be defined. Even if the term "spin-off" is being used extensively and has infiltrated our daily vocabulary in Austria, there is no standard and clear definition of the term. Not even the European Commission has given such a definition, academic spin-offs being included under the umbrella of "*start-ups and SMEs*"[Com20] so far. The same approach can be seen at the US level, where universities refer to both staff- and student-founded companies as start-ups. The closest standardized definition of the term "spin-off" comes from the Cambridge Dictionary, which defines the term in the following two ways:

> "1. *to produce a useful and unexpected result in addition to the intended result*
>
> 2. *to form a separate company from part of an existing company*:"

To add even more to the confusion, British ecosystems prefer the term "spin-out" when discussing the topic of academic entrepreneurship [Lon23], and the Cambridge Dictionary similarly defines the term as:

"*a business company that has developed from another organization*"

The local definition of the terms is even more intriguing across various educational institutions. ETH Zurich defines a "Spin-off" Company as a legally independent entity that fulfills the following criteria[Zur23]:

- the company commercializes a technology, software, and/or know-how that has been developed at ETH Zurich in research, teaching, or other operations
- at least one of the founders is a (former) employee, alumnus/alumna, student (bachelor, master, doctorate), or professor of ETH Zurich.
- the business idea and the business plan are coherent and sustainable; the founder and the founding team demonstrate entrepreneurial thinking and action;
- as a rule, Switzerland will benefit as a business location if the company is successful; and
- the company has existed for a maximum of two years at the time of recognition (founding date according to the official entry in the commercial register).

The Slovak Center of Scientific and Technical Information defines a spin-off as a legally established business entity with the primary aim of leveraging and advancing the university's intellectual property into market-applicable products or services[CDF+22]

Unfortunately, TU Wien lacked at the moment the research was conducted its definition of the term "spin-off" or a strategy for research commercialization that could have been used as a starting point for the research.

While the initial absence of a formal definition of "spin-off" at TU Wien posed a challenge during the research, an insightful glimpse into the publicly available "Leistungsvereinbarung 2022-2024"[WBfB22] between TU Wien and the Federal Ministry of Education, Science and Research reveals the institution's ongoing commitment to cultivating an academic entrepreneurial ecosystem, emphasizing technology transfer, innovation, and the provision of essential resources and infrastructure.

Entrepreneurship ecosystems result from a blend of natural evolution and deliberate intervention empowered by intelligent, adaptive leadership for their development and sustainability. Their exploration underscores their intricacy and uniqueness, and Daniel Isenberg defines the mix of six key components as influential in shaping such ecosystems: culture, policies, finance, human capital, markets, and supportive structures[Ise11]. With the proper supportive framework, such ecosystems can be built faster and more efficiently and, with time, gradually achieve self-sustainability, as success tends to foster further success within them.

An example of a thriving ecosystem is how the UK government aims to position the country as a science and technology powerhouse by fostering robust collaborations between universities and high-tech spin-off companies[UDoST23]. Their recommended recipe for success is a blend of diverse and experienced academic founders generating intellectual property and being mentored by experienced entrepreneurs, anchor institutions, especially universities, that empower researchers to produce cutting-edge intellectual property in science and technology, fostering technical expertise and facilitating connections and collaborations among local ecosystem stakeholders, a range of service providers, from accelerators to professional service firms accompanying founders on their journey, accessible investment capital for all stages of development, a mix of major science and technology corporations ready to collaborate closely with spin-offs, a backlog of a talented workforce and the proper infrastructure capable of supporting not only the early stages but also the growing stages of the spin-offs, ideally near the mother institution to facilitate further exchanges[UDoST23]. UK universities have embraced the commercialization pillar, supplementing their traditional Intellectual Propriety licensing approach with various additional services for founders, from training to transnational funding to investments. As a result, UK university spin-off investment increased from £1.06 billion in 2014 to £5.3 billion in 2021, second only to the US, but consequently also put strains on their budgets, especially since they lack the philanthropic activities of alums that are already so ingrained in the US culture [UDoST23].

However, the path from a university-based invention (RBI) to industrial application and commercial exploitation is lengthy and usually incurs significant costs. According to Samidass, about 75% of the university research has yet to undergo significant Technology Readiness Level (TRL) improvements[Swa13]. Many efforts have been put into systematically approaching the risk and uncertainty linked to Research-Based Innovations (RBIs): Technology Transfer Offices (TTOs) have been set at universities around the globe, education for entrepreneurship and innovation has been widely embraced, and academic entrepreneurship has been nurtured. However, the outcomes fall short of expectations mostly because giving value to knowledge is very difficult and complex as it requires that the TTOs possess market knowledge and are capable of evaluating a technology's impact in the industry[BPU27]. The path to commercializing Research-Based Innovations (RBIs) is a multifaceted process that involves the dynamic interplay between individuals (like researchers), entities (such as universities and firms), and various institutional factors (including governmental policies, university-related regulations, market dynamics, and the regulatory framework)[BPU27]. Proof-of-Concept (PoC) programs are already endorsed in global public policies like the EU Horizon 2020 Framework, ERC Proof-of-Concept grants, and initiatives in various countries such as Italy (MISE PoC program) and Israel (TNUFA program) have expanded beyond mere financial support and combine financial resources, industry collaborations, expertise, and training initiatives. These programs aim to validate the technical and commercial viability of Research-Based Innovations (RBIs). By mitigating technological risks, enhancing appeal to industrial partners and investors, and reducing uncertainty related to RBIs, PoC programs facilitate the transformation of these innovations into successful industrial applications[BPU27].

Spin-offs also have different requirements, and a wide variety of support systems need to be provided throughout the path of bringing their first product to market. Traditionally, three stages of development characterize the path to market of a product[Mau]. The first two stages, “Problem-Solution fit”and “Problem-Market Fit”, focus on validated learning and defining a successful path to market. The “Problem-Solution Fit” focuses on whether our attention is placed on a problem worth solving (do the customer need it and would pay for it?). The outcome of this stage is defining how the Minimum Viable Product (MVP) should look before investing costly resources into the development. The “Product-Market Fit”stage assesses how well the product built operates in the market, as the marketplace is the final arbiter of success. Once the ideal path to market has been defined, the last stage is “Scaling”.

However, sciencepreneurship should not be seen only as means to transform research into products. It brings along the metacognition critical component, “*a growth-oriented perspective through which individuals promote flexibility, creativity, continuous innovation, and renewal... [and] can identify and exploit new opportunities...*”[rHS03][LKA17]. According to Bruce Bachenheimer, professor of management at the Entrepreneurship Lab at Pace University, the definition of entrepreneurship is more complex. It should continue beyond the creation of a new venture. According to him,

> "*at its core, [entrepreneurship] is a mindset – a way of thinking and acting. It is about* ***imagining new ways to solve problems and create value****. Fundamentally, entrepreneurship is about ... the ability to recognize [and] methodically analyze [an] opportunity and, ultimately, to capture [its] value.*"

Such a definition’s downfall lies in the difficulty of measuring and analyzing these activities. Although entrepreneurial, they cannot be compared to the easily quantifiable definition focusing on new business venture creation.

1.1 Problem Statement

If we take a look at world-renowned entrepreneurial ecosystems, their success is usually connected to the proximity to a strong university[Ier19]. An excellent illustration can be found in the role MIT played in developing a top-notch ecosystem. Their achievements have been attempted to be replicated globally by many. A survey conducted in 2015 by two MIT professors, Edward Roberts and Fiona Murray emphasised the strong impact the university has had in the ecosystem: over 30,000 active companies that employed over 4.6 million people and with revenues of 1.9 trillion dollars (comparable back then to the gross domestic product of the world’s tenth-largest economy) [Deg21]. However, even with multiple delegations an visits from decision and policy makers trying to understand why this specific ecosystem flourished more than others, its success could not be replicated.

Outside the core missions of education and academic research, universities are today expected to contribute to the local economic growth by shaping and assisting with building the local entrepreneurial ecosystem [Sci21]. Spigel provided a comprehensive definition, stating that an entrepreneurial ecosystem comprises social, political, economic, and cultural elements that facilitate the establishment and growth of innovative startups[Spi17b]. This ecosystem encourages aspiring entrepreneurs and stakeholders to embrace associated risks by endorsing ventures that involve higher risk profiles. Research conducted at ETH Zurich uncovered that spin-offs from ETH Zürich create more jobs, attract more funding, generate higher returns, and have higher survival rates than the average Swiss start-up [Sci22]. Being an emerging field and given that each ecosystem is unique, universities first need to understand the ecosystem in which they are operating and derive key indicators for measuring success. Moreover, the ongoing transition towards commercialization significantly impacts a pivotal figure within this context: the scientist. Although some scarce research do exist on how this affects their social-psychological profile, the actual impact on how the integration of research commercialization reshapes their career trajectories and professional persona in Austria has been barely tackled. Analyzing the cognitive aspects of technology transfer and academic involvement is crucial to gauge its profound influence on academia's culture.

With a reputation for research excellence[Umu22] and technical innovations[Sci10], TU Wien requires a framework to build and assess its academic spin-off performance. This framework could be the basis for further decisions on how best to foster the generation of new innovative ventures known as research-based spin-offs[Scu20]. Encouraging the generation of academic spin-offs will impact the university´s ability to strengthen its position as an innovation driver and attract both funding and new talent to the ecosystem[Scu20]. However, the scarcity of literature on this topic is particularly striking when considering the unique challenges of university ecosystems in fostering entrepreneurship. While a couple of influential models have already emerged to describe entrepreneurial ecosystems, they often overlook to consider the specific needs of university settings. Instead they focus on the more extensive complex ecosystem, where the university is just one of the many facilitators within this environment. This holistic approach tends to prioritize economic factors, neglecting the social and environmental dimensions, aspects that a university with the motto "Technology for people" cannot simply overlook. Moreover, these models often consider in their analysis only individual components and factors in isolation, refraining from considering interrelations between these critical components. At the opposite end, the European Commission has a different approach. It provides a set of questions that could be used as a starting point for discussions withing the rectorate, but it lacks the structured and systematic approach that a framework can offer[HEI23].

The sole conceptual framework of university entrepreneurship identified positions Technology Transfer Offices (TTOs) as central agents of entrepreneurial activity[TAJ17]. As intermediaries, they alone are responsible for the encouragement, support, and success of entrepreneurial endeavors at the university level. However, given its unique organizational structure, this perspective would not be suitable for a university such as TU Wien. Notably, this framework overlooks critical elements such as leadership and internal governance structures, the role universities play nowadays in the technical due diligence process and the infrastructure encompassing funding, facilities, and support systems.

Moreover, the framework also focuses exclusively on incentives for key individuals from the TTO as mediators of the entrepreneurial process. It thus fails to capture the broader ecosystem dynamics and institutional mechanisms crucial for fostering entrepreneurship within the university setting. Furthermore, in terms of external forces, the framework only considers governmental policies, neglecting the intricate web of factors that impact the university ecosystem from external sources. This includes the roles of organizations dedicated to fostering entrepreneurial endeavors, prevailing global trends, societal challenges, the ramifications of globalization, and the proximity to high-tech firms, among others.

Therefore, there is a compelling need to develop a more comprehensive conceptual framework to overcome the limitations of existing frameworks and consider the multifaceted nature of university entrepreneurship that is more in line with the specific needs of the TU Wien ecosystem and its structures. The primary objective of this thesis is to develop a comprehensive conceptual framework for university entrepreneurship. This framework will be built upon existing literature on entrepreneurial ecosystems and a deep understanding of the TU Wien ecosystem, derived from semi-structured interviews with academic spin-off founders. The aim is to identify and define key performance indicators that could effectively encourage the generation of high-quality academic spin-offs.

1.2 Aim of the Work

On one side, the study aims to delve into the intricate dynamics of academic entrepreneurial ecosystems, examining their components, interactions, and underlying mechanisms. This study seeks to uncover actionable insights on constructing and optimizing these ecosystems effectively by rigorously investigating models and factors contributing to their efficiency. By understanding the incentives that trigger a stronger spin-off activity at the university level and how the university can ensure these incentives are met, solutions for fostering entrepreneurial behavior at Austrian higher education institutions can be further developed. The goal is to offer strategic guidance and key principles for cultivating a vibrant and impactful academic entrepreneurial environment through a newly developed framework for facilitating sciencepreneurial activity.

Expanding upon this objective, the study seeks to comprehensively explore the current state of the TU Wien entrepreneurial ecosystem by conducting a series of interviews. The primary focus is to gain insight into how this ecosystem influences and contributes to the creation and growth of academic spin-offs that originate from research findings.

1.3 Research Methods

1.3.1 Methodology of Research and Research Questions

To remove bias and ensure reproducible results, a systematic literature review was planned and conducted. According to the University of Oxford, a systematic literature review is a "*high-level overview of primary research on a particular research question that tries to identify, select, synthesize and appraise all high-quality research evidence relevant to that question in order to answer it*"[oO23]. For this purpose, seven steps[Uni22] have been followed:

1. **Identify and formulate the research question(s) and the scope of research**
   After preliminary readings on the challenges of building STEM entrepreneurial ecosystems at the university level, the following research questions have been identified:

   RQ 1: What is an appropriate way to drive, manage, and evaluate institutional transformation for creating university-based STEM entrepreneurial ecosystems?

   Sub-questions: What would be fitting factors that influence the adoption of entrepreneurial activities among researchers? How could be this new mindset cultivated at HEI level, and how might it influence commercialization behavior?

   RQ 2: What would be a suitable approach to asses the current status of a university's deep tech entrepreneurial ecosystem?

   RQ 3: What is an appropriate way to evaluate the impact a university has had and continues to have in the local deep tech entrepreneurial ecosystem?

2. **Develop a protocol (rationale, objectives, eligibility criteria)**

   For the purpose of the systematic literature review, effort will be made to differentiate between start-ups and spin-offs and focus the search on the latter. Based on the background of the study, the defined research goals and questions, the following hypotheses were defined:

   Hypothesis 1: We believe that universities play a defining role in the strengthening of local start-up ecosystems because they can provide the right support in the early stages of transforming research into products.

   Hypothesis 2: We believe TU Wien has already started its transition towards the new model of an entrepreneurial university because there is already a community of spin-offs existing at the university.

   Hypothesis 3: We believe the differences in academic's perception of entrepreneurial orientation are based on their own involvement in such activities as a consequence of their refection on different scientific disciplines, their department's involvement in various research projects which involved an industry partner, and their personal motivation

   Hypothesis 4: We believe the new generation of researchers is more eager to assume a hybrid role combining academia with commercialization because it offers an opportunity to a different type of career track.

   Hypothesis 5: We believe the implication of scientists in research commercialization is subjective and based on previous implications in such activities, sense-making, and identity reconstruction derived from self-imposed boundaries and priority scales.

Hypothesis 6: We believe scientists have already embraced patenting and invention disclosure activities but perceive going one step further towards setting up a spin-off as a distraction from their primary goal: to pursue science. Therefore, they employ different techniques to ensure the primacy of their academic role identity.

3. **Conduct systematic searches (including defining a search strategy, determining where to search, searching, documenting, reviewing and updating the search strategy)**

   With a clear focus on academic spin-offs, the major terms identified for performing the search are: entrepreneurship, sciencepreneurship, spin-off, spin-out, academic entrepreneurship, research commercialization, technology transfer, transferring research into a product, university incubator, pre-incubation program, business prototyping, university innovation ecosystems, university entrepreneurship, new firm creation, university startup, evaluating entrepreneurial ecosystems. The main repository where the search has been performed is the CatalogPlus provided by the TU Wien Library. Searches have also been performed on open-access databases.

4. **Selection of the relevant studies (assess each individual article whether it meets the inclusion criteria)**

   For cataloging the papers, the JabRef Paper and the Zotero repository have been used. At this stage, studies have been excluded based on titles and abstracts. If these do not provide enough information for a decision, the full text was reviewed. All excluded studies have been as well cataloged together with a reason for exclusion in the tool used. To ensure the high trustworthiness of the papers included in the research, the database search was limited to peer-reviewed journals only. When in doubt, tools like Ulrichsweb have been used to check whether an article is peer-reviewed or not.

5. **Critically appraise included articles (based on trustworthiness, value, relevance)**

   For this step, the following four aspects have been considered:

   - Author(s): are they scholars who specialize in the field and are affiliated with an academic institution?
   - Purpose: are published by professionals with the goal of knowledge sharing and facilitating discussions about ongoing research. Are the aims clearly stated? Pure opinion papers will not be considered. Are the methods adequately described?
   - Language: are they in English, and are they using highly specialized language?
   - References: are they citing their sources and include footnotes, end-notes, or parenthetical citations and/or a list of bibliographic references?

The final decision on whether an article will be included or excluded in the literature review has been made after the full texts were read.

6. **Extract relevant data from each of the articles to be included and synthesize the data (thematic synthesis and conceptual mapping)**

   The JabRef Paper repository has been used for this purpose. In parallel, a mind map was developed using the MIRO tool reflecting key factors/ key performance indicators (KPIs) identified in the literature.

7. **Report on the results**

   The literature review outcome was a set of quantitative and qualitative key performance indicators that can be merged into a framework that lays the basis of the most relevant factors and indicators of academic spin-off success and empowerment of sciencepreneurial ecosystems at the university level.

Another methodology useful for the early detection of essential needs or gaps is horizon scanning. It is "*a technique for detecting early signs of potentially important developments through a systematic examination of potential threats and opportunities, with emphasis on new technology and its effects on the issue at hand*"[oS20]. This approach enables understanding university policy implications by setting an approach, scope, process, and time frame as four key pillars[oS20]. Through the time frame selected, we have the option to focus on the near term (currently emerging issues) or on a wider time horizon. Specifically for health industry innovations, Hines P. suggests a foresight period of 2-15 years as it considers innovations less than two years as being not ripe enough to be brought into discussion, while those expected to develop in 15-20 years fully are too uncertain to be useful[Hin19].

Armed with key performance indicators, the next step was designing a semi-structured interview that will be conducted with TU Wien research-based start-ups in various stages of development. The outcome of the interview can be used to improve the services/support offered by the university to academic spin-offs and to validate the framework developed. A qualitative research method was selected as a means to capture non-standardized data. This approach was chosen as it permits the interviewer to explore relevant discussion points that come up in the course of the interview[Ade20]. The interview is a mix of closed- and open-ended questions, offering the opportunity to complement them with follow-up and why questions[Ada15]. The additional layer of spontaneous questions allows a deep dive into the topics of interest of the interviewer while at the same time limiting any pre-conceived bias the interviewer might have about the topic at hand[You18]. This methodology comes with specific challenges for the interviewer like, for example, a lengthy time investment for conducting the interviews, the need for being time-efficient and respectful of the interviewees´ time, and undergoing a post-processing intensive process. However, a structured approach and intensive planning could help minimize the hurdles associated with this type of methodology. Great effort has been put into the planning phase, ensuring enough time has been assigned to polish the interview questions. The following steps have been followed:

1. **Drafting Questions and the interview guide**

   The research guide consists of a list of questions reflective of the topic investigated[Whi08]. According to Kallio H., the guide aims to generate spontaneous, in-depth, unique, and vivid answers from participants that reflect their personal experience, facilitating the collection of data based on which new concepts can be formulated[Kal16]. Two levels have been considered for the guide: main themes and follow-up questions where participants will be encouraged to speak freely[Kal16] and provide their insights into the spinning-off process at TU Wien. The questions need to be adapted to the current stage of the company interviewed as the university usually supports both very early-stage research projects with high market potential as well as later-stage companies. The order of the questions and the extent to which the questions might evoke pressure to give socially acceptable answers have been considered in drafting the questions[New15].

   For exploring the views of the TU Wien founders, the "*Problem Interview script*"[Mau22] recommended by Ash Maurya has been used. The focus will be on identifying the motivation behind spinning-off, the issues founders face while transforming research results into successful products, how they overcame them, and what type of support would have been helpful to receive from the university. The various themes have been brought up progressively and logically into the discussion.

   The one hour interview has been divided into several major topics that are representative of the path of transferring research results into products. If an interviewee shares unique opinions not covered by the interview questions referral guide, these opinions will be considered and added as additional questions in subsequent interviews. From an ethical clearance perspective, each interview participant has been informed about the aim of the project, the anonymity policy of the study, the option to not answer any question perceived as intrusive or confidential for their business and information on how the data is being stored and who will have access rights to the interview data. If consent was given, the interview sessions were recorded, and transcripts of the interviews were generated. Alternatively, the data processing part used only the notes taken during the interview.

2. **Selecting respondents and arranging the interviews**

   To bring transparency to the sampling strategy, at least two companies representative of the same domain and each of the stages of development a spin-off undergoes will be selected: problem-solution fit, problem-market fit, business-model fit[AG14]. The criteria for selecting correspondents will be that the technology stems from research developed at TU Wien.

3. **Preparation and practice of interviews**

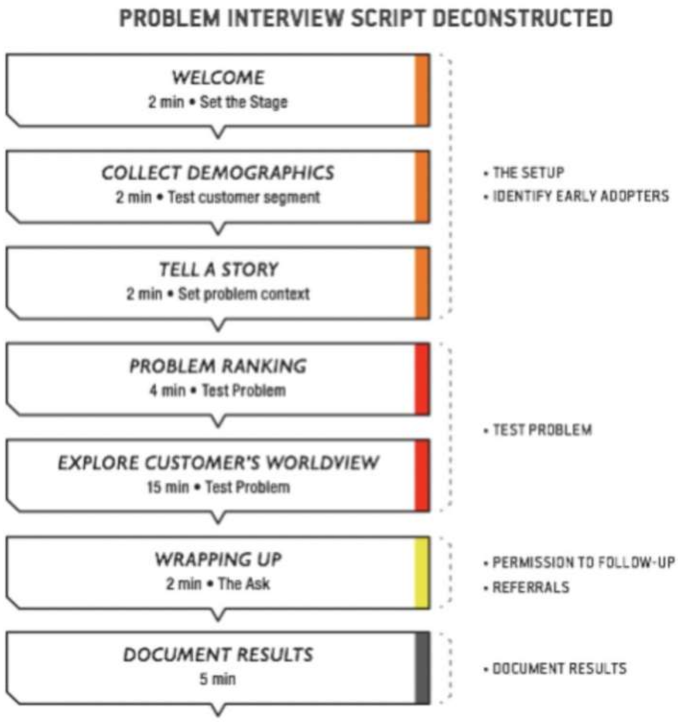

Figure 1.1: Problem Interview Script ©Ash Maurya

After defining an initial list of interview questions, a pilot interview has been concluded. The goal was to proof-check the length of the interview, the clarity of the questions asked and whether the interview will generate enough relevant data to answer the four research questions proposed[AG14]. Based on the outcome of the pilot, the interview questions and the interview guidelines were refined in order to remove ambiguous and leading questions. An expert assessment was as well included at this stage for an external critical view and to facilitate a discussion on whether the questions are representative and in line with the research questions set up[Kal16].

4. **Conducting the interviews**

   Seven interviews were conducted with founders from TU Wien-affiliated spin-offs in various stages of development. The interviewer focused on maintaining the flow of the interview and asked spontaneously follow-up questions in order to gain accurate information on the spinning-off process. If needed, verbal and non-verbal probing techniques were introduced to make the interviewee provide additional information on a specific topic.

5. **Transcription of data and storage**

   Different approaches have been used depending on whether the interviewee gave his/her consent for the interview to be recorded. Having the interview recorded and then generating a transcript would have been ideal. However, if the interviewee had not provided consent, pre-defined templates for note-taking were used to simplify and standardize the process as much as possible.

6. **Data analysis**

   This stage focuses on observing emerging patterns, features, and themes from the interviewee´s histories, perspectives, and experiences with the topic explored. For this purpose, the inductive method[Lan99] has been used, ensuring the elimination of the confirmation bias given by the existing literature. First-order and second-order themes and aggregated theoretical dimensions have been consolidated in a data structure tree, which has been iteratively updated as interviews took place. The inductive method is used in qualitative research to build new theories from data collected through observation, interviews, and other methods. The method involves identifying patterns and themes in the data and developing a macro phenomenon based on those patterns. This method allowed the combination of extensive knowledge of the institutional environment with access to the information provided by sciencepreneurs.

7. **Drawing Conclusions**

   The goal is to draw particular, less generalized findings reflective of the TU Wien ecosystem and assess how well the outcomes of the interviews are reflected in the framework obtained as a result of the literature review.

8. **Reporting the results of the study**

   The results of the study has been included in a special chapter dedicated to the outcome of the interviews. A presentation reflecting these outcomes was also planned.

To complement the qualitative study, the participating founders were also asked to complete, prior to their interview, a short questionnaire targeting the quantitative key performance indicators included in the framework. These indicators have then been analyzed across companies to assess whether they accurately reflect an academic spin-off's stage and progress development.The framework and the study results have been then synthesized in a presentation.

1.3.2 Research Limitations

The study was conducted only at TU Wien level, a university with a profound reputation for research excellence and with a well-established TTO center and Innovation Center. Therefore, the findings of the research might not apply equally to other universities and it is important to distinguish between general implications and case specifics.

The sampling frame only includes businesses with a TU Wien-affiliation who at the time of asking were in the evidence of either the TU Wien Innovation Incubation Center (i²c), INiTs or the TU Wien Research and Technology Support Service Unit founder no later than five years ago. The fact that some spin-offs are at a very early stage also meant that not all questions could have been answered. The sample size was also very small, with only spin-offs and seven fouders taking part.

The scientists sample consists mainly of researchers who have been already involved in commercialization activities and have started their journey at different stages in their professional career (e.g Master student, PhD., Post-doc, Professor).

The KPIs considered in the quantitative study are just a "brush of the iceberg". While researching the topic, it was very quickly evident that the quantitative evaluation would itself be a research topic for a master's thesis. Therefore, we must differentiate between the "Evaluation" component of the developed framework and the quantitative study aimed only yo assess the impact of the spin-offs from the study on the local ecosystem.

CHAPTER 2

Literature Review - Exploring Academic Sciencepreneurship

The study of how organizations come into being and the processes involved in initiating new ventures has emerged as a crucial domain within the field of entrepreneurship research[MW14]. The major theories aiming to understand this endeavour center around embededness theory[MJA15], the formation of entrepreneurial ecosystems[Mal18], competency - based view (CBV)[MWFS13] and resource-based view (RBV)[WB05]. While the environment theory emphasizes the interactions between subsystems, embeddedness theory complements it by bringing into the discussion the effect of the ecosystem on new venture creation. The Resource-Based View (RBV) underscores the importance of various resources possessed by universities, from financial resources to technological capabilities, human capital, and organizational assets while the competency-based view (CBV) concentrates on nurturing the entrepreneurial capabilities of individuals and making sure the future sciencepreneurs will develop an array of personal skills for effectively running deep tech innovations[MWFS13]. The research aims to combine and understand these theories' interaction and collaboration into practice and achieve conceptual coherence in the form of a joint framework.

More often than usual, when the word "entrepreneurship" is brought up, people's minds jump to famous names of successful entrepreneurs like Elon Musk, Bill Gates, and Mark Zuckerberg. Still, a closer look at the history of companies founded by these individuals reveals the importance of a more comprehensive network of supporters that played a crucial role in their successful development. Therefore, these entrepreneurs have been helped or hindered on their entrepreneurial journey by the ecosystem in which they have been operating. According to Ben Spiegel, entrepreneurial ecosystems provide "*a framework to understand the activities surrounding high-growth, high-ambition entrepreneurship*" [Spi20]. It brings together various aspects of entrepreneurship from investments to entrepreneurial education, and geographical influences on entrepreneurship and offer fresh insights into entrepreneurs' engagement with their local economy and society. This is in contrast to the general approaches from the literature focusing on individual personality traits [FLK07], demographic backgrounds [MV11], or even genetics [NS11] associated with successful entrepreneurship. The most widely accepted definition of an entrepreneurial ecosystem is given by Stam and Spigel as

> "*a set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship within a particular territory*"[SS18]

The Organisation for Economic Co-operation and Development (OECD) offers as well its definition of an entrepreneurial ecosystem that synthesizes existing definitions from the literature:

> "*a set of interconnected entrepreneurial actors (both potential and existing), entrepreneurial organisations (e.g. firms, venture capitalists, business angels, banks), institutions (universities, public sector agencies, financial bodies) and entrepreneurial processes (e.g. the business birth rate, numbers of high growth firms, levels of 'blockbuster entrepreneurship', number of serial entrepreneurs, degree of sell- out mentality within firms and levels of entrepreneurial ambition) which formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment*" [MB14]

A couple of influential models have already emerged for describing an entrepreneurial ecosystem. An example of a widely discussed, accepted, and quoted model in the literature adopted by policymakers, entrepreneurs, and researchers alike is the "Entrepreneurship Ecosystem Model" by Daniel Isenberg [Ent23]. Isenberg's framework delineates six key areas that interconnect to establish a nurturing environment for entrepreneurship: policy, finance, culture, support, human capital, and markets (see Figure 2.1). Each domain is linked to more specific elements, making it highly complex and not representative of the needs of an university ecosystem. In its whole form, it consists of more than 50 components.

Building on top of this framework, a survey, conducted by the World Economic Forum in partnership with Stanford University, Ernst & Young, and Endeavor, gathered insights from more than 1,000 entrepreneurs globally. Its aim was to gain a deeper understanding of how thriving entrepreneurial ventures expedite market access and transform into scalable, high-growth enterprises. The outcome was the identification of eight pillars important for fostering entrepreneurial ecosystems[FS13]: accessible markets, human capital workforce, funding and finance, support system, regulatory framework and infrastructure education and training, major universities as catalysts, and cultural support (see Figure 2.2). These two models consider only the individual components and factors, refraining from considering interrelations between these critical components. The third most quoted model aims to fill this gap. Researcher Spiegel [Spi17a] categorized the ecosystem

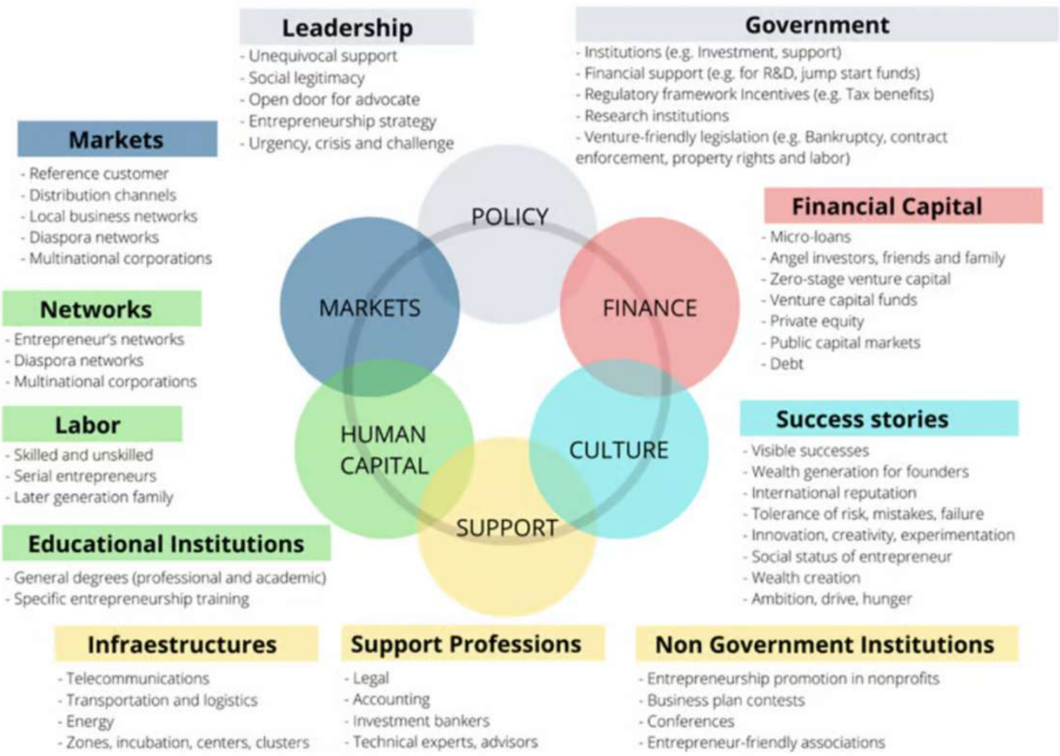

Figure 2.1: Entrepreneurship Ecosystem Model by Daniel Isenberg, Source: Ecosystem Entrepreneur [Ent23]

attributes into three categories that are interconnected, each contributing to building a stronger ecosystem over time: cultural (how entrepreneurship is understood within the region), social (access to networks), and material (with a physical presence in the region).

While the three models have similarities and overlaps, one main component stands out: **the role of universities as catalysts**. However, the university is itself an active ecosystem. Therefore, the research aims as a next step to look into how these models can be extrapolated to identify representative factors and components for sciencepreneurial academic ecosystems.

Unfortunately, there are scarce literature resources on this topic. Researchers Frank T. Rothaermel, Shanti D. Agung, and Lin Jiang, who comprised a taxonomy of the literature on academic entrepreneurship [TAJ17], attribute the absence of entrepreneurship research from the most prestigious journals to the "*embryonic stage in the life cycle of academic fields*". They base this assumption on Kuhn's framework [Kuh62] of how new scientific fields of inquiry emerge. University entrepreneurship research has centered so far mostly on stakeholder analysis and their individual perspectives, the companies that make use of the technology generated out of research results, and entrepreneurial education, with the most commonly used data sources being direct surveys and interviews with university

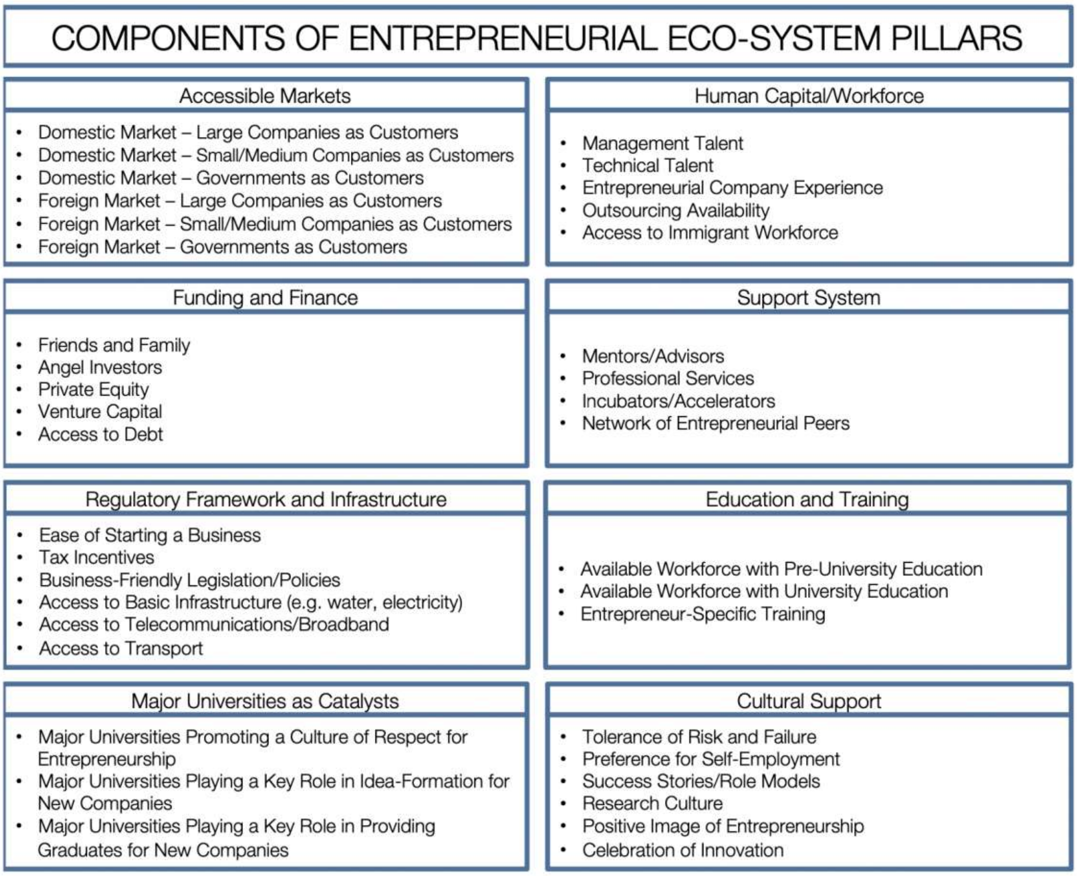

Figure 2.2: Components of Entrepreneurial Ecosystem Pillars, Source: World Economic Forum[FS13]

affiliates[TAJ17].

Rothaermel T. et al. developed, based on a pervasive literature review, a conceptual framework of university entrepreneurship that considers both internal and external factors influencing entrepreneurial activity (see Figure 2.3). It focuses on the inner ecosystem that sees the entrepreneurial university as the core of the university ecosystem. The generation of breakthroughs facilitates technology transfer enabled by technology transfer offices[TAJ17], incubators, science parks, or any other forms of support the university offers. Working closely with the industry allows the university to expand its core activity by introducing a third mission of transforming inventions into innovations and products for the betterment of society while at the same time building an additional revenue stream for the university itself[TAJ17]. These are reflected in Figure 2.4, which represents an extension of the conceptual framework from Figure 2.3 and it encompasses as well the external factors driving entrepreneurial ecosystems at university level. The existing

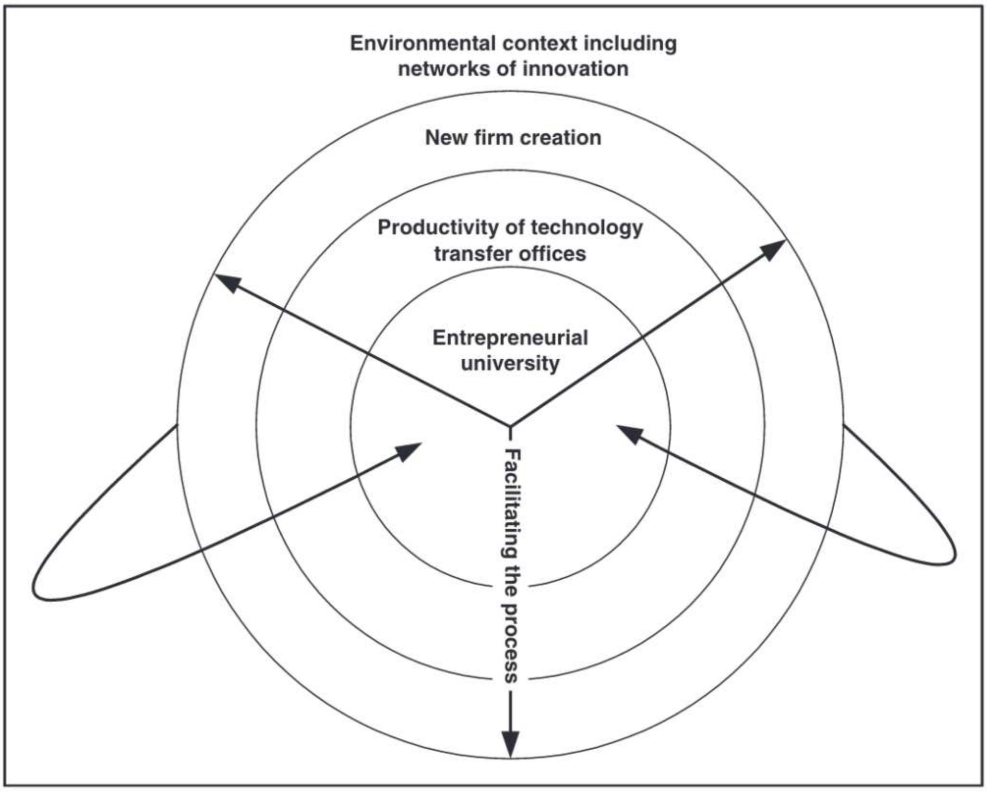

Figure 2.3: Conceptual framework of university entrepreneurship, Source:[TAJ17]

conceptual framework of university entrepreneurship, which positions Technology Transfer Offices (TTOs) as central agents, has several limitations. It overlooks crucial elements such as leadership, internal governance structures, the role universities play nowadays in the technical due diligence process and the infrastructure supporting entrepreneurial activities. Moreover, it focuses solely on incentives for TTO mediators, neglecting the broader ecosystem dynamics and institutional mechanisms that are vital for fostering entrepreneurship within a university. In terms of external forces, the framework only considers governmental policies, ignoring the myriad of factors that influence the university ecosystem. These include the roles of organizations fostering entrepreneurship, global trends, societal challenges, the effects of globalization, and the proximity to high-tech firms, among others. The HEInnovate initiative [HEI23] of the European Commission, launched in 2013 in partnership with the OECD, introduced a different approach to emphasize the importance of building up a strong entrepreneurial ecosystem. They have developed a tool for Higher Education Institutions (HEI) that wish to explore their innovative potential where the entrepreneurial ecosystem and networks are integrated as a vital component. Instead of acting as a benchmarking tool, it assesses strengths and weaknesses as a means to initiate discussions about an institution's entrepreneurial and

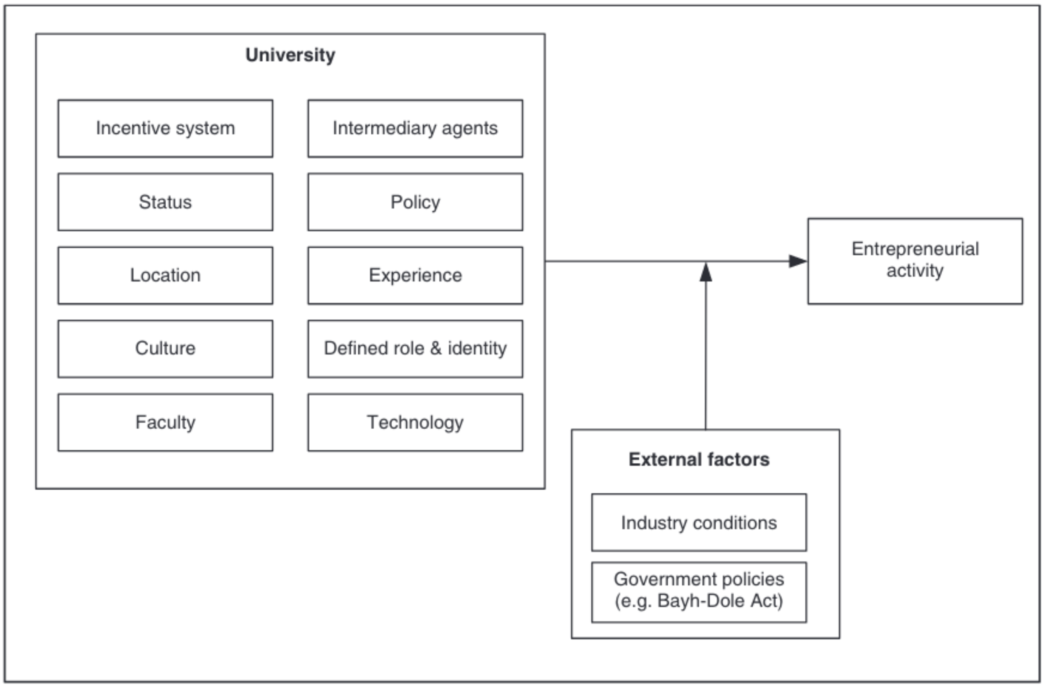

Figure 2.4: Entrepreneurial research university, source: [TAJ17]

innovative essence. It also enables comparisons of progress and changes over time.

Independently, if a self-assessment tool or a framework, defining a framework for developing an academic entrepreneurship ecosystem is challenging as the university environment is complex and multifaceted, involving various interdependent actors and factors. It requires a dynamic approach that considers the ecosystem's origins and stimulus. Therefore, as a next step, efforts were put into understanding how world-renowned academic entrepreneurial ecosystems have emerged.

The study "Creating university-based entrepreneurial ecosystems evidence from emerging world leaders" [Gra15] conducted between 2012 and 2014 at MIT identified three recurring universities cited as world leaders among the over 200 universities covered by the study: MIT, Stanford University, and Cambridge University. However, the study set out in the first phase to identify the world's most highly-regarded university-based entrepreneurial ecosystems operating outside the established technology hubs despite challenging environments for a deep dive study. Aalto University (Finland), Imperial College London (United Kingdom), Tomsk State University of Radioelectronics and Control Systems (Russia), and the University of Auckland (New Zealand) have been selected as a result of the initial research. The outcome of the study's second phase points out that the success of these universities lies in the synergies between the internal university ecosystem and the external ecosystem with whom the university is in close contact. The study emphasizes the synergies between six major factors:

- a strong senior management actively promoting entrepreneurship and innovation at all levels and a high priority for establishing markets for university outputs and a strong institutional strategy for Entrepreneurship & Innovation (e&i)
- an academic culture at a department level which supports and rewards cross-disciplinary approaches for developing innovations
- university provided services and programs for students and staff available thought the various university institutions.
- university research capability with a strong international focus
- strong external community actively collaborating with the universities to their mutual benefit and with a visible and prominent role in the university life and a strong governmental support with advantageous regional policies
- the local quality of life

As a next step, the attention was focused first on the internal university ecosystem, trying to uncover in the literature what empowers universities to create an environment that supports, encourages, and amplifies entrepreneurial activities.

2.1 Internal (University) Ecosystem

Analyzing an ecosystem requires first a good understanding of the actors active within this ecosystem. Depending on how evolved the ecosystems is, the number of stakeholders might vary. A good benchmark for conducting high-quality stakeholder engagement projects and program is the AA1000 Stakeholder Engagement Standard[Acc23].

The research conducted by Dr. Ruth Graham [Gra15] concluded that universities with a stellar reputation for E&I typically align with two developmental models, each rooted in the triggers and motivations for embracing an E&I agenda:

Model A: 'bottom-up' and community-led - a model powered by students, alumni and local entrepreneurs interested in creating a vibrant ecosystem that stimulates the local economy and prioritizes community partnerships over institutional capacity or IP ownership. Challenges arise when trying to formalize E&I within the university due to it's struggle to manage its organic growth and measure its impact.

Model B: 'top-down' and university-led - a model that stems from a desire to capitalize on university research. Driven by a robust Technology Transfer Office (TTO), it is usually applies a fully institutionalized approach that heavily values university-owned IP. However, this approach can marginalize student and alums involvement, leading to separate initiatives to nurture a broader E&I culture beyond the institution.

The next step in the research was to examine the aspect of heritage and culture, which is suggested by the literature as the primary reason universities opt for one model or another.

Welter F. introduced in 2011 through his article the importance of context for explaining entrepreneurial activities, introducing the embedded theory[Wel11]. This idea is further discussed and refined by other researchers who emphasize that sciencepreneurs are embedded in a particular ecosystem where a specific social frame, communities, networks, and resources exist[MAJ14] [MJA15]. Understanding this context has never been as crucial for fostering venture creation at the HEI level as today.

In Europe, universities have always played a vital role in our society. To embrace the industrial age, engineering schools like École Polytechnique and École Centrale in France and the Technische Hochschulen in Germany or the Imperial & Royal Polytechnic Institute of Vienna in Austria were tasked with training a new generation of engineers to integrate the latest innovations into industrial practices.[oT23] Similarly, in the USA, MIT was established under the motto Mens et Manus ("mind and hand" in Latin) to promote the progress, growth, and real-world utilization of science in conjunction with the arts, agriculture, industry, and trade[Deg21]. Even now, many years later, this motto continues to instill the same values and is seen by both the academic personnel and its students as an integral part of MIT's culture[Deg21]. Scientists even perceive themselves as "*academic entrepreneurs* "[Deg21] as they have been the sole responsible for ensuring the funding needed to pursue their research, another reason why, at MIT, the bottom-up approach proved to be such a fertile ground for a robust entrepreneurial ecosystem.

A deep dive into the literature around the culture for entrepreneurship at the MIT brought to light the importance of the **role, perception and identity of its students, alumni and academic personnel**. It is a combination of excellence, deep interest in problem solving, having an impact in the world but at the same time pride for being seen as rebels, eccentrics, even at times geeky, visionaries pursuing unconventional solutions, experimenting a lot and resilient in the face of failure [Deg21].

Research also shows that thriving entrepreneurial ecosystems are characterized by a civic culture[WN08]. People with a high degree of civic-mindedness contribute on a pro-bono basis to the well being of today's society. It can take the form of local philanthropy or mentoring, with people contributing with their time, expertise, wisdom, and even financial aid to solve our society's biggest challenges by enabling new deep-tech innovations to reach the market. An example of a local ecosystem where this type of culture has been thriving is in San Diego[SLW14] or Cambridge, Massachusetts. The outcome of a study done at MIT revealed that students who enroll at MIT have an innate desire to change the world and see entrepreneurship as a key factor for reaching the desired impact [Deg21]. The study results align with the entrepreneurial mindsets promoted by change makers like New York Times and Wall Street Journal bestseller Simon Sinek[Sin19], who emphasize that leadership needs to instill a mindset that prepares people for existential flexibility. He uses concepts from game theory and how they pertain to business, redefining how businesses should define their mission, vision, and goals, building trusting teams, studying the competition, and leading. He emphasizes that leaders should be prepared to play an infinite game where the players come and go, the rules are changeable, and there is no defined endpoint. This is only possible if a "Just Cause", a cause for which people would be willing to sacrifice their own interests to advance, is clear. Universities have here a clear advantage as, especially in Europe where taxpayer's money powers them, the breakthroughs need to be developed for the benefit of the society and need to reach and be embraced by the society, and here is where the entrepreneurial ecosystem plays an important role.

Ingrained in MIT's culture is also their collaborative, multidisciplinary focus, which also has historical implications. The wartime labs influenced their multidisciplinary, hard work, and cooperative style, and this approach is still reflected in how they operate today. Degroof Jean-Jacques quotes former MIT President Susan Hockfield about how difficult it was for her to guess from which department the researchers she was talking with belonged:

> "*Their research crossed boundaries between disciplines without any celebration or permission, and I realized that flexibility was critical to the rapid translation of new ideas from the lab to the marketplace*"[Deg21]

Building a strong sciencepreneurial ecosystem requires intensive strategic planning for the administration in line with the local strengths and weaknesses of the university[Gü11]. Strategic planning hinges significantly on defining clear and concise mission and vision statements. The accuracy in identifying and formulating these statements is pivotal for the success of strategic initiatives. Additionally, these statements play a vital role in shaping an organization's institutional identity. While a mission statement is more concrete, focuses on the present and describes the "what" and "how" of an organization, a vision statement is more aspirational and inspirational, focuses on the future and describes the "why" and "where" of an organization[Biz23]. An analysis of the mission and vision statements of 75 Turkish universities revealed that services concerning their research function are the most emphasized with the statement "Becoming a well-known, leading, and respected research university both nationally and internationally" among the most commonly underlined messages[Gü11].

A similar study was done this time in the Republic of Ireland, an ecosystem with a reputation for its top-performing universities and public technology transfer system within the European Union[FA16]. As part of the study, seven Irish University Technology Transfer Office's mission statements were analyzed to assess the presence of the commercialization pillar within their statements. The overall conclusion was that the mission statements were lacking "*explicit market making ambitions*"[FA16], "*explicit expression of their expertise*"[FA16] and "*emphasis on the effectiveness of their own commercialization mechanisms*"[FA16] even if most of the mission statements outlined the outcomes and benefits of their activities for the stakeholders[FA16]. Even more surprising was that only two of the statements (incidentally coming from the longest-established TTOs) strongly emphasized cultivating innovation and entrepreneurship culture. The majority articulated their mission by focusing on managing technology transfer, commercialization, knowledge transformation, successful exploitation of new ideas, and intellectual property[FA16].

As main actors, scientists are the ones directly affected by the broad changes in the institutional framework. Embracing commercialization means a shift in their role, activities, workload and even priorities which in turn affect their perception of and participation to technology transfer. According to Sanjay Jain et al. it requires a "*fundamental reassessment of their abilities, beliefs and priorities, and even their view of the meaning of their work*"[JSGM09]. Gaining insight into their "work identity" serves as a strong foundation for comprehending the drivers, scope, and character of changes in both role and identity. Understanding the factors enabling researchers to embrace a hybrid academic-entrepreneurial role and exploring potential governance mechanisms for these transitions are essential objectives. Even early research like the one of Merton R.K. in 1986 [Mer68] outlines that even if interested or involved in technology transfer, scientist tend to prioritize and preserve their academic role identity. The normal academic career path implies norms which encourage information sharing for the common good, lack of emotional and financial attachments, organized skepticism, impartiality and an academic prestige based on publications and similar such articles. According to his research, he emphasizes that these norms are in contradiction with the entrepreneurial role identity which promotes technology as private property, passion and optimism[Mer68].

Jain et al. [JSGM09] suggest that individuals embrace role identification by layering a new identity facet over their already existing identity. This process minimizes discrepancies associated with assuming role identities perceived as inconsistent with their current role and allows them to maintain cultivated and appreciated features of their existing identity. In literature, this blend of commercial focus with the traditional academic identity among university researchers is labeled 'Hybrid Role Identity[JSGM09].

The book "Social Theory and Social Structure"[Mer68] also suggests that adopting such a role is strongly connected with the career stage of the individual researcher. This is not surprising since the biggest concern of researchers is the interference with their academic pursuit of open science, basic science, and publications. Tenured scientists who bygone the pressure of producing academically oriented output are more likely to get involved in commercialization movements; however, many see their academic role identity as prevalent[JSGM09].

Contrary to general beliefs, professor Daniel J. Isenberg [Ise10] considers it feasible to shift societal attitudes toward entrepreneurship within a single generation. Examples are multiple: the zero tolerance for loans and stigma of bankruptcy common in Ireland until the 1980s has now transformed so much that it is believed that to earn respect and be considered credible, it was essential to be a founder deeply involved in a venture striving to achieve something significant. Also, university of Minnesota professor Rachel Schurman's research illustrates the remarkable shift in Chileans' perception of entrepreneurs from negative stereotypes of greediness to a positive view within merely a decade. This transformation was directly influenced by the Chilean government's dedicated initiative to liberalize the country's economy[Ise10].

While some feel the university's role could be to act as the custodian of the disruptive technology (since it possesses both the financial, business knowledge and negotiation skills needed) or help them find a suitable person with technical business management skills to handle the commercialization of their research, others are ready to embrace their hybrid role on an experimental basis though sabbaticals or using their free time to work on their spin-offs[JSGM09]. Scientists, especially tenure-tracked ones, sometimes delegate their entrepreneurial activities to their graduate students. Although they also only sometimes possess advanced entrepreneurial skills, they are highly motivated by such career paths. This allows the researchers to focus and nurture their primary academic role and delegate the commercialization aspects, ensuring that the disruptive technologies that result from their work reach society. Therefore, it is vital to make a comparison (based on norms, processes, and outputs) between the demands of an entrepreneurial identity and the usual academic identity, derive the benefits of identity modification, and raise awareness among scientists on these gains through the instilled university culture and values.

Taking a closer look at how entrepreneurship emerged at MIT, one can observe that the spark came not from the leadership and top levels but rather from isolated and uncoordinated initiatives of alums, students or faculty and staff members[Deg21], fostering an unwritten culture for pursuing an entrepreneurial activity. Jean-Jacques Degroof and Bob Metcalfe even consider in their book "From the Basement to the Dome: How MIT Unique Culture Created a Thriving Entrepreneurial Community" as their thesis that

> "*MIT was such a fertile ground for entrepreneurship because entrepreneurship is so well aligned with key aspects of the Institute's culture, specifically a well-ingrained bottom-up mode of decision-making; academic excellence; a keen interest in problem-solving; a belief in experimenting and a tolerance of failure; pride at being viewed as geeky outsiders; the tradition of a multidisciplinary approach to problem-solving; and the desire to have an impact on the real world. As a result of these features, entrepreneurship not only flourished at MIT, but it became a core part of the very culture that helped to sustain it.*"[Deg21]

The leadership then built on this fertile ground by adopting entrepreneurship and innovation as their core strategy centered on problem-solving, experimentation, multi-disciplinarity, user and customer centrality, and resilience.[Deg21]. You can see these values reflected in the narrative of the representatives of the institutions and not only. For example, former MIT president Rafael Reif states:

> "*We believe in learning by doing— and by making, exploring, designing, inventing, and performing too. Much of the daily work of our faculty and students happens in extraordinarily advanced laboratories, in fields from cancer, brain science, robotics, and nanomaterials to alternative energy and astrophysics. But we also have our own machine shop, a wind tunnel, an aerospace research hangar, a research nuclear reactor, and a glassblowing lab. We like to make things— and we like to make an impact. Taken as a whole, our campus is a workshop for inventing the future.*"[Deg21]

MIT's mission statement is clearly visible and promoted also though its academic and non-academic employees [Deg21]

> "'*Always think with your hands' ... essentially, start building a prototype right away and learn as you go.*" - Professor Neil Gershenfeld-
>
> "*Building a solution to a problem isn't the same as committing something to memory. It's something you live, and when you are done, you own it*" -Professor Martin Culpepper-
>
> "*Our culture at MIT stresses that risk taking is necessary for achievement. We assume that our students are good enough to take risks and succeed. They have sufficient talent, energy, and self-confidence to recover rapidly from failure and to learn from failure to become more effective in their next endeavor.*" -Lita Nelsen, Technology Licensing Office-

and in various materials shared with the MIT community like for example the yearly MIT Impact Report 2.5 or their website.

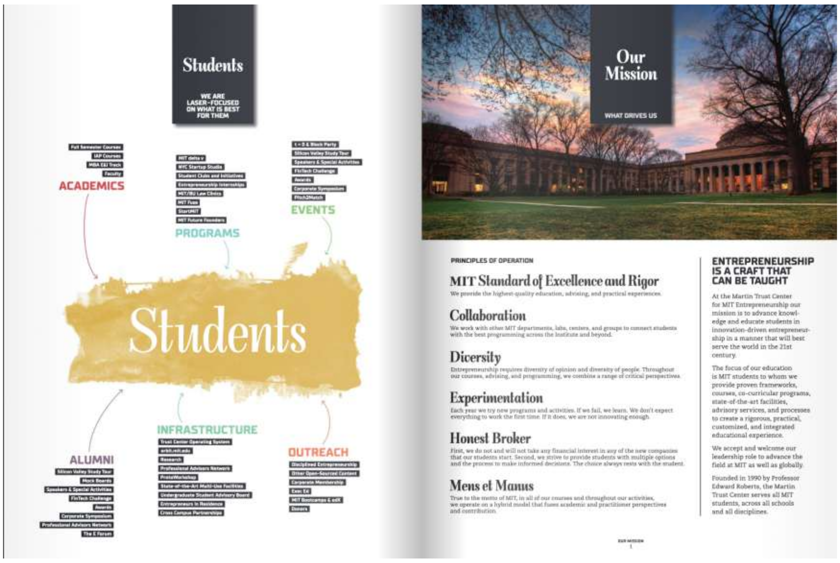

Figure 2.5: Mission Statement Martin Trust Center for MIT Entrepreneurship, Source: Extract from the MIT Impact Report 2020

Their experimentation, iterations, and learning from mistakes approach has been a key ingredient for building a tolerance for failure mentality and a taste for embracing calculated risks, qualities that are extremely useful in the entrepreneurial path. Even so, perhaps unique to MIT is a more radical form of experimentation: "*hackerism*" [Deg21]. It involves akin principles: a knack for accessing resources beyond your control, bending the rules, challenging conventions, and pushing boundaries. This spirit is so widely spread at MIT that not only is there a special mention on the Trust Center's website encouraging embracing this mentality, but it is also reflected in the Trust Center's logo: a pirate ship that calls for embracing "the spirit of a pirate" [Deg21] in combination with the "discipline of a SEAL" [Deg21]. Extracurricular activities and experimental classes related to entrepreneurship have then been transformed into formal classes and complex programs.

University culture, policies, ethical frameworks, and incentive systems are strongly connected. While many successful spin-offs that became a precious source of revenue for a university exist worldwide, spin-offs and their by-products generally provide only a very modest source of income[UDoST23]. The UK Department of Science, Innovation, and Technology recommends through an independent assessment that these streams of income should not be treated as a primary source of revenue for the commercialization endeavors of the university. This approach should be reflected in the university's intellectual propriety and negotiation policies. A better approach is to consider this additional means of income as an incentive for intellectual property inventors and to help the university further support the next generations of sciencepreneurs[UDoST23]

Multiple **policies** can influence fostering an academic entrepreneurial ecosystem. The literature mainly provides a wealth of information about University-Business Collaboration, Intellectual Propriety, Commercialization Policy, Open Innovation Policy, and, now increasingly common, Sustainability Policy and Responsible Research and Innovation Practices.

University-Business Collaboration (UBC) Policy refers to the partnerships and interactions between universities and businesses for various purposes, such as research, innovation, and entrepreneurship[MGMD18]. UBC can lead to the development of new technologies, products, and services and provide opportunities for students and academics to gain practical experience. According to Meerman A. et al., even if Higher Education Institutions (HEIs) have UBC among their vision and mission, they need more resources for fostering a long-term commitment (facilities, personnel, budget, and a responsible authority figure). [MGMD18]. Moreover, Isabelle Deschamps et al. recommend, as a result of their research, various IP tools, guides, or sources of information that combine IP transfer and open innovation for UBC. Therefore, defining an **Intellectual Property (IP) Policy** should also be a high priority for the administration of a higher education institution as it contains guidelines, rules, and procedures regarding the creation, ownership, management, protection, commercialization and incentives for inventors of intellectual property generated within the institution [Con22] [TZM18]. Usually, technology transfer offices are responsible for protecting intangible assets such as patents, copyrights, trade secrets, trademarks, and other forms of IP. Through these policies, clarity over ownership and a revenue sharing or royalty distribution between inventors and the university is transparent, facilitating trust and enhancing the university's attractiveness to collaborators, industry partners, and investors[AAT15].

The emergence of the open innovation theory and the quadruple helix model[SHS19] that engages all members of society (citizens, industry, academia and public authorities) have prompted universities to reconsider their approaches to engaging with industry and broader society. An **Open Innovation Policy** refers to the practice of universities and businesses sharing knowledge and resources to create new products, services, and businesses[AMF19].

A UBC and Open Innovation policy outlines the guidelines and procedures that govern the partnerships between universities and industry partners, respectively, the integration of external ideas and the free sharing of knowledge to drive innovation. A commercialization policy focuses on the process of converting research and development into commercial products, services, or processes. A commercialization strategy goes beyond IP; it encompasses as well the processes of evaluating the market potential of inventions and innovations, its path to market, the mitigation of conflicts of interest when the academic personnel engages in commercialization activities, and how success is being measured[SAS19].

High competitive contexts and high pressure to achieve results can create, as a consequence, frowned-upon behaviors from scientists. Consequently, universities are responsible for promoting policies that ensure scientists can conduct research and innovation activities in line with well-accepted practices and ethical and social values [GEFCM23]. **Responsible Research and Innovation** (RRI) aims to address multifaceted challenges in the research and innovation domain like public distrust in scientific endeavors, concerns over research misconduct scandals affecting integrity and independence, debates on industrialized scientific production, and the necessity for democratic engagement in shaping the trajectory of innovation and emerging technologies. According to Christian Wittrock, these policies should cover "five key areas (Ethics, Gender, Equality and Diversity, Open Access and Open Science, Science Education, and Societal/Public Engagement) and four process dimensions (Anticipation and Reflexivity, Diversity and Inclusiveness; Openness and Transparency, and Responsiveness and Adaptation)"[WFP+21]. Haven, T. even proposes complementing these practices with mandatory research integrity training for Ph.D. supervisors. Their research has shown that supervisors proficient in responsible research practices will pass their work principles down to their supervisees [HBMT23].

Sustainability policies reflect the commitment of universities to environmental sustainability, carbon management, waste and energy reduction, and the integration of sustainability across their institutional strategies and operations[SHBARPSF17]. Examples of universities that have defined sustainability policies are the University of Hul, MIT, University of Oxford or TU Graz. The policies of these universities have one thing in common: a collective commitment to environmental stewardship and sustainable practices by combining campus carbon neutrality and emissions reduction practices with resource management and respect for preserving and enhancing biodiversity and expanding green spaces on campus and paired with research and education and a shared commitment to transparency and accountability in reporting progress towards sustainability goals.

Incentive systems are an integral part of organizational change management. Rimante Rusaite, Senior Project Manager at UIIN, introduces four dimensions of an entrepreneurial culture shift in universities: raising awareness, effective communication, incentives, and navigating support [Rus23]. She assumes that the low engagement of the academic personnel in spin-off formation is due to the lack of awareness of the possibilities and the need for cultural change. Therefore, effective communication practices need to be deployed to outline engagement, sciencepreneurship, and its impact within HEIs and should be compensated with an incentive system and help in navigating the support system of the institution for the commercialization path.

Jain S. et al. consider that the role identity encountered in the social psychological literature is an appropriate means to examine the sense-making process of academics involved in technology transfer and how they embrace a new, "hybrid" role identity[JSGM09]. The same construct is supported by Christopher S. Hayter et al., who states:

> "*Pioneering research attributes commercialization-related behavior among scientists to the construction of a hybrid role identity that balances both scientific and entrepreneurial responsibilities.*"[HFR22]

They introduce a framework that builds upon the concept of "liminiality", a transitional phase between two different states or conditions, emphasizing how identity development occurs as well as why[HFR22]. The result of their study emphasizes the importance of entrepreneurial agency and passion. Both intrinsic motivations, based on individual interest like passion and altruism and extrinsic motivations like recognition, commercialization-related criteria for tenure, penalty, financial rewards could be incentive systems for these groups. Haiter and Parker especially consider tenured tracks as a source of motivation for non-tenured doctoral students interested in alternative career paths to academia[HP19]. For young researchers, peer endorsement is also perceived as a facilitator for entrepreneurial intention[FVBP19]. Acknowledgements in the form or prizes like for example the "Austrian Phoenix Founders Award" which honours start-ups, spin-offs and prototype developments and acknowledged their impact in Austria's business sector could also be a motivator for the academia.

Link and Siegel observed that offering higher percentages of royalty payments to university researchers positively impacts entrepreneurial activities. However, the research lacks an analysis on the impact of distributing such incentives towards the faculty and departmental level the innovation stems from [LS05].

Moreover, Miao Wang et al. research contradicts initial assumptions that senior academics are more likely to engage in academic entrepreneurship since obtaining tenure eliminates the pressure to publish and permits them to dedicate more time to commercialization activities[LS07], stating that there is a growing pressure on junior academic scientists to engage in commercialization endeavors. In contrast, senior academics remain focused on teaching- and research-focused objectives[WCSY21], and they are more prone to personally engage in more informal enterprising activities due to the extensive network they have built along their research career which allows them to navigate more freely without using the services of the TTO[Car07] [LS07].

Battaglia D. et al.[BPU27] places the Proof-of-concept (PoC) programs at the core of the incentive system of a university, postulating that access to such a system is vital for

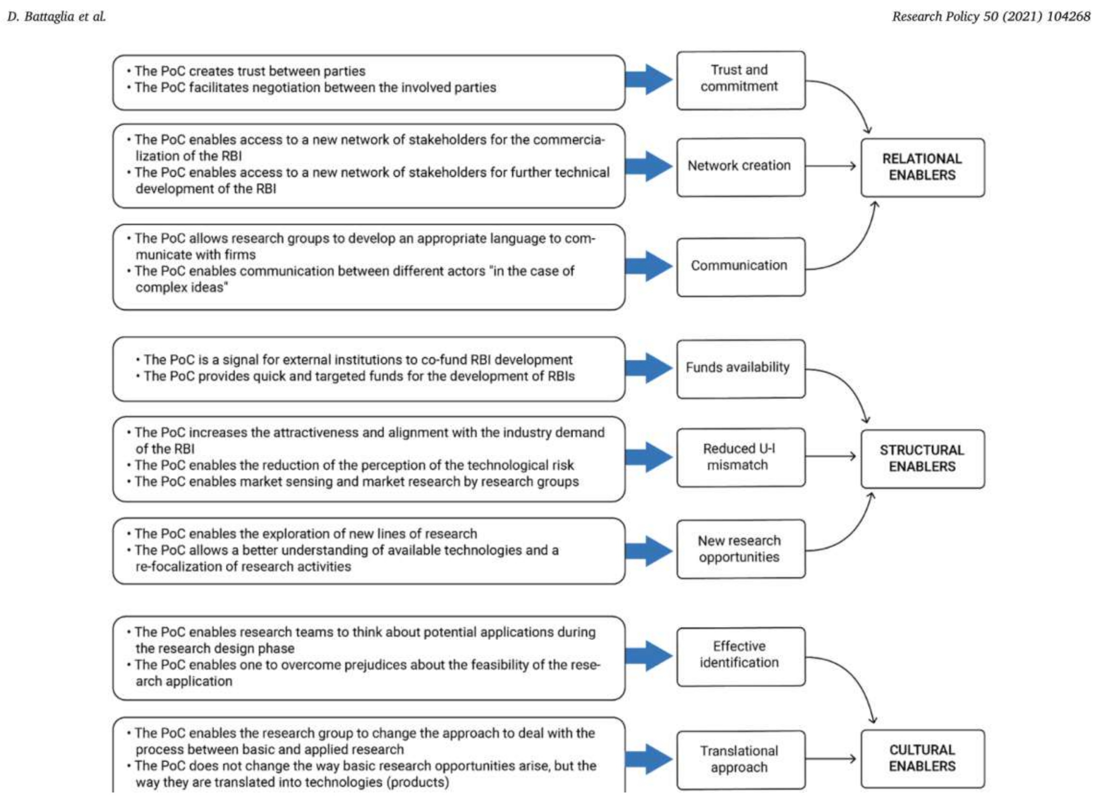

Figure 2.6: Data structure for Proof-of-Concept Enablers, source:[BPU27]

understanding the potential of the technology and raising awareness of the opportunity for commercialization it brings to academics. Their research identifies three types of enablers: relational, structural, and cultural. Relational enablers (trust and commitment, network creation and communication) aim to mitigate the gap between stakeholders in the technological development, users, and the research group. Structural enablers (availability of funds, reduced U-I mismatch, new research opportunities) propel the path to market the research outcome. Cultural enablers (effective identification, translational approach) empower scholars to contemplate external applications that challenge existing beliefs that hinder commercialization. Figure 2.6 centralizes their findings and the relationship among them.

Dr. Ruth Graham highlights in her study[Gra15] the vital role played by "*a small number of university champions for change*" and their personal connections with the industry and entrepreneurial community and the support received from regional, national, or governmental agencies. Working on research projects with industry partners is positively associated with an interest in research commercialization[PTM$^+$13]. A strong professional identity as a scientist can sometimes limit an individual's involvement in entrepreneurial activities. A good understanding of barriers and enablers for fostering a sciencepreneurial identity is needed. Moreover, since the professional networks of scientists tend to be limited to the academic world, encouraging entrepreneurial outcomes requires removing this limitation and supporting future founders to expand their network outside this threshold[HFR22]. Universities can leverage alumni networks, research networks, industry networks, funding networks, and even student networks on the path to commercialization of breakthroughs. Even with the lack of specific skills, social networks, and other resources needed for transforming research into products, researchers believe that at the core of successful technology commercialization lies the purposeful engagement of the scientists[HFR22]. An individual purposeful engagement can be facilitated and inhibited by social norms. A collective where commercialization is seen as detrimental to traditional scientific values or an "unnecessary distraction" can manifest at all levels of the academic chain (in the lab, at departmental and institutional level)[HFR22]. The creation of a cross-campus committee made of key position individuals across all university departments with a background in sciencepreneurship who can work together to implement the mission and vision of the university is seen by D. Welsh as a key resource for cultural change. The committee can also act as advisors and asses application grants connected to innovation and entrepreneurship[Wel14].

Status is as well an important component in the development of a strong academic sciencepreneurial ecosystem. The best universities boast a high position in various ranking scores, Nobel laureates affiliated with their university, various renowned prizes and awards, Christian Doppler Labs and a culture for excellence and exceeding expectations. This of course, attracts on one side the attention of highly-qualified professors eager to join an ecosystem that breathes innovation and, on the other side, the resources needed to experiment and foster innovation. From access to well-equipped research facilities and an established academic network to funding and engaged students, the university status lends credibility to an academic institution[ONVH22].

Cameron Davis et al. from McKinsey and Company firmly believe that the ecosystem has a higher chance of growth when a region's existing skill base and institutional strengths are leveraged[DSSY23]. A university's research areas usually outline **interdisciplinary domains of expertise**, forming the foundation for its scientific identity and the strength of its research profile. While many inventions can be incremental innovations, slight improvements of existing technologies, and would be more suitable for the licensing route, universities have the resources to generate radical innovations and breakthroughs that will drastically change the status quo. Licensing these technologies to existing companies might be difficult as they tend to cannibalize existing solutions[SOWOM22] or are so disruptive that new markets need to be created[MM19]. This is especially relevant for the type of research the university conducts. Basic research provides a fertile ground for discoveries; experimental research can help validate concepts developed from basic research and give scientists the confidence to pursue a sciencepreneurial path, while applied research is directed towards solving current problems and generating solutions that can be rapidly transferred to the market.

Independently of the type of research or domain or ecosystem an university operates in, an important constant for assessing the state of a technology has been the Technology Readiness Level (TRL) Model developed at the National Aeronautics and Space Administration (NASA) in the 1970s. Technology Readiness Level (TRL) is a systematic method for evaluating the maturity of a technology or innovation. It offers a scale from 1 to 9, where TRL 1 signifies the earliest stage of conceptualization, while TRL 9 represents the highest level of maturity, indicating widespread deployment and utilization[Man23]. However, researchers are challenging the traditional Technology Readiness Level (TRL) model, outlining its shortcomings and improvement opportunities[OEJT20]. KTH University even developed a new method to assess the status of innovation on its pathway to the market using six critical areas of innovation development called the KTH Innovation Readiness Level[Inn23].

Moreover, universities have the responsibility to challenge the feasibility of breakthroughs to avoid potential risks and harm to individuals, like in the case of the blood tests conducted by Theranos Labs. Dr. John P. A. Ioannidis was very vocal about their technology being seen as revolutionary in the medical space despite its lack of publications that other scientists could challenge and scrutinize[Kha17].

The ethos of the educational setting, including its commonly held values, norms, leadership, infrastructure, and specific entrepreneurial offerings, can influence both the intentions and actions related to entrepreneurship[MJA15]. Dianne Welsh recommends in her practical guidebook for creating creative campus-wide cross-disciplinary entrepreneurship[Wel14] that management should ensure monetary support for operations and human resources from the beginning. She points out that one of the institution's most common mistakes is minimizing the importance of setting up the necessary infrastructure for such cross-disciplinary programs. She also emphasizes the need for a dedicated director and a minimum of one full-time employee for every 20,000 students, covering additionally overlooked positions like a webmaster or a media manager, and a visible space on campus with a dedicated place for hosting networking events.

Research parks and campuses, followed by science parks, demonstrate the highest research activity among innovation infrastructures[MT15]. Research parks, along with incubators, tend to establish research activity and foster university-industry collaborations more rapidly compared to other intermediary infrastructures[MT15]. The age of a park influences the speed of university-industry partnerships, with newer parks showing greater potential for fostering open innovation among their resident ventures[MT15].

University infrastructure often includes laboratories, research facilities, equipment, and other technical resources that can be costly for a newly established spin-off to acquire independently. Accessing these resources allows the spin-off to utilize specialized facilities without significant upfront investment. Imperial College London for example, offers through the Imperial White City Incubator a combination of laboratory and office space for new and growing ventures independently of their sector and their stage[Lon17]. The incubator features well-equipped and adaptable laboratories ranging from 25 to 100 square meters, providing versatile scientific research and development spaces. These labs have shared amenities such as autoclaves and glass washers, facilitating various scientific processes and experiments. Additionally, the incubator offers individual private office suites varying in size from 15 to 50 square meters, tailored to meet diverse requirements. These offices are designed to accommodate different client needs, providing a mix of styles and sizes suitable for ventures seeking dedicated office spaces alongside their laboratory facilities.

Another example of infrastructure development is the ecosystem developed around the University of Strathclyde in Glasgow. The Glasgow City Innovation District[Dis24] is part of the Glasgow City Region's three Innovation Districts, which have been shaped and underpinned by significant investment, promoting economic growth and urban regeneration. The hub for entrepreneurship, innovation, and collaboration, was designed to drive inclusive economic growth and tackle societal and global challenges. It brings together ambitious, forward-thinking people to have access to top notch research developed at the University of Strathclyde to nurture and accelerate growth. The District resulted from a successful partnership between the Glasgow City Council, the University of Strathclyde, Scottish Enterprise, the Glasgow Chamber of Commerce, and Entrepreneurial Scotland. It aims to create a thriving community of companies, researchers, and innovation support organizations that promote innovation and develop innovation skills.

In-line with the research pillar of universities, research centers have been the standard organizational entity within an university to foster collaboration and innovation together with the industry[BB03]. However, innovation is reshaping conventional work environments into open and adaptable spaces, fostering cross-disciplinary collaboration commonly known as "*innovation spaces*" [DAMP21]. Lorena Delgado et al. defines an innovation space as a

> "*place dedicated to stimulating the creativity of users, which executes innovation projects taking advantage of the availability of adapted environments and resources, allowing prototyping and creativity. In fact, these spaces are used to increase the capability to generate new products*"[DAMP21]

Innovation spaces have gained immense popularity, especially for the higher education sector, which has been investing heavily in constructing such spaces[DAMP21]. These creative hubs can include Fab Labs, Makerspaces, Co-working spaces, and Living Labs, creativity rooms, research centers and others and are seen by universities as a means to combine research, teaching, learning, and business within academia and fostering "*collaborative learning*"[DAMP21]. These physical spaces can be easily be transformed into "*innovation laboratories*"[DAMP21] to support innovative projects with the industry within a creative environment that make use of dynamic capabilities, a flat hierarchy that fosters participation and double-cycle learning concepts[LM05].

An emerging trend in academia involves the establishment of 'Learning Factories,' which are educational replicas of industrial setups, mainly focused on Industry 4.0 technologies. For a Learning Factory to be considered industrially and educationally significant, it should ideally meet four key criteria: inclusion of authentic processes, reconfigurability, production of physical products, and incorporation of pedagogical elements to support learning[NMM22]. Examples of such factories include the MIT.nano Fabrication Facility that provides cutting-edge nanoscale fabrication and characterization tools for research in nanoscience and nanotechnology, the M-Cube Pilot Plant (ETH Zurich, Switzerland) that focuses on sustainable chemical and process engineering for environmentally friendly manufacturing processes or SCALE-UP (University of Cambridge, UK) that focuses on logistics and supply chain research, offering a space to test new logistics technologies and strategies.

Makerspaces are designated areas on university campuses that provide students, researchers, faculty, and sometimes the broader community access to tools, expertise, and space to engage in applied cross-disciplinary learning and experimentation through prototyping[Kla20]. It helps individuals to muster confidence in their ability to experiment with materials and technologies to manufacture things, which according to Liz Orwin, is an important aspect, especially for women and underrepresented minorities[Kla20]. Moreover, Matthias Friessnig and Christian Ramsauser have investigated the connection between the maker movement, product development, and the start-ups with local hardware start-ups from the UnternehmerTUM MakerSpace and have developed a structured Maker Movement Element framework that can be used as guideline[FR21]. Example of such campuses can be found at various universities, for example at the Stanford University - Stanford Product Realization Lab (PRL), at Carnegie Mellon University - IDeATe (Integrative Design, Arts, and Technology Network) or at the University of California, Berkeley - Jacobs Institute for Design Innovation.

Funding is powering the support system that fosters an academic entrepreneurial ecosystem and ensures new technologies are fed to the venture capital sector. While sources of funding can vary widely (internal funds, philantrophy, investments, research funding), it has been difficult to correlate a specific source to an increased number of ventures generated. However, Jessica Sarceda and Steve T. Cho's research shows that VC backed universities have generated more ventures than non-VC backed universities[SC20].

A significant source of funding comes from philanthropy, especially in the US where paradigm for entrepreneurial philanthropy[HMS11] has been in continuous use since the late nineteenth century. They define entrepreneurial philanthropy as

> "*the pursuit by entrepreneurs on a not-for-profit basis of big social objectives through active investment of their economic, cultural, social and symbolic resources.*"[HMS11]

These individuals and others like them stand out through their determination and perseverance in accumulating their fortunes and their desire to contribute a significant part of their wealth in projects that promise a high social return[HMS11]. Through this approach, they engage in the "world making process" and put themselves at the cornerstone between business and philanthropy [HMS11].

To increase the income from this stream, university networks need to be leveraged. Alumni network donations can contribute to establishing or enhancing university-affiliated entrepreneurial formats (e.g. venture funds to support early-stage science-based start-ups, entrepreneurial fellowships or scholarships, research grants, and especially Proof of Concept grants)

Proof of Concept (PoC) funding has long been seen as a standalone instrument to bridge the gap between invention, industry application, and commercialization for promising embryonic research-based inventions (RBIs). The lack of funding sources that allow inventions to be developed to a point when they are market-ready is seen by many as one of the leading causes why inventions cannot cross the "*valley of death*"[BPU27]. Universities are increasingly adopting Proof-of-Concept programs to create new mechanisms that boost the Technology Readiness Level (TRL)[BPU27]. These initiatives aim to elevate the maturity of Research-Based Innovations (RBIs), enhance their readiness for investment or successful commercialization (licensing to external industrial partners or sale), and foster the generation of spin-off ventures[BPu21]. They combine PoC funding with an extensive support system, harmonizing research, and commercial activities to help the fast transition to commercial application [BPU27]. Therefore, Battaglia D. et al. [BPU27] emphasize the need to fund not only PoC as a standalone financial tool for increasing the TRL of RBIs but also allocate both financial and organizational resources to foster an infrastructure around the PoC that is responsible for boosting the commercialization of RBIs. The reasoning behind this is twofold: on one side, the scientists face multiple challenges on their commercialization track that need to be addressed with the help of experts; on the other side, even "early-stage" investors see these early stages of RBI extremely risky and prefer to invest in proven technologies where risks can be easier assessed and managed[BPU27]. Startup Estonia even developed a program to educate local investors how to invest effectively[OEC20]. Consequently, it allows them to easily attract investors to their funds, find cooperation partners, and minimize unnecessary documentation.

Universities often offer various **entrepreneurship formats** to support affiliates to explore, develop and launching business ventures. These formats can include: education on entrepreneurship and innovation, pre-incubation, incubation and acceleration programs, hackathons and competitions, entrepreneurship centers and hubs, funding and investment opportunities, networking events and conferences on innovation and entrepreneurship, an entrepreneur in residence or an advisor in residence program, platforms for innovation partnerships and investment and the traditional Technology Transfer Offices[OEC20]. The DutchCE university consortium, for example, holds around 600 events and programs a year, ranging from entrepreneurship education for students or (aspiring) entrepreneurs to innovation challenges with corporate innovators, start-ups, and students. They have a validation program (Get Started), an incubation program (Get Business), and acceleration programs as collaborators for the later stages of development[OEC20].

With education being one of the main functions a university has to provide, the students (either at the bachelor, master, or Ph.D. level) are the ultimate customers. Entrepreneurial education has become a must and is now considered a cornerstone for success. Its importance is revealed in the unconventional speech of one the former presidents of the

Kauffmann Foundation, Carl Schramm, who compares starting a business in America with the traditional anticipation of marriage and parenthood[Wel14].

New concepts like the reverse classroom centered on learning by doing are revolutionizing traditional courses. Students are required to study at home and perform their homework in class. The focus is on experiences and skill sets they can apply in the real world[Kha11].

Cross-disciplinary entrepreneurship provides the much-needed skill sets of tomorrow's society. In the vision of Leo Higdon, there are seven traits that define the 21st century "*liberally educated, entrepreneurially informed student*": the ability to challenge conventional thinking, the ability to recognize abstract relationships and detect connections where others do not, understanding the importance and dynamics of teams, the ability to not lose sight of the preoverall goal as well as vital skills such as learning from the encountered obstacles and efficiently, effectively and persuasively communication[Hig05].

Online university offerings have opened new educational opportunities to students who lack the time commitment to attend traditional classes. Moreover, universities like Stanford now allow access to any student, independent of their university affiliation, to online entrepreneurial-centered courses. In contrast, universities like MIT have opened all their course databases to the public. Access to knowledge is believed to legitimize the "HERO within"[DSDP08], providing a confidence boost and a positive view on overcoming barriers.

But does education on entrepreneurship and innovation at the HEI level lead to more venture creation? Kyoung-Joo, L. and Yang-Joong, Y. set up to settle this matter after they noticed that most studies done primarily depended on subjective and perceptual data from students, and the results were controversial and challenging the classroom format of this type of education. They employed an objective perspective using official data from university-level education programs and observed a positive impact on venture formation[KJYJ02].

Figure 2.7 reflects the structured approach taken by The Trust Center with its entrepreneurial programs. It follows a systematic approach throughout the academic year, commencing with introductory courses and gradually advancing through various levels and offerings. The outcome of such an approach is an ecosystem capable of accommodating diverse entrepreneurial interests, prioritizing the entrepreneurial learning journey and not the number of start-ups founded. It has the capacity to support both the individuals seeking only to broaden their knowledge on the subject and the ones committed to starting their own venture. It provides value to those aiming to acquire entrepreneurial skills and apply them in the corporate, nonprofit, or other organizational contexts, as well as to those interested in fostering entrepreneurship within accelerators and support structures or utilizing their skills in policy-making[Deg21].

Moreover, moving our attention from the student perspective to the academic employee perspective, sciencepreneurial education does not result in lower quality research. On the contrary, the positive impact outlined so far on the student's side can also be observed at the university's scientific personnel level. According to researcher Ricardo Fini and

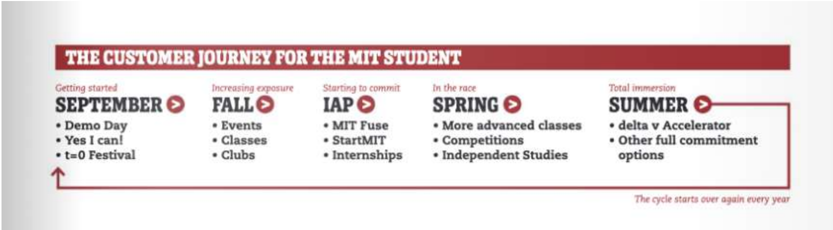

Figure 2.7: Customer Journey for the MIT Student -. Source: Extract from the MIT Impact Report 2022

his team, “entrepreneurship leads to more impactful research, mediated by exploration” and encourages interdisciplinary approaches because it shifts their attention from pure academic questions to critical real-world challenges [FPR21]. This, of course, does not mean that every scientist should be trained for the sole purpose of becoming an entrepreneur. On the contrary, their study looked at over 9,500 academics employed at Imperial between 2001 and 2011 who remained in their research position, and it showed a positive impact on the depth of their research. Kyoung-Joo, L. and Yang-Joong, Y. even recommend that the university administration allocate more financial and human resources and facilitate collaboration between education program managers and other formats for entrepreneurship and innovation available within the university (e.g., incubators and venture funds)[KJYJ02].

MIT built its programs by leveraging its close relationship with MIT alumni. The difficulty they faced was ensuring a culture centered on a "give-back mentality" that simultaneously avoids conflict of interest and unbiased, impartial advice from them [Deg21]. By emphasizing their support is educational-only, aiming to introduce practical learning experiences for mentees, the management managed to gain founders’ trust in various stages of development very fast: from very early-stage teams who don’t even have a business model to advanced projects, already on their commercialization path.

> "*We don’t screen to pick winners; rather, VMS’s mission is to use any plausible idea as the focus for practical education on the venture creation process.*"[Deg21]

Sometimes, these alumni join the more formal programs of universities like the Entrepreneur in Residence (EIR) or Advisor in Residence (AIR) programs run within incubation programs. Business incubators, especially in technology, drive national competitiveness by fostering knowledge exchange and continuous learning. The success of incubated ventures relies on collaborative efforts between businesses and incubators, leveraging skilled consultants for practical actions. This dynamic relationship shows promise, driven by high-quality interactions, contributing significantly to positive outcomes[MB19]. The idea is that EIRs, respectively AIRs, work closely with teams for some time, providing guidance, knowledge transfer, and support with business strategy and other engagement opportunities (investors, partnerships, collaborations, etc.). In Europe, an example of such a program is offered at Eindhoven University, where five entrepreneurs in residence are there to support the commercialization endeavors of founders[Uni24].

MIT is also home to a large variety of **student-led organizations and professional clubs**, which are very active and contribute significantly to the culture of bringing innovations to society by facilitating learning and networking opportunities: MIT boasts an Entrepreneurship Club[EC23] that aims to bring together exceptional founders and offer them the resources and networks needed for venture building, a Public Innovation Club[Sch23] that tackles the implications of the intersection between the public sector and technology on the future roles of business leaders, a Venture Capital and Private Equity Club (VCPE)[fME23] there to assist its members in learning everything about private investing and over 400 clubs within the MIT School of Engineering[oE23] like for example the Solar Electric Vehicle Team.

Traditionally, **Technology Transfer Offices(TTOs)** are at the core of a university's research commercialization process. However, as the innovation landscape changes, Weckowska, D.M. is of the opinion that even the Technology Transfer Offices(TTOs) need to rethink their role from a transaction-focused to a relation-focused approach[Wec15]. Moreover, Battaglia D. enforces that TTOs should play a more active role in the early stages of research outcomes commercialization and PoC programs. Their role should go beyond the simple selection of promising RBIs. It should encompass support for assessing market applications of technologies and facilitating access to the correct network to validate market assumptions [BPU27]. This approach allows for fostering both technology push and pull.

With a changing landscape, it is more vital than ever that attitudes toward increasing trust in the university technology transfer office (and/or equivalent) must be fostered. A study done in the UK revealed that only 39% of founders consider they received a "fair deal" from the university[UDoST23]. Their recommendation is a more transparent negotiation process based on market norms. If a generalized spinning-off guide is not possible, it is recommendable that universities are willing to publish and share more information about their typical deal terms and expectations on time to complete the spin-off process[UDoST23]. Furthermore, the study also emphasizes that some universities employ rigid stage-gate processes leading to delays, while others mandate approvals from academic committees lacking commercial expertise and meeting irregularly. It is recommended that the university approvals should be entrusted to trusted individuals rather than infrequently convening committees[UDoST23].

Moreover, some universities have expanded their service portfolio outside of identifying and protecting intellectual property, negotiating licensing agreements, and facilitating technology transfer from university to industry with the introduction of Entrepreneurial/Innovation Centers. They aim to offer formats and support services to help university affiliates expand their entrepreneurial skills and encourage the founding of new ventures[Wan21]. Pre-incubation, incubation and acceleration programs, pitching competitions, training, consulting, facilitating access to funding, and assisting with business plan preparation are examples of how university-based entrepreneurship can contribute to local business development outside their educational path. Data on the impact of incubators on the success of deep tech ventures is scarce. However, after studying the impact of incubator support in Israel, Prof. Daniel J. Isenberg concluded that when well-conceived and managed, incubators require 20 years or longer to generate a measurable impact[Ise10].

Over recent decades, universities have developed **University-Affiliated Venture Capital (UVC) funds** to address the funding shortage for new ventures stemming from academic research. Yet, more information is needed regarding their distinct features, roles, investment principles, and governance structures. These organizations strive to blend the commercial principles of venture funding with the academic ethos of educational institutions and research centers. According to Nina Magomedova et al., these types of funds stand out from traditional CV funds "*.... in terms of investment interests (their primary goal is to facilitate the financing and creation of USOs), shareholders (the university often has a stake in the fund) and size (they tend to be smaller)* "[MVM23]. The study's authors express concern about the homogeneity of reluctance to invest in early-stage high-risk innovations from traditional European VC funds. One of the first initiatives for creating a university venture fund in Europe came from the UK where all universities were invited to join the University Challenge Fund[MVM23]. Today, various universities have setu up venture arms and the concept is widely embraced.

Most **university competition formats** encountered are business plan competitions, pitch challenges, hackathons, and, more recently, Innovation Challenges. At MIT, for example, most such competitions are initiated by students and continue to be managed by students.[Deg21].

University alliances and collaborations with other regions foster international collaborations and knowledge exchange with impact on a global level. Such an example is the Singapore-MIT Alliance for Research and Technology (SMART)[fRT23] launched in 2007 in collaboration with the National Research Foundation of Singaporte (NRF). Its aim was to mitigate technological risks and define a go-to-market strategy for technologies. As well, The DutchCE functions as a consortium of Dutch Universities aiming to strengthen and apply entrepreneurship education and research while supporting policy-making and promoting the excellence of the Dutch ecosystem.[OEC20]. At European level, the European Commission initiated the European University Initiative, aiming to foster 60 European Universities Alliances with over 500 HEIs until the middle of 2024.

Forums and Think Thanks are also formats sciencepreneurial formats encountered at universities. For example, the MIT-China Innovation and Entrepreneurship Forum (MIT-CHIEF), initiated in 2011 by MIT students, serves as a nonprofit organization fostering connections between US and Chinese entrepreneurial communities through events like its annual conference, business plan contests, and trips to China. Over eight years, it has engaged over 31,500 participants and evolved into the largest Sino-US startup community on the East Coast. MIT-CHIEF's impact includes collaborations with numerous corporations, incubators, and investors, facilitating notable successes for startups like Smarking and XTalPi, which have gone on to secure significant funding and achieve breakthroughs in their respective industries[Deg21]. The London School of Economics (LSE) Ideas (LSE IDEAS) is ranked as the best university-affiliated think tan in the 2019 Global Go To Think Tank Index. LSE IDEAS is known for its research and influence on policy, and its global reputation for excellence is an important part of maintaining LSE's mission to shape the world.

Innovation and innovation commercialization, as a constantly evolving, dynamic process, present notable challenges regarding their measurement. The **evaluation of an entrepreneurial academic ecosystem** can, in itself, be the topic of an entire master's thesis. Therefore, this research was primarily focused on the identification of key pillars that can then be expanded into a fully-fledged evaluation framework.

OECD provides all HEI institutions the "Oslo Manual"[OEC18] manual that contains guidelines for collecting, reporting, and using data on innovation. Since it aims to establish standardized methods for collecting and reporting information about innovative activities across various sectors and economies, it should be a must-read for any university affiliate engaged in the assessment task. Only by ensuring sound measurement of data collection and reporting efforts can policy members make sense of the efficiency and effectiveness of their policies. OECD also offers much information on the global and national context within a comprehensive assessment of individual OECD members and partner countries. This enables more nuanced and relevant metric definitions aligned with broader trends and local conditions. Over the past twenty years, UK universities have been the motor of the local spin-off ecosystems and as thus benefited from increased governmental funding though the Higher Education Innovation Fund (HEIF) in England. Consequently, universities are increasingly assessed also on their commercialisation performance through the Impact component of the Research Excellence Framework (REF), the UK's system for assessing the quality of research in UK higher education institutions [UDoST23]. Although centrally focused on assessing research quality and impact, it indirectly considers elements related to entrepreneurship, especially in determining the impact of research outputs on society, industry, and the economy.

Universities operate currently on three main pillars: research, teaching and service (or engagement)[Dim20]. Defined broadly, research focuses on the generation of new knowledge, while teaching concerns itself with the dissemination and transfer of the knowledge. The service pillar focuses on the role of the university within the ecosystem or society [Dim20]. Each of these pillars are unique and contain a different understanding of how a good performance is defined, thus different key performance indicators for evaluating its stage and impact. Rothaermel T. et al. proposes as potential key reference points formal contracts, cooperation agreements, research support, licensing and the quality of commercial output, marketing activities, quality of commercial output, involvement in research joint ventures, existence of incubators and science parks[TAJ17]

Strong academic research and a culture of innovation within universities often serve as catalysts for entrepreneurship and **impacts the society and the ecosystem multi-faceted**. On an academic level, the institutions will expand its reputation as innovation driver and building entrepreneurial mindsets, which in turn will foster collaborations, attracting funding, and inspiring innovative research aligned with practical applications. On a societal level, an entrepreneurial mindset that complements existing tech knowledge can lead to the creation of innovative solutions that address pressing social and environmental challenges. It fosters a culture of problem-solving, creativity, and resilience, which are essential for developing groundbreaking ideas and products. Moreover, entrepreneurial success stories and initiatives can inspire and drive programs aimed at enhancing entrepreneurship education, skill development, and training, preparing individuals for entrepreneurial endeavors. From an economic perspective, more spin-offs means economic growth by creating jobs, stimulating local economies and contribute to the development of new industries or sectors though the introduction of radical innovations. These new technologies that have the potential to address environmental needs and improve overall sustainability.

University ecosystems with a strong entrepreneurial and innovation focus are powerhouses for the economy. Beyond revenue and employment, we can observe in multiple cases that major entrepreneurial campuses emerged as a consequence. Universities can be a powerhouse for high tech clusters and industrial parks. For example, The Kendall Square[Ass23] where a new industry, biotechnology emerged is a result of the proximity to MIT [Deg21]. According to the book "From the Basement to the Dome: How MITs Unique Culture Created a Thriving Entrepreneurial Community" the interaction between investors, entrepreneurs, drug development veterans and the easiness with which you can meet all these people in this small area is the reason why many choose this ecosystem as their base and decide to remain here long-term.

Moreover, MIT alumni not only founded start-ups, but also went on and launched accelerators, incubators and coworking spaces that acted as a multiplier for start-up creation[Deg21]. An example is Techstars, one of the most recognized for-profit accelerators in the area. But similar organizations can be seen throughout US, for example Berkeley Skydeck or HarvardAE. Similarly, one can find examples of Venture funds of alumni investing in alumni. Castor Ventures is such an example at MIT or Strawberry Creek Ventures at Berkeley. Similarly, in Europe the TU Investment Club Alumni of TU Münich reunites people working in investment banks, hedge funds, PE/VC funds, start-ups, university or mid-sized and large industrial enterprises.

2.2 External Ecosystem

Scholars have also recognized the important role external factors like various policies and laws, industry and regional ecosystem can have on the development of an academic entrepreneurial ecosystem[Etz03].

Regional ecosystems exhibit significant variations across different locations when it comes to how their entrepreneurial ecosystems form and perform as they are a distinct mix of cultures[HT14], economic histories, local policy initiatives, labor markets, and sectors and industries and, as a result, clearly differentiate from the term “ecosystem” used in management and policy literature (e.g innovation ecosystem) [Spi20]. These informal institutions might benefit and are influenced by the existence of role model entrepreneurs who contribute with their extensive expertise, network, and vision to the ecosystem[AH15].

In 1995, Bahrami and Evans were among the first to describe the Silicon Valley ecosystem as a "*mutually supportive spiral of entrepreneurship and innovation*", identifying its main components and the key process that enables the recycling of old to new firms, angel funding and a sophisticated service infrastructure[Mal18]. Looking at the environment today, the Valley boasts a complete array: technology, capital, skilled individuals, numerous ventures, and a culture that promotes collaborative innovation and accepts setbacks. However, this ecosystem's chaotic evolution was possible only due to a strong local aerospace industry, a Californian open culture, an academic ecosystem at Stanford centered around close collaborations with the industry, Fairchild Semiconductors, a liberal immigration policy that allowed an influx of doctoral students into the campus and a lot of luck. [Ise10].

Another example of the importance of a robust local ecosystem is the Aalto University in Finland, according to the study "Creating university-based entrepreneurial ecosystems evidence from emerging world leaders" [Gra15]. Their national educational strategy centered on research and innovation closely intertwined with industry needs has notably received substantial support both from industrial sectors and, via a technology innovation funding initiative, from the government. Additionally, the Finnish Funding Agency for Technology and Innovation (Tekes) has significantly contributed by providing financial backing to numerous entrepreneurial and innovative endeavors, among which the area of Espoo, one of Finland's major R&D centers.

Proximity to industries within the regional ecosystem facilitates collaboration between universities and businesses. This collaboration can lead to joint research projects, technology transfer, and specific job skill set specifications, fostering an entrepreneurial spirit and influencing the entrepreneurial activity at a university.

At national level, although entrepreneurship typically operates locally, entrepreneurial ecosystems are often recognized and analyzed nationally as distant resources can also be critical [Mal18]. Especially in small countries and due to globalization new firms are sometimes "born global". The example of Israeli entrepreneurs that build up links to London and Silicon Valley from the onset of their companies is brought up in the literature by Schäfer S. [Sch17] already in 2017 as a result of his research. Maleki defines Finland and the Netherlands as excellent examples of entrepreneurial ecosystems at the national scale[Mal18].

The development of spin-offs and start-ups can be influenced not only by the entrepreneurial atmosphere within a university but also by the national societal perceptions regarding the desirability of entrepreneurial endeavors[STM18]. National culture refers to "*the values, beliefs, and assumptions learned in early childhood that distinguish one group of people from another*"[NN96]. Cultural values impact how entrepreneurial thinking is shaped, including aspects like independence, creativity, and risk-taking, which are essential for determining how desirable entrepreneurial behaviors are perceived within a society and directly impact the supportiveness of the external environment for new venture creation. Moreover, the government's ability to facilitate entrepreneurial endeavors is directly connected with the policies designed with the cultural context in mind.[STM18].

A survey conducted with over 120 spin-offs at universities from the Czech Republic, Spain, and the Slovak Republic revealed that forward-thinking governments who grasp the importance of supporting entrepreneurship and innovation through policies and funding mechanisms can be a significant motivator for increasing spin-off formation [CDF+22]. Even though the administration should commit to ongoing experimentation, many governments adopt an erroneous approach to developing entrepreneurial ecosystems. They strive for an unachievable ideal of an ecosystem and seek best practices from economies vastly different from theirs. Instead of trying to recreate the next Silicon Valley, governmental leadership should strive to analyze the strengths and weaknesses of its local entrepreneurial dimensions and tailor their support to fit its needs (circumstances, resources, geographic position, culture). Professor of Management Daniel J. Isenberg[Ise10] discusses this aspect and additionally believes that effective practices that emerge from trial and error can be found in remote corners of the earth, where resources, legal frameworks, transparent governance, and democratic values may be scarce. He also recognizes Rwanda, Chile, Israel, and Iceland as supportive ecosystems for entrepreneurship due to the aid given; Rwanda's president reportedly even boasted that "*Entrepreneurship is the most sure way of development.*" [Ise10]. Of course, the government alone cannot foster a thriving ecosystem. The private and nonprofit sectors have to complement their endeavors and contribute responsibly. It is essential that these stakeholders are involved from early on and that thriving ventures are celebrated and highly publicized. The media holds significance beyond commemorating victories; it can influence and transform perspectives and mindsets. Government agencies have the power to promote them within official publications, press releases, or awards, bring in foreign delegations for visits, or bring delegations for visits to strengthen international relations and present them as role models for the ecosystems and be used as a source of examples for pushing reforms [Ise10].

Promoting, supporting, and strengthening clusters of interconnected companies, educational institutions, and other organizations centered within an area or region can be easily supported nationally. It is recommended that governments reinforce and build on existing or emerging clusters instead of creating new ones. Isenberg is of a strong opinion that " To justify cluster development efforts, some seeds of a cluster should have already passed a market test...."[Ise10]. Therefore, the role of the government is to gently encourage supportive economic activity around already successful ventures.

Funded internationalization programs ensure that local breakthroughs aim for a global reach. The Startup Delta/TechLeap.NL program, for example, supports the internationalization of Dutch start-ups through international missions for groups of Dutch start-ups at global network events, globally known entrepreneurial ecosystems for a chance to learn and further develop the local ecosystem and promising destinations for Dutch start-ups[OEC20].

Legal, Bureaucratic, and Regulatory Frameworks are usually the main tools for supporting the formation of entrepreneurial ecosystems and consequently increasing entrepreneurial activities. However, the administration has a more comprehensive, holistic role to play than just this part because usually legal and regulatory reforms often take many years to push through, leaving entrepreneurial endeavors alone to fend for themselves over this period. Prof. of Management Daniel J. Isenberg's extensive research pinpoints a couple of reforms that are generally perceived as impactful on venture creation: decriminalizing bankruptcy, shielding shareholders from creditors, allowing entrepreneurs to quickly start over, changing the focus of unemployment protection from making dismissals challenging to offering assistance and support for those without employment, creating and liberalizing capital markets, simplified tax regimes and robust auditing and collection, removing administrative and legal barriers to venture formation[Ise10]

Although Europe is a global leader when it comes to research and innovation[Cou23] and has had and still has a mandate to encourage breakthrough technology generation at the university level, European universities tend to fall behind their U.S. counterparts when it comes to technology transfer largely to differing legal systems[TAJ17].

Over the past six years, the Austrian government has been intensively discussing with ecosystem representatives to introduce legal and tax measures to encourage the creation and growth of start-ups and spin-offs in Austria. Among the measures recently introduced, we can name the introduction of the new legal form “FlexKapG” [Inv23] that facilitates a reduction of the minimum capital upon incorporation to 10,000 euros (50% must still be paid in) and a new tax model for the participation of employees where 75% of the invested amount is taxed at a capital gains tax rate of 27.5%, while the remaining 25% is taxed at the progressive income tax rate. However, this measure is limited to companies with less than 100 employees and sales under €40 million. [Inv23]

At European level, the European Commission advocates for policies supporting technology transfer, innovation and entrepreneurial education within universities. Their reports position universities as facilitators for breakthroughs and have devised a series of initiatives to foster entrepreneurial activities in universities.

The European Innovation Council (EIC) offers various forms of support to facilitate the transformation of research into market-ready products or services[Cou24]. Their funding opportunities provide substantial funding to high-risk, high-potential innovations throughout their development life-cycle, from early-stage research to market entry. The funding scheme is complemented by access to coaching, mentoring, and entrepreneurial education, helping innovators refine their business models, validate their technologies, and prepare for market entry. These activities are usually outsourced to the members of their Partnership Program, among which many universities offering research commercialization programs locally. The EIC also provides access to a wide array of networking opportunities within the broader European innovation ecosystems by facilitating partnerships, access to investors, and other EU initiatives and networks operating in this realm.

Programs like the Horizon 2020, Marie Skłodowska-Curie Actions, European Research Area (ERA), Erasmus+ Program, or the European Research Infrastructures (ERICs) facilitate research exchanges, cultivating interdisciplinary collaboration and nurturing an environment that encourages diverse fields to work together, leading to groundbreaking innovations.

Global trends are pivotal in fostering university entrepreneurial activities by influencing the direction, focus, and support for innovation and entrepreneurship. Global trends highlight emerging needs, challenges, and opportunities and influence investment and funding patterns. Universities leverage these trends to align their research and entrepreneurial efforts with areas of high demand or societal significance. Social, environmental, or economic trends guide universities to develop research and entrepreneurial activities addressing pressing global challenges like climate change, the aging population, healthcare access, or sustainable development. It fosters a culture that values innovation, risk-taking, and problem-solving, essential for entrepreneurial success.

Emerging technologies bring transformative potential and risks that require careful governance. A proposed framework, comprising values, design criteria, and tools, aims to guide national and international governance efforts has been proposed by the OECD for this purpose. It emphasizes strategic intelligence, stakeholder engagement, and adaptable standards to foster responsible innovation and international cooperation, aiming for broader stakeholder involvement and agile governance mechanisms across diverse emerging technologies[OSiToD24]. Since building national competitiveness through targeted investment in different areas of science and technology R&D is a key aspect, it is expected that this will result in a stronger investment in the academic innovation ecosystem.

The World Intellectual Property Organization (WIPO) created the the Academic Intellectual Property (IP) Legal Framework[WIP24]. It refers to the rules, regulations, and policies governing the ownership, protection, and commercialization of intellectual property created within academic institutions on four levels: international, national, institutional, and professional associations-related levels. They aim to encourage innovation, incentivize research, and balance the interests of creators, academic institutions, and society in accessing and benefiting from intellectual property generated within academic settings.

Through the literature review, we've uncovered various factors influencing academic entrepreneurship. The next chapter aims to make sense of these insights, weaving them together to provide a clearer understanding of how these factors shape the landscape of entrepreneurship within academia.

CHAPTER 3

A Framework for Developing an Academic Sciencepreneurial Ecosystem

After conducting an extensive and comprehensive review of the available literature on academic entrepreneurial ecosystems, incentives, factors and risks, the findings have been meticulously synthesized, compiled and consolidated into a robust framework. This framework encapsulates the crucial components and considerations essential for constructing effective academic entrepreneurial ecosystems. It serves as a comprehensive guide, encompassing key facets from the literature to facilitate a holistic approach in designing and nurturing these ecosystems for optimal success. It serves as a foundational guide, consolidating critical insights to aid in the creation and cultivation of robust academic entrepreneurial environments.

The framework considers at its core that both internal and external factors influence the facilitation of entrepreneurial ecosystems at the university level. The developed framework decomposes and explains each of these factors on a deeper level and will be explained in detail below.

3.1 Internal Factors

The findings could be categorized into six pillars, each playing a crucial role in facilitating sciencepreneurship as depicted in Figure 3.2

3.1.1 People, Heritage, Policies and Culture

People, heritage, policies, and culture all work together to facilitate a well-functioning, innovative entrepreneurial ecosystem. On one side, people bring diverse skills, a piece of

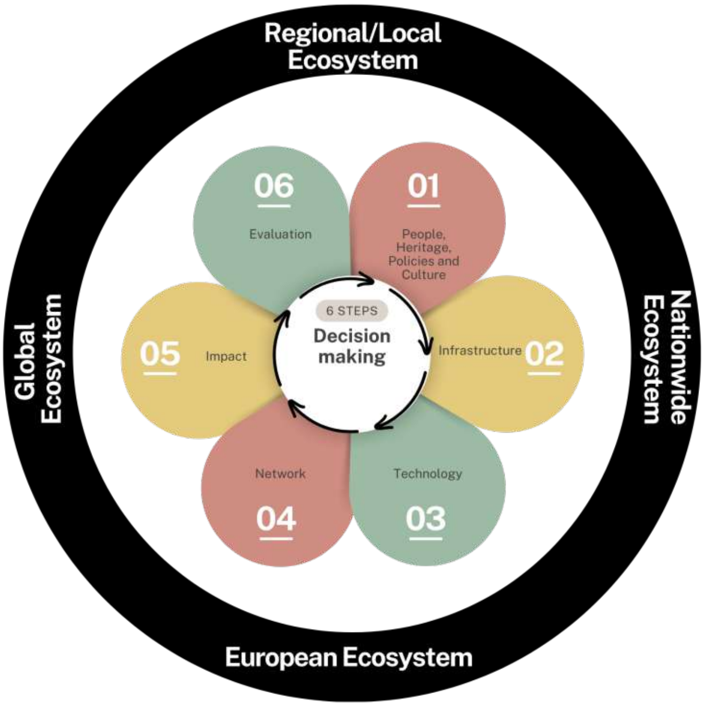

Figure 3.1: Proposed Framework for Developing an Academic Sciencepreneurial Ecosystem

vast knowledge and experience that fosters innovation and problem-solving. They are champions for change that, through their motivation, expertise, research, and dedication, generate new ideas, technologies, and solutions and educate future technologists that contribute to the well-being of the entire society. The more personnel with experience in sciencepreneurship, entrepreneurship, and product innovation or with an industrial background or simply engaging actively such people voluntarily in the academic community, the easier it is to infuse this mindset into university projects and education and to foster a culture of innovation and stimulating entrepreneurship among students and faculty. These change-makers understand market demands, customer needs, and the value of innovation, bridging the gap between academic research and real-world applications. Fostering entrepreneurship and innovation requires clear sciencepreneurship- relevant key performance indicators for evaluating scientific personnel that play a crucial role in the career development of all staff linked to implementing the institution's entrepreneurship and innovation (e&i) agenda.

Heritage serves as a foundation upon which these new ideas can be built. Individuals' cultural identity is reflected in how they collaborate, network, exchange knowledge, drive innovation, inspire, lead, facilitate trust, and embrace new ideas. It often influences an

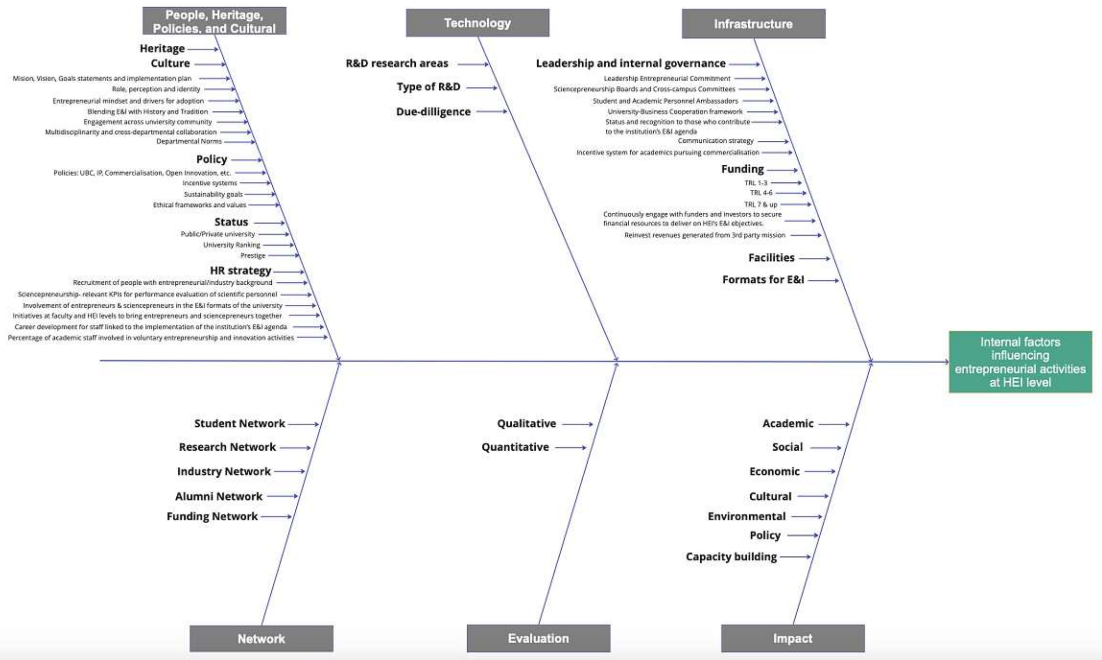

Figure 3.2: Internal Factors for Developing an Academic Sciencepreneurial Ecosystem

ecosystem's unwritten, implicit, and spontaneous aspects of culture. Shaping a culture for entrepreneurship and innovation is a complex endeavor that requires blending a mission, vision, goals statements, and an implementation plan at the university level with a good understanding of the implications of integrating the third mission of research commercialization on the role, perception, and identity of its academic personnel and the generation of a new hybrid role identity model that blends research and research commercialisation. This is only possible if trust is nurtured in the relationship between academics and the university technology transfer office and additional support systems facilitating transforming research into products (e.g entrepreneurship centers or equivalent). When these support systems are seen as supporting, providing open communication and transparent processes in combination with valuable inputs, resources, and guidance, they inherently generate a positive perceived value among the academic personnel.

Policies play a pivotal role in shaping the environment and incentives for academic entrepreneurship and innovation. They cover a wide variety and such examples of such policies are:

- University-Business Collaboration (UBC) Policies aiming to foster synergies, promote knowledge exchange, and facilitate mutual benefits between academia and the business world
- Open Innovation Policies fostering collaboration, knowledge exchange, and external partnerships to stimulate innovation among different stakeholders

- Intellectual Property (IP) Policy that outlines the ownership, management and protection of intellectual propriety resulting from research endeavors for commercial and non-commercial purposes
- Commercialization Policy outlining strategies and guidelines to facilitate and support the commercialization of university-developed technologies or innovations
- Spin-off Policy emphasising the procedures, criteria, and support mechanisms for transforming research into products and introducing them on the market by establishing new companies based on university-generated breakthroughs.
- Sustainability Policy reflecting the institution's dedication to fostering a culture of sustainability through its principles and strategies for integrating the topic among its operations, educational offering, research and innovation and community management
- Responsible Research and Ethics Policy encompasses guidelines, standards, and principles that guide researchers, faculty, and students in conducting research with integrity, transparency, and ethical considerations upholding in this way the highest standards of integrity and responsibility.
- Research commercialization incentive system emphasizing the spinning-off process, expectations and incentives for academics to transform their research results into products both at the university, faculty and departmental level

How this overall blend is then implemented within the departmental norms can act as a catalyst that enables its members to respond swiftly to changes in the landscape and deal with the societal challenges that require different problem-solving approaches.

Additionally, the status of a university plays a vital role in building a robust sciencepreneurial ecosystem and contributes to the culture for innovation and entrepreneurship as high rankings, affiliations with Nobel laureates, prestigious awards, and a culture of excellence attract top professors, academic personnel, students and resources for innovation, offering credibility and essential support for the academic institution. Moreover, while both public and private universities can actively engage in entrepreneurship and innovation, the differences in funding, governance, priorities, and regulatory environments between the two types of institutions can influence the extent, approach, and agility with which they participate in entrepreneurial activities.

3.1.2 Technology

Technology acts as an enabler, catalyst, and driver of innovation as the foundation for developing new products, services, or solutions derived from academic research. Universities often concentrate their research and development efforts in specific areas, developing specialized knowledge and expertise that can then be transferred into the market, becoming the breeding ground for startups and entrepreneurship. These focused research areas often align with industry needs, contributing to further development of the local ecosystem and increasing the likelihood of commercialization of research results. Moreover, the type of research—whether basic, applied, or experimental—plays an essential role in shaping innovation's nature, pace, and outcomes within an ecosystem. While basic research lays the groundwork for innovation by uncovering fundamental principles and theories, its long-term impact on innovation is significant as it often leads to breakthroughs and paradigm shifts. Applied research is usually closely connected to industry collaboration and is, thus, more directly linked to commercialization. Since the problem is easily validated within collaborations, they are easily transferable to industry for further development and commercial exploitation. Experimental research bridges the gap between basic and applied research by validating concepts and theories through experimentation. Experimental research can lead to the development of prototypes, proofs of concept, or validation of theories, which are crucial steps in advancing innovation and technology development.

Universities can also play a critical role in technical due diligence. Through the peer review process, breakthroughs from the scientific process go through an unbiased evaluation by experts, ensuring that the technology's scientific foundation is thoroughly scrutinized, validated, and aligned with the highest standards of academic integrity. Scientific rigor is therefore ensured, and potential risks and limitations are easily identified within this process. Organizations and investors can receive reliable insights on technology readiness, market applicability, and potential challenges, aiding informed decision-making for the technology transfer process.

3.1.3 Infrastructure

Access to well-equipped facilities, event halls, and other spaces for co-creation (coworking space, maker space, innovation campus, pilot factories, living labs, collab center, student space, and any other such spaces) facilitate collaboration, innovation, and experimental learning and development, nurturing a culture for innovation and sciencepreneurship. These spaces provide the necessary environment and resources for a wide variety of formats for e&i to develop and thrive within a university. From open innovation, entrepreneurial education and coaching, advisory and mentoring to student clubs, competitions, awards, and societies to a well-functioning technology transfer office and/or innovation center to pre-incubation, incubation, and acceleration formats and venture funds. However, infrastructure is about more than just facilities and the formats developed on top of these facilities. Foremost is about leadership and governance. Leadership's commitment to entrepreneurship and innovation is reflected in the university's mission, vision, and strategy, in the existence of leads for these topics at the rectorate and dean level, in the existence of a model for coordinating & implementing entrepreneurial and innovation activities across university and being able to define objectives with associated performance metrics reflective of the sciencepreneurial endeavors. To these, one can also add autonomy to act, promoting initiative, facilitating creativity, and enabling dynamic decision-making. Infrastructure is also about ensuring funding opportunities to support the development of promising discoveries and breakthroughs across all TRLs and reinvesting the revenues generated from the third-party mission into developing new opportunities for promising early-stage research projects.

3.1.4 Network

University networks serve as catalysts for building robust academic entrepreneurial ecosystems. Either through its student networks, which tend to be self-organized with a bottom-up approach to entrepreneurship and sciencepreneurship, or through its research networks, which tend to have well-defined structures and encompass researchers, academic institutions, organizations, and experts, all working together to advance knowledge and have the capacity to influence even policy, universities are breeding grounds for innovations. The existence of additional alliances like, for example, alums, philanthropic, and investor networks only strengthens the capacity for innovation or the ecosystems. Alums and industry representatives with an entrepreneurial background motivated by non-monetary incentives can be a cornerstone for building up a sciencepreneurial mindset among the university's academic personnel.

3.1.5 Evaluation

Since each ecosystem is unique, universities need to define the means for evaluating their sciencepreneurial ecosystem in line with their mission, vision, and goals from both a quantitative and qualitative perspective. Quantitative key performance indicators (KPIs) are usually easily defined and range from university rankings to KPIs for assessing intellectual property valorization like the number of patents applied and/or granted per year, number of active patents, revenue from the commercialization of patents/year, Expenditure for IP /year, number of invention disclosures/year, income/revenue from licenses /year, to KPIs for assessing spin-off formation like number of spin-offs supported, number of spin-offs founded, number of spin-off founded that crossed the three-year threshold or other KPIs related to the pre-incubation, incubation, acceleration or other venture-building formats (e.g VC funds) affiliated to the university, to KPIs for assessing blending e&i with research like volume of scientific articles and publications blending e&i with the specific topic (per nature of research), number of e&i educational formats offered at university level, number of academic staff with business/entrepreneurial/industry experience per specialisation. Qualitative KPIs are more challenging to define as they are more representative of the behaviors and attitudes toward sciencepreneurship. Examples of such metrics could be the prominence of sciencepreneurs as role models among the students and the academic personnel, values and behavior alignment, perceived incentive system and barriers, depth and quality of collaborations between academia, industry, government, and local communities, impact and mutual benefit derived from collaborations and initiatives, the ecosystem's ability to adapt to changes in the entrepreneurial landscape and sustain its initiatives or fostering continuous innovation and growth.

3.1.6 Impact

As hubs for critical thinking, universities play a pivotal role in educating how to assess and in assessing the impact of new technologies. Shaping responsible innovation requires a multilayered approach, expanding outside the academic impact of innovations. Pioneers must blend in their assessment besides academic impact, social, economic, cultural, environmental, policy, and capacity-building references. While academic impact focuses on measuring the reach, relevance, and contributions of academic endeavors within the academic community, social impact focuses on innovations' impact on individuals, communities, societies, or the broader world. Economic impact considers at the forefront the economic impact of embracing new technologies, while cultural impact focuses on cultural norms, values, traditions, and societal behaviors. Environmental impact assesses the effect on ecosystems, natural resources, and the planet's overall health. Capacity building involves strengthening the abilities, knowledge, and resources of individuals, organizations, or communities, and policy impact focuses on policies, regulations, and governance frameworks and how they shape how societies function and evolve.

3.2 External Factors

The findings could be categorized into four pillars, each playing a crucial role in facilitating sciencepreneurship as depicted in Figure 3.3

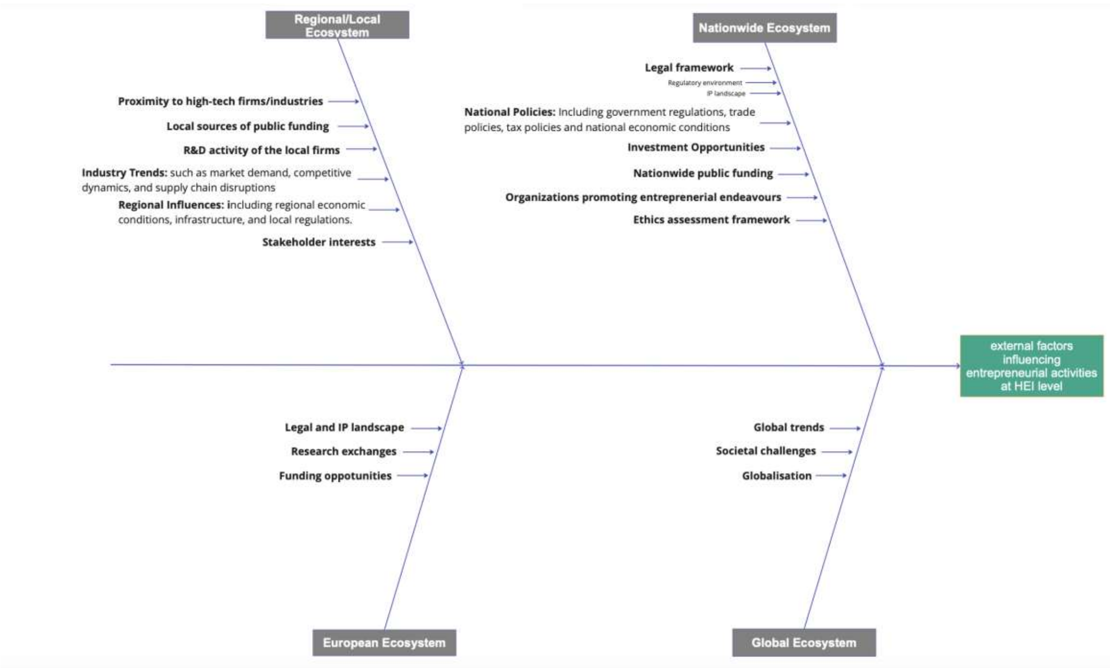

Figure 3.3: External Factors for Developing an Academic Sciencepreneurial Ecosystem

3.2.1 Regional/Local Ecosystem

The regional ecosystem and the academic ecosystem in which it operates are in a symbiotic relationship. They live close together, depend on each other, and get various benefits from the other. For example, the proximity to high-tech firms/industries drives collaboration opportunities, real-world problems, market insights, and access to a wealth of industry expertise that can be later leveraged within the university's technology transfer process. Also, an intense R&D activity usually brings along investments in resources, infrastructure, local sources of funding and other funding opportunities, and the need for very skilled professionals, contributing to forming strong specialized clusters reflecting the industry trends and the regional stakeholder interest in the regional economic conditions. These could only be developed with the existing and continuously developing local regulations, competitive dynamics, and supply chain.

3.2.2 Nationwide Ecosystem

Supporting entrepreneurship and innovation through policies and funding mechanisms can be a significant motivator for increasing spin-off formation. Although operating within a European framework, there are still legal discrepancies between countries regarding the regulatory environment, business registration processes, and intellectual property landscape. Governmental regulations, trade policies, tax policies, and national economic conditions can be catalysts for attracting businesses and investment opportunities to the country. Existing nationwide networks of business angels, VCs, family offices, and endowments facilitate thriving academic ecosystems through cash flow injections alongside nationwide governmental public funding, which generally tackle the early stage of company formation and research. The wide variety of organizations supporting and promoting sciencepreneurial endeavors also plays an important role. In Austria alone, organizations like ABA invest in Austria [ABA23], Austrian Start-ups[Sta23], WKO Advantage Austria[AUS23], or GIN[GIN23] have put a lot of effort into both supporting internally and externally promoting the entrepreneurial and sciencepreneurial endeavors coming from innovations made in Austria. To this, we can add the ethical and responsible research dimensions, as many countries have at least drafted a best practice guide for research integrity and ethics; some even have developed AI Ethics Guidelines that influence the strength of a technological trend in the country.

3.2.3 European Ecosystem

Like the nationwide ecosystem, tax incentives, regulatory and IP frameworks, and startup-friendly policies impact academic entrepreneurial ecosystems. Harmonized regulations facilitate cross-border collaborations and European governments have the capacity to define policies that encourage academia-industry partnerships and entrepreneurship, which builds on top of Europe's strong reputation for collaborative research initiatives among universities. Moreover, the funding programs of the European Research Council, Horizon Europe, and other organizations providing funding opportunities for research commercialization facilitate funds to support innovative research and stimulate entrepreneurship within academia. This environment is complemented by an evolving investment landscape that includes venture capital firms, angel investors, and public funding supporting academic startups, fostering a culture of innovation and entrepreneurship through their support of technology transfer directly influencing the activity of the academic ecosystem.

3.2.4 Global Ecosystem

Global connectivity allows sciencepreneurs to identify global market needs and encourages them to develop technologies that address global and societal challenges while creating scalable spin-offs. Rapid technological advancements provide fertile ground for academic entrepreneurs to innovate and create disruptive solutions with global applications. Global trends in technological innovation influence the direction of academic research and, consequently, technology transfer. These trends create opportunities for academia to develop cutting-edge solutions with commercial potential. Very often, societal challenges are the drivers of the innovative path of such technologies. Increasing global awareness of sustainability, for example, drives trends toward environmentally friendly and responsible entrepreneurship. Demographic shifts (e.g., aging populations), cultural changes, and the perceived attitude toward risk-taking can shape innovation and market demand and can even influence government policies toward entrepreneurship.

Understanding and navigating all these factors are crucial for fostering inclusive, adaptive, and thriving academic entrepreneurial ecosystems worldwide.

CHAPTER 4

Facilitating Academic Sciencepreneurial Activity - Study

4.1 Qualitative Study

Qualitative studies offer a nuanced approach to understanding complex phenomena, often employing interviews to delve into individuals' experiences, perceptions, and perspectives. Setting up interviews involves meticulous planning, including participant selection and protocol design. For the purpose of the qualitative study, interview questions have been defined for each of the main pillars identified in the framework as outlined below.

University ecosystem - People, Heritage, Policies, and Cultural Landscape

At what stage in your career did you decide to create this start-up (e.g., Ph.D, Postdoctoral, etc.)?

Can you describe the moment when you first considered the possibility of spinning out a startup based on your research? What factors or events led to this consideration?

What are the primary benefits you see in spinning out a startup from your academic work? How do these benefits align with your personal and professional goals?

Have you considered alternative paths, such as licensing your technology to an existing company or collaborating with industry, and what led you to consider spinning out a startup as the preferred approach?

How do you weigh the potential impact of your research within the academic community versus the broader societal impact that a startup might offer? What factors are influencing this decision?Could you share an example of a specific moment or situation where you felt torn between your role as a scientist and the potential of being a founder? How did you navigate that situation?

Are you aware of any policies or strategies at the university level for facilitating an entrepreneurial mindset/ encouraging the generation of academic spin-offs? (e.g. UBC Policy, Open Innovation Policy, IP Policy, Ethical framework etc.)

What role, if any, either directly or indirectly, did other university research staff (academics, post-docs, PhD students) play at different stages in the startup? Did they support/hinder you?

Are other research staff members part of your founding team (Research staff def. to include)?

Is there anything that you have learned during your experience of the start-up process that you think should be included in formal training for PhD students, post-docs, or early career academics?

From your perspective, what specific incentives or support measures do you believe would most effectively encourage and facilitate academic staff members in spinning off their research into entrepreneurial ventures, and how might the university enhance or introduce these incentives?

University ecosystem - Technology

Did the university's status or reputation play a role in your commercialisation path?

Is your spin-off stemming from a research project where an industry partner was involved?

What was unique about the academic research results that led you to consider the commercialisation / spin-off route?

How, if at all, did your technology or business model change through the startup? Did you have to pivot at any stage? How did the university support this change?

University ecosystem - Infrastructure

How would you define the entrepreneurial ecosystem of the university?

Can you describe the initial support you received from your university when you decided to spin off your startup? What resources or programs were made available to you?

How did the support you received from the university evolved after the initial stage of spinning-off up to 1 year after the company foundation:

- Were there specific educational programs or entrepreneurship courses offered by your university that you found valuable in building your entrepreneurial skills?
- Did your university provide any funding, grants, or office space or access to other infrastructure to facilitate the startup's early development?

- What types of intellectual property support or legal assistance did you receive from your university when it came to licensing your academic research for the startup?
- How did your university assist in connecting you with potential co-founders, advisors, or industry partners?

At which stage was the entrepreneurial support received from the university most active?

Are you part of any network affiliated to the university that contributed to your commercialization efforts?

What was the greatest challenge in your relationship with the university in the early stage of your start-up?

What type of support would have been in your opinion vital and should have been provided by the university?

University Ecosystem - Impact

Do you think that your university start-up shaped subsequent academic research?

Would you consider engaging in a research collaboration with the TU Wien as a spin-off now or in the near future?

How do you (plan to) measure the success and outcomes of your academic spin-off? Are there specific benchmarks or indicators you will use/use to gauge the impact, and how do you hope these outcomes will contribute to the broader academic and entrepreneurial landscape?

How do you envision your research making a tangible difference through the spin-off?

External Ecosystem

Can you describe the startup ecosystem in your region and how it supported your venture? Did you engage with local incubators, accelerators, or innovation hubs?

- Were there any government grants, incentives, or startup-friendly policies that played a role in your startup's development?
- Did you seek out partnerships with other startups or established companies in your ecosystem? How did these collaborations benefit your venture?
- Have you participated in networking events, pitch competitions, or industry conferences within your ecosystem that helped raise your startup's profile and connect with potential clients or partners?
- Did you access any mentorship or advisory programs within the ecosystem (outside the university), and how did these relationships impact your startup's growth?

Could you please share how the proximity to high-tech firms in this area has influenced or contributed to the company's growth and innovation strategies?

Could you provide some insights into how industry trends have influenced the development and success of your company?

What is your company's view on the influence of the legal framework, trade policies, and the regulatory system on your operations and strategic decisions? I'm interested in understanding how these external factors have shaped the company's approach and outcomes.

How has your company recognized and harnessed the opportunities presented by societal changes, such as demographic shifts and evolving cultural and social attitudes?

How important was the availability of a skilled workforce or talent pool in your ecosystem for hiring team members? What do you consider as skilled?

What challenges or barriers did you encounter in navigating the ecosystem, and how did you overcome them?

No incentive system - ask them about their career path. What they would have considered as an incentive

How would you describe the overall impact resulting from the transformation of your research into a marketable product? Please detail how this product has influenced or changed aspects of society, considering its introduction into the market.

4.2 Quantitative Study

In this section, you'll find the quantitative study questions utilized in the research. These questions were specifically designed to gather numerical data, aiming to quantify various aspects and patterns within the study's scope. The structured nature of these inquiries allows for statistical analysis and objective evaluation of the gathered information.

Founding year:

Is the spin-off still active? Yes/NO

What is the legal form of the company: FexCo/ GmbH/ AG/ OG/ KG/ Sole Proprietorship/ Other

Type of company: public/private *Public companies trade their shares on the stock market, while private companies are held privately, often by founders, investors, or employees.* **Do you plan to go public in the next year?** yes/no

Has the spin-off obtained the title of "TU Wien Spin-off"? yes/no (if no, why not?)

Headquarter Country: **Subsidiaries Countries**:

Sector (select all that apply): Biotech, EdTech, FinTech, MedTech, InsurTech, PropTech, Cybersecurity, Leisure and entertainment, Logistics, FoodTech, Aeropsace, Advanced Manufacturing and Robotics, Blockchain, AgriTech, Digital Health, AI and Big Data, Climate Tech, E-Commerce, Materials Science, Gaming, Retail, Wellbeing, Wearable technology, Esports, HR tech, Transportation, Space Tech, IoT, Other

Product Data:

How many products has your spin-off already brought to the market?

No of products under development (if applicable):

Are the products sold only locally, or are they available outside Austria too? (select all that apply) at national level (Austria)/ in the DACH region/ in Europe/in the USA/ in Asia/ globally/ does not apply (no products on the market)

Communication Language within the spin-off team:

Founder Data:

No. of founders:

No. of female foudners:

No. of male founders:

No. of gender-neutral founders:

At the moment the company was founded, in which age groups does your founder team fall into? (select all that apply): under 20 years old/ 20-25 years old/ 25-30 years old/ 35-40 years old/ 40-45 years old/45-50 years old/ over 50 years old/ other

Employee Data: No. of employees (excluding the founder team):

No. of full time female employees:

No. of part time female employees:

No. of full time male employees:

No. of part time male employees:

No. of full time gender-neutral employees:

No. of part time gender-neutral employees: No. of (m/f/x) employees with other working arrangements:

No. of employees that have graduated or are students of TU Wien:

No. of employees that were part of the scientific personnel of TU Wien:

Please select the aspects that most accurately represent your affiliation with TU Wien at the time when support from the university was provided (multiple selections possible):

- ☐ The spin-off is based on the PhD work at TU Wien of one of the founders
- ☐ The founder team contains/contained TU Wien scientific employees
- ☐ The founder team contains/contained PhDs undergoing their PhD at TU Wien
- ☐ The spin-off is based on a/more patent(s) filed by TU Wien and there exists (or is under negotiation) a License Agreement with the TU Wien
- ☐ At least a member of the founder team underwent the Extended Studies on Innovation Curriculum for students
- ☐ The founder team contains alumni of TU Wien
- ☐ The spin-off is a result of an Open Innovation Collaboration with the TUW

Please select the specific support networks, resources, or aid you received from TU Wien during your entire commercialization path:

- ☐ participation in the TUW i2ncubator Program
- ☐ Office space in the i²c Founder Space
- ☐ I²c Award (commercialization grant for PhDs that comes along with a spot in the TUW i²ncubator and office space in the i²c Founder Space)
- ☐ Financial support from the TUW i2ncubator through the aws Jumpstart program
- ☐ Mentoring from the TU Wien Innovation Incubation Center Advisors outside the incubation program (e.g prior to the start of the incubation program, as alumni after the completion of the program)
- ☐ Financial support for participation at fairs/events
- ☐ Discounts for participation at fairs/events
- ☐ Support with Fundraising
- ☐ Lab space
- ☐ Perks due to the affiliation to the TU Wien/TUW Innovation Incubation Center/TUW i2ncubator (e.g. aws/google cloud credits, HubSpot for startups or other such formats)
- ☐ participation at workshops covering a wide variety of topics related to research commercialization and entrepreneurship
- ☐ Knowledge exchange among TUW Founders (e.g buddy system, Founder Night, Mastermind program, etc.)

- ☐ participation in the TUW i2ncubator Negotiation Club
- ☐ IP Protection Services
- ☐ IP Strategy Services
- ☐ Support with research and development contract negotiations
- ☐ Support with finding collaboration partners offered by TUW Innovation Incubation Center
- ☐ support with finding collaboration partners offered by TUW Fundraising and Industry Relations
- ☐ support offered by the TUW Responsible Research Practices department
- ☐ facilitating joint research collaborations with the TUW after the founding of your spin-off
- ☐ support for public grant applications

Intellectual Propriety

Does your company have an IP Strategy? yes/no

No. of Patents owned:

How many of these patents are digital patents?:

No. Of Patents pending:

What other means of IP protection are you using?

Expenditure for IP /year: < 10k / 10-50k / 50-100k / 200-500k/ 500k-1 mio./ >1 mio. / Does not apply (no expenditure for IP)

How many license agreement deals your company has/has had with TU Wien?:

Financial and Fundraising Data:

Is your company already making revenue? Yes/ No

What is your company's current revenue? < 10k / 10-50k / 50-100k / 200-500k/ 500k-1 mio./ >1 mio. / Does not apply (no revenue)

Is your company already profitable? Yes / No

Last completed funding round stage: Pre-seed/ Seed /Series A /Series B /Series C and up /currently bootstrapping

Type of investors already on board (multiple selections possible):

- ☐ None

- ☐ Friends and Family
- ☐ Business Angel(s)
- ☐ Venture Capitalists (VCs)
- ☐ Private Equity Firms
- ☐ Corporate Investors
- ☐ Crowdfunding Investors
- ☐ Family Offices
- ☐ Incubator(s) or Accelerator(s)
- ☐ Banks
- ☐ Other

Amount of money raised from investors from founding date until now: < 10k / 10-50k / 50-100k / 200-500k/ 500k-1 mio./ >1 mio. / Does not apply (no investor on board)

Amount of money raised from public grants from founding date until now: < 10k / 10-50k / 50-100k / 200-500k/ 500k-1 mio./ >1 mio. / Does not apply (no grant received)

Do you plan to start a fundraising round in the next 1 year? yes/no

4.3 Findings and Discussions

This section presents the unique findings of our study, which involved six active TU Wien spin-offs that received diverse forms of support from the university. Our primary aim was to map the current sciencepreneurship ecosystem at the university using key interview questions that are representative of the framework developed. The study was possible through the voluntary participation of seven founders, including a spin-off that provided individual insights from both co-founders. This distinctive approach shed light on the collaborative dynamics within the founder team, offering a diverse range of expertise and backgrounds to learn from. This was particularly valuable as, due to the division of roles and responsibilities, some of the founders could not answer certain questions.

Before conducting the study, effort was put into comprehending the dynamic entrepreneurial landscape of the university guided by the proposed framework through an exploration of online data available to both externals and employees of TU Wien.

To assess the status of the university, we first set our focus on university rankings, and we could easily find on the TU Wien Website a breakdown of the position of TU Wien within various university rankings together with a clear statement that part of the internationalization strategy of TU Wien, they plan to affirm their position in the

Die TU Wien in den vier relevantesten internationalen Rankings

Ranking	TU Wien	Uni Wien	ETH Zürich	TU München
QS-Ranking	184	130	7	37
THE-Ranking	251-300	119	11	30
Leiden Ranking	460	219	16	189
Shanghai Ranking (ARWU)	301-400	151-200	20	56

Figure 4.1: TU Wien in the four most relevant international ratings, Source: TU Wien Website

QS World University Rankings and the World THE Rankings as one of the Top 250 universities[WIe24b]. Image 4.1 outlines that TU Wien is in the top 200 universities globally. Moreover, according to the newly issued "THE Subject Ranking 2023", TU Wien occupies #93 for Computer Science[WIe24c]. Furthermore, TU Wien benefited from a boost in prestige in 2023 when the physicist Ferenc Krausz, renowned for his groundbreaking research conducted at TU Wien, was awarded the Nobel prize for his innovative experimental methods for generating attosecond light pulses[WKO24]. Moreover, TU Wien hosts 17 Christian Doppler Labs, a commitment to innovation and excellence by conducting application-oriented fundamental research at the highest level. These partnerships are globally recognized as a leading model for facilitating collaboration between renowned scientists and innovative companies.

Assessing other aspects of the People, Heritage, and Culture pillar was not as straightforward. However, it was easy to find TU Wien's mission statement on their website. Under the motto "Technology for people", the university combines in their mission statement central keywords: "progressing from theory to realization - from concept to application in the spirit of an 'Innovation and Entrepreneurship University'"[Wie24a] and "knowledge and technology transfer" under five main research areas where the university stands out: Computational Science and Engineering, Quantum Physics and Quantum Technologies, Materials and Matter, Information and Communication Technology, Energy and Environment. However, there are no references or words of encouragement toward alternative career tracks for scientific personnel or Ph.D. students[Wie24a].

Set out to find out how prevalent the topic of "spin-offs" is at TU Wien, a simple search as an external on the TU Wien website for the keyword "spin-off" over the year 2023 and the first two months of 2024 revealed only 39 results, respectively, 42 for the internal view, including references to the archive where some events were stored. Filtering by "News" only 13 results were given, and out of these results, five articles were actually relevant and promoted either a spin-off, an award won by a TU Wien spin-off, or a grant a spin-off can apply for. Considering the low engagement of the topic in the communication strategy, one could deduce that alternative career tracks are not explicitly promoted university-wide. The Faculty of Informatics has, however, a dedicated page for spin-offs and startups, providing a platform to promote the numerous innovative companies that have emerged from their faculty. Surprisingly, 50 departments were mentioned for this keyword search, but none of the departments mentioned were the Research and Technology Transfer the Innovation Incubation Center, nor any of the Business Informatics departments within the TU Wien. However, under educational programs, two courses offered to PhD students were visible. My research revealed that TU Wien offers actually more than 43 lectures supplementary to these two either on creativity, innovation, entrepreneurship, business modelling and more which have been added in Annex A.

While conducting an investigation into TU Wien's strategy and policies, the search revealed only information about the Human Resource Strategy for Researchers and the Policy for Research Data Management. On a secondary search, a TU code of conduct based on the European Code of Conduct for Research Integrity, as well as a Patent guide explaining the steps in the patenting process, were identified. Unfortunately, no reference was found for any other type of policy, strategy, or guideline for those interested in spinning out/off technology. Unlike other universities, TU Wien also does not have a public definition of the term "academic spin-off" or "academic spin-out." TU Wien has, however, a website where example technologies are available to browse. While the initial absence of a formal definition of "spin-off" at TU Wien posed a challenge during the research, an insightful glimpse into the publicly available "Leistungsvereinbarung 2022-2024"[WBfB22] between TU Wien and the Federal Ministry of Education, Science and Research reveals the institution's ongoing commitment to cultivating an academic entrepreneurial ecosystem, emphasizing technology transfer, innovation, and the provision of essential resources and infrastructure. Unfortunately, no other references to the framework were identified. The university does not publicly provide any information on any boards and cross-campus committees, on how they blend E&I with history and tradition, or any reference to a specific status or recognition towards those contributing to the E&I agenda and to the existence of any incentive system for those considering pursuing an entrepreneurial path nor any type of funding for transforming research into products.

Armed with an idea about the university's ecosystem, the next step consisted of conducting the study and familiarizing myself even more with the unwritten aspects of the academic sciencepreneurial ecosystem. The results of the study are detailed below.

4.3.1 Qualitative study

Internal factors influencing entrepreneurial activities at HEI level

One remarkable aspect of the TU Wien academic entrepreneurial ecosystem is the diverse perspectives held by our interviewees. While their views varied widely, they agreed on two key aspects. Firstly, the pivotal role of the TU Wien Innovation Incubation Center as the heart of the entrepreneurial ecosystem of TU Wien. They stand out through the support offered, and even the spin-offs who have not participated in the incubation program actively attend the networking events they organize. They bring a different mentality to the university, where innovations have the floor to share what makes them unique, get feedback, find the right cooperation partner and path to market and learn more about customer needs, in contrast to the cultural inclination towards research characterized by of secrecy around what you are working on and the idea that 'industry is bad'. Some interviewees were even adamant, sharing that the ecosystem is the Innovation Incubation Center, and there is nothing else at the university. Four interviewees shared that the Innovation Incubation Center opened the ecosystem for them. They remember the internal messages from the service unit well, even if they acknowledge that it was only when they considered an alternative career track that they got engaged and reached out. Especially those from fundamental research had challenges grasping the usefulness of the opportunities offered.

Secondly, the TU Wien entrepreneurial ecosystem has evolved significantly over the past years. It has transformed into a very 'tech-focused ecosystem supporting spin-offs or founders from TU Wien. This evolution is a testament to the ecosystem's adaptability and its capacity to really transition technology into products, making it an attractive prospect for potential investors and entrepreneurs. However, they challenge the clarity of the direction TU Wien wants to pursue as the ecosystem lacks visibility and promotion, especially internally. There is a lot of potential, but the challenge is whether the management is able to understand, support, and capitalize on this potential. Ph.D. students, for example, need to be adequately informed about the spinning-off opportunities at TU Wien, which is a matter of concern. They need to be made aware that spinning off is encouraged at TU Wien. One founder even challenges whether spin-offs are seen as opportunities or extensions of existing universities' working groups.

Most of the founders started assessing the business potential of their research already during their Ph.D. and, at the end of their Ph.D., spun off by pursuing one of the various grants from the ecosystem. One specifically praises the FFG Spin-off Fellowship which is actually a grant give to the university as the one of the pivotal factors for their success. Only two of the seven spin-offs have professors in their founder team, and one spun off very late, with two founders already having a professorship status but having a Ph.D. and a master's student as part of their founding team. Determination and a strong affinity for an entrepreneurial path can also play an important role. One founder, for instance, expressed that his interest in founding a company dates back to high school. His studies at TU Wien further honed his skills, helping him identify the right market gap to start a successful company.

The factors that determined the interviewed founders to spin off their research range from personal determination to meeting the right people at the right time to encouraging feedback from the industry. Four of the founders emphasized the role industry played in their early stages. One founder built a prototype just to validate whether the research conducted was actually working and asked some experts to try it out out of research interest. The prototype not only received great feedback and suggestions on how to make it better, but these experts also tweeted about the prototype, generating a lot of buzz in that niche domain. The positive feedback from testers and the many follow-ups from people who wanted to buy the product due to the tweets spurred the founder to explore commercialization opportunities. Other two spin-offs had a similar commercialization path. They presented their research at conferences, congresses and trade fairs and the industry approached them with a lot of interest. This, in turn, triggered the thought to valorize the result.

All founders spoke about key people who played an essential role in their decision to commercialize. These people range from representatives of the Research and Technology Transfer Support office for the patenting process or who encouraged them to apply to some specific grants that would suit their stage immensely to supervisors who, even with limited business expertise, encouraged them to consider the research result´s commercial potential to representatives from the Innovation Incubation Center with whom their discussed their research potential and learned about the following steps to consider. We can also add the positive response from grant institutions in Austria that gave them confidence in the potential of the research.

Out of the seven founders interviewed, only one strongly desired to pursue a career track in the startup world. For this person, pushing forward to do something efficient and senseful was a strong motivator. The rest haven´t even considered this alternative career track before their engagement with the industry. One even mentioned that convincing was needed to consider exploring the potential of the technology, and the other founders played a crucial role in this as they strongly believed in the potential of the technology, even if not as close to the technology itself as the founder. Finally, one founder decided to found a company due to current personal circumstances: moved to Vienna after leaving tenure at another university. The founder explicitly said that leaving tenure would not have been an option in different circumstances.

Surprisingly, none of the founders considered other commercialization paths for their innovations. On one side, the technologies were too early or only working for specific use cases, and further development needed to be done for use in the industry. On the other hand, very specific and scarce knowledge would have been required if licensing had been considered, and it wouldn't have been possible to implement it without it. Most importantly, after learning about the potential of their research, the majority were driven by their hands-on mentality to implement and do something with it within a spin-off. One founder even shared they loved the challenge it brought.

At a personal level, founders find immense fulfillment in spinning off their research. They are driven by a deep passion for their research topic, enjoy immensely working on it, and, through the spin-off, they are rewarded both intellectually and financially. The remuneration they receive for their efforts is not just a financial one, but as well in the form of recognition and the satisfaction of bringing something they developed to the market. Since, most of the time, governmental funding was given to further transform the research into a product, they see it as a duty to give back to society by actually commercializing the technology. Multiple founders agree that being a Ph.D. could be similar to being a founder in many ways. Both require motivation and resilience to build something or research something. However, being a founder allows you to work on something you are passionate about with more freedom, speed, fewer boundaries, and overloaded structures compared to academia. Spinning off from academia can also provide a buffer and a certain level of security for the early stages of company formation. Academia can offer the ability to already work towards the product, leverage grants supporting this path, and not have to start from scratch with the responsibility of employees and all the challenges of running a company.

On a societal level, founders recognize a significant gap between research results and their accessibility to the public. In many cases, universities develop fundamental research that, while academically valuable, is not readily usable by the industry. This gap underscores the importance of bridging the divide between academia and industry, a responsibility founders are uniquely positioned to address. Academia can even sometimes kill great legacy projects due to the lack of long-term scientific employees capable of passing on crucial knowledge about the research project to new employees. When grants are awarded, what already exists at the university could be more valorized; it gets put to sleep as it is easier to start something from scratch instead of investing a considerable amount of time into understanding older solutions existing and building on top of them.

The personal and societal perspectives also reflect how they evaluate their research's impact on the academic community versus the broader society. They consider that academic impact is restricted to publications, novelty, and peer reviews, and sometimes, due to its complexity, the research is difficult to reproduce. While a lot of interesting research is being done, it is far from the market. Building a product is different. You are operating at a completely different level, and your job is to close the gap between research and marketable products. Novelty is important, of course, but within an SME, you just have to be better than the status quo. It is also less anonymous; people can use it easily, and it forces you to develop a completely different mindset from your existing scientific one.

All founders faced a culture clash between their scientific persona and the newly added founder persona throughout the commercialization path, and all admit they still struggle with it to this day. Their major challenge is their internal fight between curiosity, discovery, and perfectionism with the pressure to deliver a product within time, financial, and resource constraints to ensure the company´s survival. This is reflected not only in the product development phase but also in how the product is being introduced. They would always like to get into the needy, greedy details of how their technology works. However, they often have to dile down their excitement for the technology and present a unified strategic approach about why their technology is unique and ensure they can sell the product. The transition from academia to entrepreneurship is not just a change in title, but a significant shift in responsibilities. As a Ph.D. student, your focus was on attending a few meetings, but as a founder, a substantial part of your daily job is no longer development but rather management. Additionally, risk-taking and risk management are also different when you are a scientist versus a founder.

Unfortunately, the founders unanimously voiced a significant shortfall in their understanding of the university's policies and strategies that foster an entrepreneurial mindset and promote the creation of academic spin-offs. Their knowledge is limited to a broad overview, primarily centered around inventions, patents, and intellectual property rights ownership. The founders' awareness was most pronounced for the IP policy, followed by the University-Business-Collaboration policy (two founders) and ethics (one founder). According to the founders, the policies are not really visible. Instead, especially around IP, there is a robust word-of-mouth-driven community at TU Wien, where much of the information shared is informal. The information learned about the UBC policy is either based on their own experience from engaging in collaboration with the TU Wien or through workshops on writing research applications where topics like research collaborations were discussed. As scientists, ethics in research is a topic they are aware of and know of the existence of support in this area, but have yet to engage as they consider it is not something needed for their spin-offs up to now. Overall, the founders are aware there is a lot more happening at TU Wien since they initiated their spin-offs but challenge the existence of policies that encourage the generation of spin-offs even now. Similar to the policy situation, the founders were also unaware of any incentive system at TU Wien for spinning off. However, they openly talked about what they personally perceived as an incentive, and that is:

- the educational programs and guidance offered by the Innovation Incubation Center,
- the support received by the Research and Technolgy Transfer Support for protecting the intellectual property,
- the network of founders at the university, a supportive community that shares experiences and provides guidance,
- the option to reduce employment time at TU Wien and work besides on the spin-off,
- specific lectures and, more importantly, lecturers and their approach to lecturing,
- Problem validation interviews arranged through the TUW i2c incubation program and INiTS.

The educational programs and guidance offered by the Innovation Incubation Center are seen as pivotal. The incubation program is not only a catalyst for transferring research results into products but also a beacon of quality support. The founders who participated in the program praised the personalized support and the quality and engagement of the mentors within the program. The program has built up a strong network and engages it to find the right support system for the founders. Additionally, being affiliated with an incubation program strengthens their position on the market as they are not seen as one of the many SMEs that pop up overnight on the internet and can disappear at any point. The founders who did not participate in the program were also aware of the support the department is offering but expressed that they learned too late about the program's existence. By then, they already engaged with other programs, such as INiTS.

The incentive systems for two of the interviewed founders were more on the IP level. TU Wien boasts experienced people supporting the patenting process. This support was pivotal for a spin-off at the beginning of the road with no knowledge of the patenting process. It was also their first insight into a potential IP strategy. They continued using the same lawyer for their next patents and were able to set up, with the lawyer's help, an IP strategy for the company.

The power of example provided by the network of founders at the university also played a pivotal role. The founders found it enlightening learning about other people's journeys, knowing that someone underwent the same challenges and invested much effort, but it paid off, depending on how each individual defines success (e.g., money, freedom). One university department from which one of the interviewed founders was stemming already had many people with startup experience willing to share their knowledge about building a company during lunchtime. Although the norm out of the interview was that the other academic personnel (academics, post-docs, Ph.D. students) were supportive (some even acting as sparring partners) or at least neutral towards their spin-off initiatives, one founder specifically mentioned how professorship hindered their spinning-off process. Some departments are reticent to the process and still operate under a mentality that 'industry is bad'.

One spin-off shared how important it was that one of their co-founders managed to negotiate a reduction in the working time to 32 hours, which freed eight additional hours of intense work on the spin-off. Providing such incentives in the future could encourage more spin-offs considering that six out of the seven interviewees had at the moment when they spun out at least one co-founder from the academic community of TU Wien.

Lectures can also be a powerful incentive if delivered in an interactive way. The founder dearly remembers a specific lecture where the lecturer challenged the students to research and discuss the advantages and disadvantages of a particular solution. This process ended up sparking the idea for the spin-off. The lecturer also supported the next steps and provided the first industry contacts for early market research. Additional support came from both INiTS and the i2c, who opened their network to help with the problem validation process.

Regarding the role that affiliation with TU Wien had on their commercialization path, the founders acknowledge that TU Wien has a strong reputation not only in Austria but also in the DACH region. The affiliation offered credibility in that they had the knowledge and background to build the product. However, how much this influenced the commercialization path is hard to assess. On one side, one founder mentions that they always start their introduction with the fact that they developed the technology during their Ph.D. studies at TU Wien and thus have no means of comparison if this is or is not an incentive for their customers to work with them. Another founder acknowledges receiving their first customer through TU Wien, and a professor intermediated the meeting. However, it is not easy to assess how many of the other customers were due to the TU Wien affiliation or because of their very active campaigns. One spin-off has zero customers in Austria and challenges the importance of affiliation with the university. However, one thing is clear: outside the DACH region where TU Wien's name is less influential (according to the founders), everyone understands the concept of a “spin-off”, which can be a source of credibility.

Even if two of the spin-offs developed their technology after spinning off, they all considered and discussed within their team the uniqueness of the research and its potential, even if they had only a limited understanding of the market. The process was more straightforward for those who already had a working prototype. The technology either worked well for specific use cases, or they could already define a clear unique value proposition. They had a technology push, not a market pull, so the uniqueness of their technology was at the center of their attention. For the ones who developed the technology later, it was similar to a gamble. They understood the potential the technology could bring but have yet to try it in an end application. They believed they could find a more efficient solution than the status quo.

The interviews were also set to assess the role industry partners played in fostering a commercialization path for the technology. Surprisingly, none of the spin-offs developed their research projects in collaboration with an industry partner. They developed them in a purely research context with no third-party funds. However, they have all reached in parallel to various experts for feedback. Some even used students as an intermediary source for market validation. One founder shares that TU Wien students tend to study longer than other students and, therefore, must work beside their studies. This means you can access a wealth of market insights through this target group.

For the majority, the technology has not changed much. They did not have to pivot significantly product-wise, but the spin-offs eliminated some options during the process as they were running pilot projects with the industry or implemented micro changes that could not be easily pinpointed. One team had to develop an intermediary, so their efforts concentrated more on bringing it into the final application. However, much exploration and validation were involved on the business model side. Some needed to learn what a business model was when they started the endeavor. It was a steep learning curve. The university and other TU Wien institutions like INiTS played an important role, especially in the early stages of their development. On the one hand, on the educational side, helping the new founders complement their technical skills with business competencies and, on the other hand, acting as a sparring partner for finding a viable business model for their products. Below, you can find a list of the most essential sources of support received from the university in the early stages of company formation:

Support received directly from the university:

- Support from the Research and Technology Transfer Support on IP protection and licensing;

  To quote one of the founders, the department’s support can be summarized in a sentence: ’They were from sketchy to scary to very helpful, everything.’ Four out of the seven spin-offs consider the support of the department pivotal. Their experts facilitated the patenting process, and one spin-off even praised the speed with which they patent technologies as a unique selling point. In their case, it made a massive difference for the company as they were unaware that a similar technology had been developed at another university. Fortunately, TU Wien was faster in the patenting process. Another founder shares that they reached out to them as they had a corporation interested in paying for the research they developed and wanted to understand what the best approach to do this would be. This initiated a series of exchanges centered on whether the technology is patentable. During this process, the scientists did not feel they were discussing on an 'eye-to-eye' level and that there were hidden interests from the university's side that they could not make sense of at that point. Regarding IP licensing, the spin-offs acknowledge they received fair deals, but the negotiation process was cumbersome for some. Also, there is much word of mouth, not necessarily all good about the negotiation processes with the university. As a scientist negotiating against a team of lawyers, it can be pretty challenging so the time investment in the negotiation was significant on their side as they had to understand "lawyer language" and its implications on the future of the spin-off. The support received stopped after the patent filing, respectively, after the negotiation, but in some cases, it played a role in the early IP strategy of the spin-off.

- Access to infrastructure: lab space and coworking space

  Two spin-offs emphasized the importance of access to lab space for their spin-offs. As a newly founded company, one cannot afford to build one's own lab space. However, this type of support was not free of charge from the university but rather mediated through research and research commercialization grants. Examples are the FFG Spin-off fellowship or other research grants from the EIC, where hefty overheads (86%) were paid to the university. The teams, however, received free desk space within the TU Wien Founder Space managed by the TU Wien Innovation Incubation Center while in their programs, and some could continue renting desk space within the coworking space even after graduation from the program (pending availabilities and needs of the new founders joining the program). This support was beneficial, as renting out office space can be challenging. It usually requires a minimum of two years commitment (sometimes even five), and as a spin-off, it is not easy to assess whether you will still be on the market to make such commitments.

- Support from the Innovation Incubation Center: training and individualized mentoring on business and product development, access to a vast network and a dedicated alumni community, access to desk space in the Founder Space coworkingspace

  The founders who underwent the programs offered by the service unit valued the support received immensely. From the STARTacademy to the incubation program and beyond through the community built around the center, the support received shows the dedication and the commitment of the people involved in supporting the program. The teams praised the individualized support they received within the programs as every spin-off is different, and thus, the challenges always required a personal touch. They had access to mentors with industry experience who worked closely with them on both business and product development and had the flexibility to choose with whom they worked. The support evolved from weekly to bi-weekly to monthly workshops and mentoring sessions within the program. They learned a lot about managing people and how to structure themselves, the team, respectively their roles and responsibilities to build a high-performing team. These learnings were so valuable that they are still used to this day in their workflows. After graduation, the alums are still actively engaged in the community, and the sense of belonging is strong as they still feel that they can pop in at any time to ask a question and will always find the help they need there. Interestingly enough, one founder shared that the support received from the Innovation Incubation Center was constant and continues to exist even now. They still have touch points with the mentors and are active in the community but believe the support is perceived as more intense at the beginning because they lacked much knowledge, while now, they have learned a lot from running a business for a couple of years already. Challenges still exist, but they ask for support less often due to their already existing learning curve. Additionally, the incubator supported the founders with a vast network to which one usually would not have access. They leveraged this network to find co-founders, industry partners, and investors and validate their assumptions about the market. This was the only department that helped facilitate access to networks.

- Other support from TU Wien includes departmental contributions to the spin-off, the role of formal and less formal exchange, financial support, and educational programs

  The departments from which the spin-offs originated also played a crucial role in the process. While the leadership and direct supervisors were generally supportive, one of the spin-offs characterized the environment as initially daunting and uninviting. To quote the founder, "from harsh, scary weird because the industry was bad, bad to now every Ph.D. needs to develop something that could be spun out." However, there has been a notable shift in perspective, with one founder noting the transformation from a negative perception to an expectation that every Ph.D. should contribute to potential spin-off projects. This shift underscores the significance of educating leadership on the advantages of integrating research and commercialization and granting them the freedom to explore innovative approaches, ultimately fostering a change in mindset.

  Scientific employees from other departments acted for some spin-offs as sparring partners that generated exciting discussions between the spin-off and the institution. Some were in a more structured manner, through existing collaborations with the TUW, and some were more informal.

  None of the spin-offs received any financial support from TU Wien for their commercialization path. This is something missing completely at TU Wien.

Outside the education offered by the TU Wien Innovation Incubation Center, the founders did not receive any type of additional training. One of the interviewed founders shared that an MBA was pursued, but the founders covered the costs entirely. Another founder could recall that during their employment at TU Wien, there was an internal professional development offer that might have also contained some business training.

Support received from TU Wien affiliated organizations:

- Some spin-offs took part in the INiTS startup camp and their incubation program. During these formats, their business model was challenged, and they received access to the network affiliated with the program. However, one founder shares that the network of the Innovation Incubation Center is much stronger, and there is much more support given at i2c compared to INiTS. One founder also recalled that they were offered office space at advantageous prices in correlation to the stage of their company from INiTS. However, they were highly dependent on lab space and never used this opportunity.

Two spin-offs shared that TU Wien did not play a role in their commercialization path. Both spin-offs were in contact with the RTS for the licensing process but barely received any support after. One spin-off shares that they navigated their path to market with support from the programs offered by the European Commission. They have a very good understanding of the real needs of deep tech spin-offs, especially when it comes to monetary requirements and how to build such resource-intensive innovations to market.

When asked about the areas where they felt the university's support was lacking, the founders identified the following key aspects:

- One founder expressed a strong desire for enhanced support in the early stages. For instance, when their spin-off was awarded the Spin-off Fellowship grant, they struggled to define a path to market and received very little support. They felt that engaging in in-depth discussions with an expert and formulating an exploitation strategy would have been invaluable at that stage. Such support should be provided even before the incubation program.
- One key suggestion that resonated with both TU Wien and the local ecosystem was the need to cater to hardware startups' unique challenges and requirements. For example, concepts in the incubation program were often explained using examples from the software side. A more pronounced focus on hardware development could potentially yield significant benefits for the entire ecosystem.
- Access to lab space is especially problematic for startups in Vienna. An intermediate strategy that would facilitate lab space use by TU Wien spin-offs could be considered.

- Access to computational power since the university has it and it is not always being used, and at the beginning of the road, it does not make sense for a small startup to buy a server rack or something similar.
- Standardization of contracts and a less Austrian negotiation style
- Legal support should also be included in the offerings. At this point, it is understandable that such support might not be possible as the university's interests do not always align with the interests of the spin-off. However, legal advice is one of the most cost-intensive forms of support for a spin-off. If one is not in a position to have someone from the legal field among friends or colleagues, more costly mistakes are likely to happen due to the legal cost savings from this early stage.

On their path to market, the spin-offs encountered three challenges dealing with the university ecosystem that needs to be mentioned, analyzed in depth, and improved.

- *IP licensing negotiations*

  The most significant challenge encountered by the spin-offs was the process of IP negotiation with the TU Wien. Even if the outcome was positive, these negotiations are not only intense, time-consuming, and lengthy, but they also play a crucial role in determining the success of the spin-offs' journey to the market. Some of the founders have questioned whether the university's mindset is truly focused on getting technology into the market. Without prior information and the possibility to ask and connect with people who underwent or are in the process of spinning off, the founders feel they would have been underprepared for a negotiation. Fairness and manageable terms for such a young company should be the university's priority, as they should want to create an environment where spin-offs can thrive in the early stages. The founders felt they needed more fundamental legal knowledge when negotiating with the team of lawyers from the TUW, and legal support is costly. It is important to mention that not all founders had a bad experience with the negotiation process. Some mentioned that everything went smoothly and fast, and the conditions negotiated were fair.

- *Research collaborations*

  As a research institution, TU Wien is a fertile ground for new research collaborations with spin-offs. However, these collaborations come with their own set of challenges, as highlighted by the founders in the interview. The founders expressed their frustration with the lack of understanding from the university's side about the agility required when working with a spin-off. They often find that institutes underdeliver, show little respect for deadlines, and face no consequences for their actions. This situation is particularly draining for a spin-off, as it usually ends up consuming more resources than it brings. The founders prefer to work with

COMET centers due to their more industrial orientation and reliable track record in delivering results. These centers are better equipped to understand customer needs, as they are one step closer to the industry. The founders shared that the university needs to better understand how spin-offs operate and the importance of respecting engagements and deadlines. It is also cheaper and easier to work with COMET centers since it is an easy application process, the funding rates are lower but one can still achieve more with a small budget than what one gets with a big budget at a university. They see the research outcomes coming from the university as nice research values, but it is not helping them get closer to the market. Additionally, the whole contract negotiation for the research collaboration is not only time-consuming but also costly as it usually requires the services of a lawyer to set them up and discuss details, even if no IP will ever be generated. This is one side of the "Austrian" style of collaboration and negotiation mentioned already multiple times by the founders. It also translates into the fact that if you know someone and they want to support you, you can easily be integrated into a research collaboration project. Usually, it can be very difficult for a small company like a spin-off to get the same treatment.

- *Communicating the desire to spin-off at institutional level*

  Lastly, one spin-off encountered some challenges at the institutional level. Communicating their intent to spin off and the potential for departure upon success was challenging due to their lack of prior experience and understanding of spin-off dynamics. It is crucial for the university ecosystem to foster a culture of open communication and understanding, where the needs of all stakeholders, including spin-offs, are heard and addressed.

57% of the interviewees, constituting four out of seven participants, expressed a belief that their academic spin-off significantly influenced subsequent academic research endeavors. Their contributions include generating new funding sources for the institution to explore novel research areas stemming from the spin-off's initiatives, creating intermediates applicable across diverse fields, thereby necessitating further research engagement, and actively collaborating with the TU Wien on joint research projects aimed at advancing shared interests across both institutions. Two spin-offs, however, did not generate subsequent research. One interviewee cited a collaboration experience that did not lead to the expected outcomes, and the second interviewee noted that their product was in a very niche market with limited potential for widespread application.

Recognizing the challenges and gaps in support that founders often face, they have underscored the significance of including the following topics in the formal training of scientific personnel and beyond, fostering a more supportive environment for entrepreneurship and technology collaboration.

- Training for professors

  - Implementing training sessions for this specific category on recognizing potential in student and research projects and raising awareness of the university's support to both the students and its academic personnel will encourage them to provide appropriate guidance to those seeking support.

- Spin-off essentials for the personnel of TU Wien (This high-level introduction should be not only for the academic personnel but also for all the personnel of TU Wien involved in innovation processes)
  - The interviewees recommend offering essential information on spin-offs and spin-offs, what defines them, how they work, what to expect, and the lengthy development process involved in transforming research into a spin-off, especially considering the differences between different domains when pursuing this path (e.g., hardware vs. software vs. life science).
  - Raise awareness and encourage collaboration between spin-offs and the university to facilitate technology transfer and commercialization for the benefit of both parties.
  - A spinning-off guide that ensures all the details are clearly communicated, thereby removing barriers and encouraging entrepreneurship and research commercialization as the lack of policies or the lack or the visibility of those policies can influence option for alternative career tracks.

- Education for the academic personnel & Ph.D. students
  - Insights and clarity on the spin-off development process within the university and the development process within a spin-off;
  - Understanding product development and translating research into marketable products intertwined with examples from peers to foster a better understanding of product development (especially for hardware spin-offs);
  - The benefits of exposure to industry-related topics, and the importance of early touch points with experts to drive the direction of the development;
  - Intellectual Propriety education: integrating IP rights education into Ph.D. programs and providing information on IP ownership and the spinning-off process;
  - Opening up the opportunity to alternative career paths and the benefits of entrepreneurial endeavors for the academic personnel through the power of example. Present scientists who spun off their research and who can share their path to market;
  - Include economic insights and soft skills training covering topics such as effective communication, project management, team leadership, etc.;
  - Offer individual support to discuss the market potential of early-stage research projects that want to pursue a spin-off;

Surprisingly, only a minority of interviewees are affiliated with university networks. Moreover, they were not even aware that such networks exist, although they all emphasized in their interviews the importance of continuous dialogue and the new perspectives it brings. Only one interviewee is part of the TU Wien Alumni Club, which boasts an expansive alumni network across various industries and hierarchical levels, but expressed no support came through this network. The i2c alumni network was mentioned as a source of knowledge exchange between founders. Outside these two, one founder is still part of an informal group managed by students who graduated from a specific field of study, and another founder actively participates in a female university meetup organized by the faculty.

Not surprisingly, the impact has a different meaning for the interviewees as founders of a spin-off. They emphasize the gap between research and practical technology usage and the high amount of effort that a spin-off still requires to invest for the technology to be usable by society. While they all expressed humility regarding the idea of changing society, they do hope their innovations will at least influence the domains in which the spin-offs operate, especially since they introduce new, sustainable alternative products to the market that can have a disruptive impact on industry practices, workflows but not without benefits in the form of cost or waste reduction. Since all operate in a Business to Business (B2B) context, their impact on society is more indirect.

External factors influencing entrepreneurial activities at HEI level

The interview was strategically designed to delve into the founders' perception of the ecosystem, considering that spin-offs operate not only within the university ecosystem but also within a broader, local, regional, or country-wide ecosystem. This approach aimed to uncover how the university's external ecosystem influenced their market path. Several interviewees (three out of seven) shared that they had limited interaction with the wider ecosystem, most of the time confined to the public grants available. The reasons for this were diverse and specific to each founder. They either had a niche solution, and their target customer was not within this regional ecosystem, or their focus on hardware made them feel not integrated into a software-driven ecosystem like the one in Vienna and Austria. It was difficult to "cut through the noise" and connect with specialized investors, mentors, and programs, for example. All founders, however, praise the financial support offered by the Austrian ecosystem, especially for the early stages of company formation, compared to the DACH or European ecosystem, where securing funding, particularly for the early stages of high-tech startups, is challenging due to the existing risk-averse mentality. Austria boasts an outstanding and unique grant ecosystem with grants available for both scaling and bridging the gap between research and product. Multiple times, the interviewees mentioned Austria Wirtschaftsservice (aws - Austrian Business Service) and the FFG, the Austrian funding agency for business-oriented research, development, and innovation, as well as the local Vienna Business Agency which only provides funding support for companies established in Vienna. Compared to European ecosystem, securing funding to develop the technology further and scale up was easier for them in Austria. Additionally, one founder mentions explicitly that the local Viennese ecosystem is "small but very solid," emphasizing its strength and supportiveness for learning from each other's mistakes. Although my research shows Austria has been working diligently on providing start-up-friendly policies such as the “Rot-Weiß-Rot - Karte”,which facilitates the employment of highly qualified workers, skilled workers in shortage occupations, or the introduction of FlexCo, the newly introduced capital company for innovative start-ups and founders, none of the founders mentioned such initiatives. The focus was exclusively on financial support since, to quote one of the founders, “you cannot really operate without money”.

Despite being aware of the presence of incubators, accelerators, and innovation hubs within Austria and the European ecosystem, spin-offs demonstrated a strategic approach in their engagement with such programs. The majority (six out of seven) chose to participate only in programs relevant to their industry, a decision aimed at maximizing impact and return on their time investment. This strategic decision-making process is exemplified by one founder who viewed the programs offered by ventures as more of a marketing endeavor than a real chance to explore a POC with the industry. Another spin-off's experience serves as a cautionary tale, reflecting on the strategic decision to engage with multiple programs in Europe. This spin-off was involved in several programs, including two simultaneous incubation programs, which strained their resources. The founder even highlighted the similarities within the programs and the fact that commitments could not be circumvented. One spin-off praised the support offered by the European Commission, highlighting the benefits they have from being integrated into the EU Innovation Ecosystem. Surprisingly, when asked this question, two spin-offs explicitly mentioned the INiTS incubation program and their camp, raising questions about whether INiTS is perceived as part of or as an external player in the TU Wien academic entrepreneurial ecosystem.

66% (four out of six spin-offs) have engaged so far in partnerships with other startups either formally or less formally. An example of a less formal way is organizing events and inviting the other spin-off's founders as speakers, bringing each other up in conversations with the industry or investors if there is a good fit. They also see the other spin-offs as a support network. A more formal collaboration example comes from another spin-off whose founder mentioned that they prefer working only with startups or small companies because they dare to try something new and are very agile like them. In comparison, big corporations can be very slow. However, three spin-offs collaborate with established companies to run pilots in the product development lifecycle or as a multiplier by integrating their solution. One even mentioned that the selection criteria for selecting other corporations to collaborate is influenced by whether their production is Austrian/DACH-focused. Not surprisingly, for one spin-off, the proximity to high-tech firms benefited product development, especially in manufacturing, where a strong competition from China exists. A good communication strategy and mutual respect ensure that a collaborator can sometimes even transition into a customer. However, the majority (5 out of 7) interviewees expressed that the proximity to high-tech firms in the area did not influence nor contribute to the spin-off's growth.

Their view of pitching events and competitions varies widely from domain to domain. The more deep tech the company, the less value it sees in attending such events. They believe their more specialized products are, on one side, more difficult to understand and convey to a non/expert within a pitching competition. They believe what is evaluated more during these competition is one's ability to present an easy story everyone can understand successfully. They would rather invest their time more efficiently in their family or in further developing the product. However, they also admit that sometimes one cannot escape these pitch competitions. They see it as something you occasionally have to do if it's in the company's interest, and one has to adjust the messaging to what the bubble expects to hear from such a pitch. The founders explicitly mentioned that if they see no potential to meet some customers there or for other synergies, they prefer to keep their engagement to the minimum. The more software-oriented spin-offs found these events very helpful, though admitting the ecosystem in Austria is quite small, and by attending a couple of such events, you are easily introduced to the whole community. Trade fairs, however, are seen as necessary and important, especially as a source for finding pilot customers. They feel that they have to be there year after year to build credibility that they were not just a 'one-year startup'.

All founders except one shared that industry trends have influenced the development and success of the company. Some of the trends mentioned by the founders are green energy, miniaturization, sustainability, and digitalization. Some of the companies even leveraged a combination of the trends. Additionally, just the mere discussions of regulatory and policy changes brought one spin-off an extra push. The founders also shared how they harnessed the opportunities presented by societal changes. Some leveraged society´s interest in unethical behavior and how people engage on platforms like Twitter or YouTube to fight such behavior. Others leveraged demographic shifts in the population, the fact that the younger generation with an appetite for change and innovation is stepping into leadership positions and, with it, a shift towards embracing sustainable products.

The founders also discussed the impact of the legal framework, trade policies, and regulatory system on the spin-off operations and strategic decisions. One spin-off especially has no Austrian clients, which can be challenging on the legal side, especially regarding contracts. They have acquired the service of a legal expert who checks all documents required for international clients and collaborations to ensure they are not being taken advantage of. The regulatory framework can be a nuisance (according to four of the founders), but all agree that the requirements are understandable and connected to safety constraints. One compares it to a mathematical formulation; if you know the formula, it is easy to calculate, aka. navigate the certifications. Labor law received a bit of backlash about the requirements for working hours management. It is understandable why this is needed, but as a founder, a lot of time must be consumed on the deliverables. Outside this aspect, WKO was praised for its labor law guidelines, which are clear, concise, and helpful, especially at the beginning.

Of course, the founders also encountered multiple challenges and barriers in this external ecosystem. One founder mentions the requirements of some public funding agencies that require two reports instead of just one per year, as required by law, which adds to the expenses the spin-off has for accounting. Another founder mentioned that the “Gewerbe” application had been a hindrance, and later on, hiring people from abroad was challenging with the new office of the MA. Very little information was available, and it wasn’t easy to navigate the process. The founder had to be there every morning in person at 10 am and wait for new information. Perhaps the most surprising finding was that it took a spin-off of two years to obtain the production permit in Lower Austria, something that the team could not even imagine could happen when they decided to move their production site. Three founders, however, have a very positive outlook and have yet to meet any significant barriers in their commercialization path up to now. One founder even expressed that the ecosystem itself was very helpful, that one can put any request in, and that something always comes back, even if the reply is simply “wrong channel”.

Access to a skilled workforce is a cornerstone for the spin-offs since they require very specialized employees. Being close to the university allows them to meet talented and motivated professionals early on. Some even work part-time besides their studies for the spin-offs before graduation. Two founders shared that they already had to expand their search outside the borders of Austria, and one is planning to do so. They believe there are only so many professionals to hire for their industry if one considers not everyone concludes their studies and that limited educational offers exist at the university level on specific topics relevant to them. Finding people in software engineering and administration has been more challenging for one of the spin-offs, especially finding people who can drive a company that is changing every day. However, even if the talent pool is essential and sometimes finding the right people can be difficult, the founders remain positive about Vienna’s prospects to attract more talent. Being one of the most livable cities, they believe international talent will consider moving to the ecosystem.

Lastly, 100% of the interviewees would still choose Vienna as their HQ if they were to spin off again. The quality of life is unbeatable, and the funding landscape is outstanding (even for hardware startups, despite the risk-averse mentality). They acknowledge it would have been easier for them to for example, found the company in the US, Denmark, or Sweden based on the opportunities available in the ecosystem and the entrepreneurial level of the academic institutions there.

4.3.2 Quantitative Study

The qualitative part of the study set out to assess the impact the interviewed spin-offs have had on the ecosystem, as quantifying and evaluating their impact on the broader ecosystem remains a challenging task. The study aimed to uncover metrics and indicators of impact, including but not limited to economic value creation, innovation diffusion, and job creation. Through the questionnaire, the results provided valuable insights into the tangible effects of the six spin-offs on the ecosystem, setting the ground for informed decision-making for academic institutions on how to facilitate best the development of strategies to foster academic entrepreneurship.

83% respectively, five out of the six active companies used the GmbH as a legal form for their company, and only one used the FlexCo. It is not surprising since five of the companies were founded between 2018 and 2021, and the FlexCo was only recently established as a legal form in Austria. To support this, the company founded in 2022 has FlexCo as a legal form. The spin-offs have between two (1 spin-off) and four cofounders (2 spin-offs), with an average of 3 cofounders per spin-off. Out of the total of seventeen founders, twelve were male (70.59%), five were female (29.41%), and zero were non-binary. Sixteen of the seventeen founders involved in the spin-offs are/have been affiliated with TU Wien either through their studies or employment at TU Wien. Actually, when prompted to accurately describe their affiliation to TU Wien at the moment of their company formation, 66% (4 spin-offs) mentioned their founder team incorporated alums of TU Wien as visible in Figure 4.2 Additionally, 50% justified their affiliation based on the inclusion in their founder team of a TU Wien scientific employee or the spin-off establishment was rooted in the Ph.D. work at TU Wien of one of the founders. In two instances, at the moment of founding the spin-off, at least one founder was undergoing a Ph.D. study. However, only two spin-offs were based on one or more patents filed by TU Wien with corresponding license agreements between the spin-off and the university.

At the time of the establishment of the spin-offs, the companies had founders distributed across various age groups: three had founders aged 25-30 years old respectively 30-35 years old, one 35-40 years old , one had at least one founder in the age group 40-45 years old, and one in the age group 45-50 years old. The most predominant age groups among the founders were 25-30 and 35-40.

All spin-offs that took part in the study are private companies, and only one company (16.7%) intends to go public in the next three years. All spin-offs have Austria as their headquarters, and 83% (5 spin-offs) do not have any subsidiaries founded. One spin-off, however, has a US subsidiary.

The companies are currently at pre-seed (33.3% or two spin-offs), respectively, seed stage (66.7% or four spin-offs). 66.7% (four out of six) spin-offs are already making revenue, but only one company is already profitable.

Considering the praise brought to the Austrian public grant ecosystem, it is no surprise that all spin-offs benefited substantially or more modestly from public funding. Four of six spin-offs have already been received between 1-5 mio. EUR in public grants, while the two other spin-offs received one between 500k - 1mio. EUR respectively below 10k. These funding opportunities were compensated with investments for third-party funding. Three spin-offs already have a business angel on board, two have a family office as an investor, and one has already convinced a corporate investor to invest in them. Three spin-offs already raised between 1-5 mio. EUR, while 2 raised smaller tickets: one below 10k and one between 300-500k. Four of the six spin-offs plan a fundraising round in the next year.

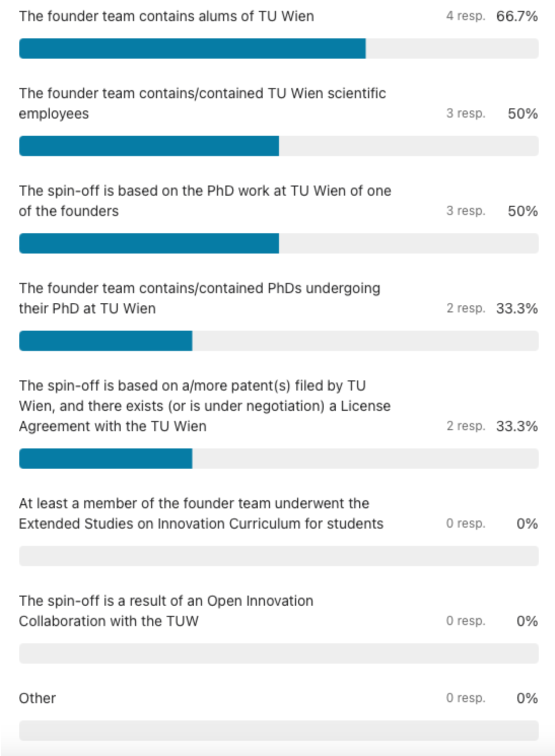

Figure 4.2: Aspects that most accurately represent the spin-off's affiliation with TU Wien at the moment of founding

Surprisingly, only 66.7% of the spin-offs have obtained the official title of "TU Wien Spin-off" from the TU Wien. Two spin-offs (33.3%) have not yet obtained this status. However, all spin-offs from the study are acknowledged in the media by TU Wien as a TU Wien spin-off.

The six spin-offs have products with applications in more than 11 domains including advanced manufacturing and robotics (33.3%), AI and Big Data (33.3%), climate tech (33.3%), aerospace (16.7%), biotech (16.7%), IoT (16.7%), logistics(16.7%), materials science (16.7%), PropTech (16.7%), scientific instrumentation(16.7%) and nanotech (16.7%) and have brought on the market altogether six products. Five of the spin-offs (83.3%) are selling these products already on the global market, while one spin-off only offers their products in Europe and one only in the USA. Three spin-offs are still in the process of bringing their products (8 altogether) to the market. Overall, the spin-offs have 22 products in development that will soon reach the market.

The six spin-offs collectively created 62 employment places (founders not included in the count), with a single spin-off employing a substantial 58.73% of the workforce (37 employees). Unfortunately, it is believed that two spin-offs submitted inaccurate data for the next steps in the employee countdown evaluation, as the total number of employees does not add up with the breakdown of employees per gender. If we were to consider the gender breakdown input as correct, we would obtain the following statistics: Total number of employees: 67 Total number of female employees: 21 (31.34%) Total number of male employees: 46 (68.65%) A more detailed breakdown can be found in4.1. Additionally, 2 spin-offs have each employee with a specific working agreement for which gender was not defined.

No. of employees	Full-time female employees	Part-time female employees	Full-time male employees	Part-time male employees	Full time non-binary employees	Part time non-binary employees
67	14	7	34	12	0	0
Percentage	20,89 %	10,44 %	50,74%	17,91%	0%	0%

Table 4.1: No. of employees breakdown per gender before adjustment

No. of employees	Full-time female employees	Part-time female employees	Full-time male employees	Part-time male employees	Full time non-binary employees	Part time non-binary employees
54	12	6	28	8	0	0
Percentage	22,22%	11,11 %	51,85%	14,81%	0%	0%

Table 4.2: No. of employees breakdown per gender after adjustment

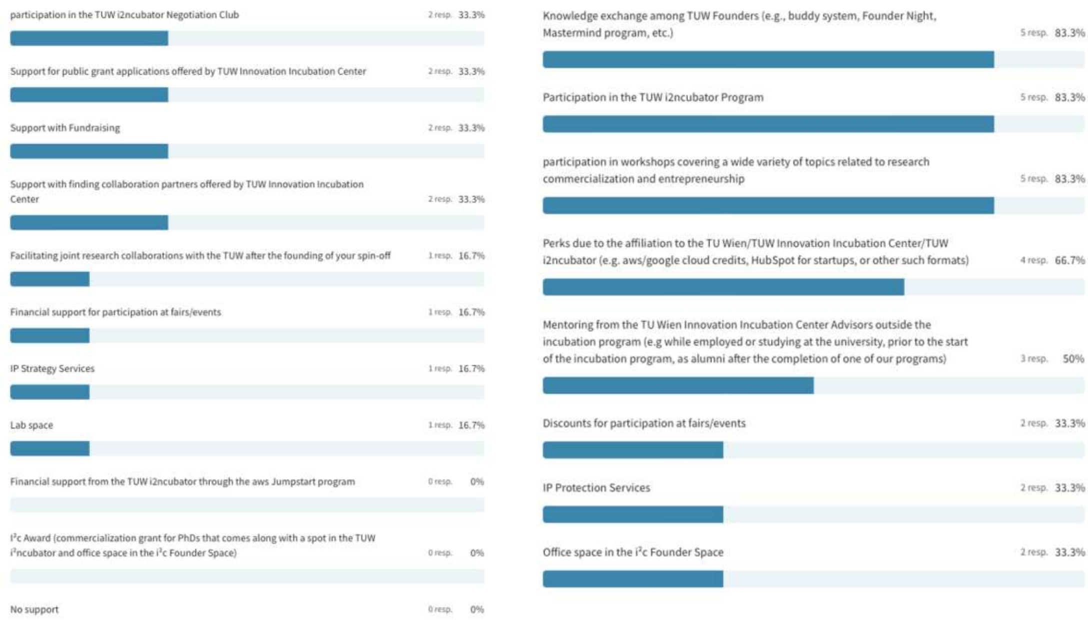

Figure 4.3: Support services the spin-offs received from TU Wien during their entire commercialization path

If the input of the two spin-offs is not considered for the subsequent statistical analysis and considering the data correction, the five spin-offs generated 54 employment places, of which 12 were full-time female employees (22.22%), 28 full-time male employees (52.85%), 6 part-time female employees (11.11%), and 8 part-time male employees (14.81%). 19 of these employees are students or alums of TU Wien (35.18%), and four are former scientific personnel of TU Wien (7.40%). Overall female employees accounted for 33.33% of the workforce while male employees for 66.66%. The breakdown is visible in 4.2

During their entire commercialization path, the spin-offs received various support from the academic institution. However, the knowledge exchange between founders stood out as something almost all spin-offs benefited from, indicating a strong founder community shaping at TU Wien. Additionally, the educational programs on topics related to research commercialization were also highly used by the sciencepreneurs, with 83.3% of the spin-offs having attended at least one such workshop. Figure 4.3 offers an in-depth breakdown of all the support offered. Surprisingly, outside the support provided by the Innovation Incubation Center and the Research and Technology Transfer service unit, no other support was offered by any other department from TU Wien. As a deep tech company, intellectual property is usually a crucial topic. Therefore, the study wanted to learn more about the spin-off approach to the subject. The results showed that five out of 6 companies have an IP strategy, and they have an average IP expenditure between 10-50k per year.

CHAPTER 5

Conclusions and Further Research

5.1 Conclusions

The framework proposed combines concepts from major theories. While the environment theory emphasizes the interactions between subsystems, embeddedness theory complements it by bringing into the discussion the effect of the ecosystem on new venture creation. The Resource-Based View (RBV) underscores the importance of various resources possessed by universities, from financial resources to technological capabilities, human capital, and organizational assets, while the competency-based view (CBV) concentrates on nurturing the entrepreneurial capabilities of individuals and making sure the future sciencepreneurs will develop an array of personal skills for effectively running deep tech innovations. It aims to overcome the limitations of existing frameworks and consider the multifaceted nature of university entrepreneurship that is more in line with the specific needs of the TU Wien ecosystem and its structures.

According to the studies reviewed, the success of leading universities is rooted in the synergies between their internal and external university ecosystems. These synergies outline a close engagement that is evident in six key factors: a strong senior management that champions E&I, an academic culture at the departmental level that rewards cross-disciplinary approaches for developing innovations, university research capabilities with a strong international focus, a vibrant external community that mutually benefits from the collaboration combined with robust governmental support and advantageous regional policies topped by the local quality of life. These factors have propelled these universities to the forefront of university entrepreneurship. Two developmental models are representative of how universities with a stellar reputation implement their E&I agenda: “bottom-up and community-led”, respectively “top-down”.

To better outline the major learnings from both the literature review and the study, the information was centralized in accordance with the pillars identified in the proposed framework below.

5.1.1 Internal factors influencing entrepreneurial activities at HEI level

People, Heritage, Policies and Culture

At the framework's core lies that sciencepreneurs are embedded in a particular ecosystem where a specific social frame, communities, networks, and resources exist. Only by understanding this context first can one understand its current status, culture for E&I, and what next steps can be made to strengthen this ecosystem considering the role, perception, and identity of its students, alums, and academic personnel. According to the interviewees, the TU Wien entrepreneurial ecosystem has evolved significantly over the past years. It has transformed into a very tech-focused ecosystem supporting spin-offs or founders from TU Wien. This evolution is a testament to the ecosystem's adaptability and its capacity to really transition technology into products, making it an attractive prospect for potential investors and entrepreneurs.

Thriving entrepreneurial ecosystems are characterized by civic culture combined with a multidisciplinary focus, an aspect confirmed by the study that highlighted the interviewees' innate desire to invest time, expertise, wisdom, and financial aid to bring an impactful product from their academic work to society.

Building a solid sciencepreneurial ecosystem requires intensive strategic planning for the administration in line with the university's strengths and weaknesses. Mission, vision, goal statements, and policies play an essential role in defining the playfield for future sciencepreneurs and defining an organization's institutional identity. The lack of such a guidance system leaves room for unclarities. It also affects the sense of belonging to the university for those embarking on this alternative career track, as pinpointed by the quantitative study. The literature mainly provides a wealth of information about University-Business Collaboration, Intellectual Propriety, Commercialization Policy, Open Innovation Policy, and, now increasingly common, Sustainability Policy and Responsible Research and Innovation Practices and their role in the commercialization path. Unfortunately, although TU Wien has a public mission statement that integrates the concept of an "entrepreneurial university", it joined the majority of universities that articulated their mission by focusing on intellectual propriety, managing technology transfer, commercialization, and knowledge transformation. The lack of policies for academics interested in exploring new ideas and technologies and including such endeavors in the university's communication strategy only widens the gap between research and a final product that could be used in society. As main actors, scientists are the ones directly affected by the broad changes in the institutional framework. Embracing commercialization means a shift in their role, activities, workload, and even priorities, which in turn affect their perception of and participation in technology transfer known as "Hybrid Role Identity". All founders interviewed faced a culture clash between their scientific persona and the newly added founder persona throughout the commercialization path, and all admit they still struggle with it to this day. Their major challenge is their internal fight between curiosity, discovery, and perfectionism with the pressure to deliver a product within time, financial, and resource constraints to ensure the company´s survival.

Esteemed universities often hold top positions in rankings, have affiliations with Nobel laureates, receive prestigious awards, establish Christian Doppler Labs, and cultivate a culture of excellence. Such standing attracts highly qualified professors and motivated students seeking innovative environments and resources for experimentation. It also draws in the necessary resources to support innovation. Consequently, some of the interviewees highlighted the impact their affiliation as a university spin-off had on their commercialization path.

Tenured scientists who have bygone the pressure of producing academically oriented output are more likely to get involved in commercialization movements; however, many see their academic role identity as prevalent and encourage younger professionals to be the initiators of research commercialization initiatives. This aspect was confirmed by the multiple statements from the interviewees about the role their supervisors and other academic personnel played in choosing the spin-off path.

Both the literature and the results of the study praise and emphasize the vital role played by \say{a small number of university champions for change} that contributed either through the power of example or through their network to the ecosystem and their path to commercialization. The study pinpoints that social norms, for instance, at the faculty level, can be catalysts for spin-off generation. The fact that this department allowed discussions about what it means to bring technology to the market in an informal setting (over lunch) opened up a new pathway for its Ph.D. students. All founders spoke about key people who played an essential role in their decision to commercialize. These people range from representatives of the Research and Technology Transfer Support office for the patenting process or who encouraged them to apply to some specific grants that would suit their stage immensely to supervisors who, even with limited business expertise, encouraged them to consider the research result´s commercial potential to representatives from the Innovation Incubation Center with whom their discussed their research potential and learned about the following steps to consider.

Technology

Fostering spin-off generation out of the interdisciplinary fields of expertise where a university has its strengths allows it to generate radical innovations and breakthroughs that will drastically change the status quo. Moreover, the university's role has expanded to incorporate as well the responsibility to challenge the feasibility of breakthroughs to avoid potential risks and harm to individuals.

The type of research—whether basic, applied, or experimental—plays an essential role in shaping innovation's nature, pace, and outcomes within an ecosystem. While basic research lays the groundwork for innovation by uncovering fundamental principles and theories, its long-term impact on innovation is significant as it often leads to breakthroughs and paradigm shifts. Applied research is usually closely connected to industry collaboration and is, thus, more directly linked to commercialization. Three of the spin-offs involved in the study are a true testament that fundamental research can generate spin-offs. However, it usually requires an intermediate in the commercialization path.

Infrastructure

A collective where commercialization is seen as detrimental to traditional scientific values or an “unnecessary distraction” can manifest at all levels of the academic chain (in the lab, at departmental and institutional level)[HFR22]. The creation of a cross-campus committee made of key position individuals across all university departments with a background in sciencepreneurship or industry engagement who can work together to implement the mission and vision of the university is seen by D. Welsh as a key resource for cultural change. The committee can also act as advisors and asses application grants connected to innovation and entrepreneurship. She points out that one of the institution’s most common mistakes is minimizing the importance of setting up the necessary infrastructure for such cross-disciplinary programs. She also emphasizes the need for a dedicated director and a minimum of one full-time employee for every 20,000 students, covering additionally overlooked positions like a webmaster or a media manager and a visible space on campus with a dedicated place for hosting networking events.

References to incentive systems in the literature resume to relational (trust and commitment, network creation and communication), structural (availability of funds, reduced U-I mismatch, new research opportunities), and cultural (effective identification, translational approach) enablers. However, the study conducted pinpointed the lack of awareness of incentives at TU Wien and the fact that the training, the formats that provide support (e.g., incubation program), and the option of a flexible working time are the main drivers of sciencepreneurship besides a personal innate motivation to change the world and build something. The factors that determined the interviewed founders to spin off their research in the first place range from personal determination to meeting the right people at the right time to encouraging feedback from the industry or grant institutions.

Emerging examples of university infrastructure are Innovation Spaces (Fab Labs, Makerspaces, coworking spaces, Living Labs, and Innovation Labs) and Learning Factories. University infrastructure should include laboratories, research facilities, equipment, and other technical resources that can be costly for a newly established spin-off to acquire independently. Accessing these resources allows the spin-off to utilize specialized facilities without significant upfront investment. All the non-software-oriented spin-offs that participated in the interview emphasized this topic.

Funding is powering the support system that fosters an academic entrepreneurial ecosystem and ensures new technologies are fed to the venture capital sector. Funding for PoCs and building the MVP have been among the spin-offs’ most praised and impactful funding sources. The university ecosystem is building strongly on leveraging public funding opportunities for this stage. Still, it lags in leveraging entrepreneurial philanthropy and offering itself funding for either the early or later stages (e.g., through its own venture fund). Some universities have developed University-Affiliated Venture Capital (UVC) funds to address the funding shortage for new ventures stemming from academic research.

These organizations strive to blend the commercial principles of venture funding with the academic ethos of educational institutions and research centers. TU Wien has yet to have such a fund and, therefore, its spin-offs rely heavily on the funding support offered by public institutions like aws, FFG, and Vienna Business Agency.

Universities often offer various entrepreneurship formats to support affiliates to explore, develop and launch business ventures. These formats can include education on entrepreneurship and innovation, pre-incubation, incubation and acceleration programs, hackathons and competitions, entrepreneurship centers and hubs, funding and investment opportunities, networking events and conferences on innovation and entrepreneurship, an entrepreneur in residence or an advisor in residence program, platforms for innovation partnerships and investment and the traditional Technology Transfer Offices with its already well-established IP support service. TU Wien can boast a comprehensive support system through the services of the RTS and Innovation Incubation Center. However, the visibility of its service among academic personnel needs to be improved, especially regarding the offers of the latter service unit. The interviewees. The founders who underwent the programs offered by the service unit valued the support received immensely. From the STARTacademy to the incubation program and beyond through the community built around the center, the support received shows the dedication and the commitment of the people involved in supporting the program. The teams praised the individualized support they received within the programs as every spin-off is different, and thus, the challenges always required a personal touch. They had access to mentors with industry experience who worked closely with them on both business and product development and had the flexibility to choose with whom they worked. The support evolved from weekly to bi-weekly to monthly workshops and mentoring sessions within the program. One founder even suggested to raise awareness of the formats offered among the professors so as to provide guidance for those seeking support. The study also revealed areas where the university's support was lacking: catering to hardware startups' unique challenges and requirements, access to lab space, access to computational power and legal advice.

Regarding aspects of IP and licensing, the literature suggests offering a clear guide on how to spin off technology together with more information about typical deal terms and expectations on time to complete the spin-off process. The need for such an approach also stands out from the study, as the interviewees emphasized a perceived discrepancy between the power of negotiation of the future founders and the university. This is because the scientists and future founders lack the law expertise to grasp the implications of the contractual terms quickly and feel at a disadvantage negotiating against a team of professional law experts and negotiators. They consider the negotiations intense, time-consuming, and lengthy.

TU Wien serves as a fertile ground for new research collaborations with spin-offs with 57% of the interviewees expressing their academic spin-off significantly influenced subsequent academic research, but founders expressed frustration with the university's lack of agility and accountability in these partnerships. They often find that institutes under-deliver, show little respect for deadlines, and face no consequences for their actions.

Most university competition formats encountered are business plan competitions, pitch challenges, hackathons, and, more recently, Innovation Challenges and are perceived differently depending of the domain of the spin-off. Very deep tech spin-offs prefer to engage only with formats where the return on investment is high, otherwise prefer to invest the time more efficiently into product development.

Network

Leveraging industry, funding, research, and even student networks can facilitate the path to the commercialization of breakthroughs. However, at TU Wien, interviewees were not fully aware of how to learn about and leverage these networks.

Evaluation

Every ecosystem is unique and thus requires personalized performance indicators defined in line with the vision and goals of the university. The thesis did not focus on the evaluation metrics due to their complexity and has proposed it as a further research topic.

Impact

Shaping responsible innovation requires a multilayered approach. Pioneers must blend in their assessment besides academic impact, social, economic, cultural, environmental, policy, and capacity-building references. The study outlined the shift in the mentality of sciencepreneurs from a focus strictly centered on academic endeavors and impact within the academic community to how bringing disruptive technologies to the market impacts individuals, communities, and societies and what they find rewarding on a personal and professional level throughout this process.

The six spin-offs generated more than 54 employment places, brought to the market eight products with applications in more than 11 domains, and have 22 products in development that will soon reach the market. Out of the six, four spin-offs are already making revenue and one is already profitable.

5.1.2 External factors influencing entrepreneurial activities at HEI level

Regional Ecosystem

Regional ecosystems are a distinct mix of cultures, economic histories, local policy initiatives, labor markets, and sectors and industries that facilitate a unique environment where innovations can thrive. The type of R&D and activity of the local industry highly influence it contributing to forming strong specialized clusters reflective of these industry trends. Four of the founders emphasized the role industry played in their early stages. They either presented their research at conferences, congresses, and trade fairs, and the industry approached them with much interest, or they reached out individually to experts to test their prototype within a research context.

Surprisingly, none of the spin-offs developed their research projects in collaboration with an industry partner. They developed them in a purely research context with no third-party funds. However, they have all reached in parallel to various experts for feedback. Some even used students as an intermediary source for market validation since TU Wien students tend to study longer than other students and, therefore, must work besides their studies. This means you can access a wealth of market insights through this target group.

The study highlighted two significant insights directly linked to challenges encountered by founders in the local ecosystem. Firstly, it took one spin-off two years to obtain a production permit in Lower Austria. Secondly, another spin-off encountered difficulties hiring foreigners from outside the EU and found the information and support provided by the relevant authorities confusing.

Nationwide Ecosystem

The generation of spin-offs can be fostered by the national societal perceptions represented by the national culture for entrepreneurship (values, beliefs, and assumptions learned in early childhood that influence independence, creativity, and risk-taking combined with a series of exits that put the spotlight on the Austrian startup ecosystem). This culture of entrepreneurship is reflected in the policies of the ecosystem. Unfortunately, too often, policymakers strive for an unachievable ideal of an ecosystem and seek best practices from vastly different economies. Instead of trying to recreate the next Silicon Valley, governmental leadership should strive to analyze the strengths and weaknesses of its local entrepreneurial dimensions and tailor their support to fit its needs (circumstances, resources, geographic position, culture). The government alone cannot foster a thriving ecosystem. The private and nonprofit sectors have to complement their endeavors and contribute responsibly. It is essential that these stakeholders are involved from early on and that thriving ventures are celebrated and highly publicized.

All founders praised the financial support offered by the Austrian ecosystem, especially for the early stages of company formation, compared to the DACH or European ecosystem, where securing funding, particularly for the early stages of high-tech startups, is challenging due to the existing risk-averse mentality. Austria boasts an outstanding and unique grant ecosystem with grants available for both scaling and bridging the gap between research and product.

Legal, Bureaucratic, and Regulatory Frameworks are usually the main tools for supporting the formation of entrepreneurial ecosystems and consequently increasing entrepreneurial activities while at the same time also attracting businesses and investment opportunities to the country. However, the impact of such approaches often takes many years to push through and requires time to evaluate the impact of such policies.

Nationwide networks of business angels, VCs, family offices, and endowments facilitate thriving academic ecosystems through cash flow injections alongside nationwide governmental public funding, which generally tackle the early stage of company formation and research.

Promoting, supporting, and strengthening clusters of interconnected companies, educational institutions, and other organizations centered within an area or region can be easily supported nationally. It is recommended that governments reinforce and build on existing or emerging clusters instead of creating new ones.

The introduction of funded internationalization programs could ensure that local breakthroughs aim for a global reach and are more visible in the global markets.

European Ecosystem

Although a global leader in R&D, Europe lags behind the US in technology transfer largely due to the legal system. The European Commission, however, advocates for policies supporting technology transfer, innovation, and entrepreneurial education within universities and offers various forms of support to facilitate the transformation of research into market-ready products or services. Harmonized regulations facilitate cross-border collaborations and European governments have the capacity to define policies that encourage academia-industry partnerships and entrepreneurship, which builds on top of Europe's strong reputation for collaborative research initiatives among universities.

Despite being aware of the presence of incubators, accelerators, and innovation hubs within Austria and the European ecosystem, spin-offs demonstrated a strategic approach in their engagement with such programs. The majority (six out of seven) chose to participate only in programs relevant to their industry, a decision aimed at maximizing impact and return on their time investment. One spin-off explicitly praised the support received by the EIC in their commercialization path. They offer a wide array of networking opportunities within the broader European innovation ecosystems by facilitating partnerships, access to investors, and other EU initiatives and networks operating in this realm.

Global Ecosystem

Globalization impacts the commercialization path of innovations significantly. Global connectivity allows sciencepreneurs to identify global market needs and encourages them to develop technologies that address global and societal challenges while creating scalable spin-offs. Some companies are, in some cases, instantly born global.

Global trends are pivotal in fostering university entrepreneurial activities by influencing the direction, focus, and support for innovation and entrepreneurship. Global trends highlight emerging needs, challenges, and opportunities and influence investment and funding patterns. Universities leverage these trends to align their research and entrepreneurial efforts with areas of high demand or societal significance, and spin-offs leverage these trends to speed up their path to market. These trends create opportunities for academia to develop cutting-edge solutions with commercial potential.

Emerging technologies bring transformative potential and risks that require careful governance. A proposed framework, comprising values, design criteria, and tools, aims to guide national and international governance efforts has been proposed by the OECD for this purpose. Additionally, the WIPO has created the Academic Intellectual Property Legal Framework containing rules, regulations, and policies governing the ownership, protection, and commercialization of intellectual property created within academic institutions on four levels: international, national, institutional, and professional associations-related levels.

I would like to conclude this section with a personal reflection on the research questions, hypotheses, methodology, and real-life applications of the proposed framework as a result of the study.

From the outset, the significance of this endeavor was underscored by the formulation of three pivotal research questions and six crucial hypotheses. The culmination of this study unequivocally validates the proposed framework as a robust and dependable tool to address RQ1, RQ2, and RQ3, along with their respective sub-questions. While the framework is not without its imperfections, its integration into the workflow offers a systematic approach to the challenges of fostering STEM-based entrepreneurial ecosystems. Its adaptability and flexibility allow for the incorporation of unique ecosystem characteristics, providing a roadmap for transformational processes. At the same time, the framework combines a holistic stakeholder management perspective and blends concepts from the environment, embeddedness theory, RBV, and CBV theory. This versatility also enables the framework to serve as a basis for monitoring and evaluating progress over time, a concept further explored in the proposed future research chapter.

The qualitative research methods used were tailored to fit the thesis's specific research questions and objectives. The semi-structured interviews were conducted with individuals active in the start-up world, who have themselves laid the foundation of academic spin-offs, making them the ideal practitioners to offer valuable context, depth, and rich insights into the subjective experiences to the research questions and hypotheses. Narrative analysis was used to examine personal narratives shared by the individuals to understand how they make meaning of their experiences and identities to reveal underlying themes or motives. The qualitative research was complemented by analysing various documents, policy documents and media artifacts to interpret and synthesize textual and visual data to uncover patterns, themes or discourses relevant to the research topic. Visual methods were used to capture the founder's experiences, spatial relationships in ways that enrich qualitative inquiry.

The framework was applied in a real-world setting at TU Wien which allowed for a detailed exploration of specific instances where the framework was implemented, highlighting its strengths, weaknesses, and practical implications as emphasized below.

The result of the study confirmed "Hypothesis 1: We believe that universities play a defining role in the strengthening of local start-up ecosystems because they can provide the right support in the early stages of transforming research into products" as all the interviewees acknowledged the support from the university was the most impactful and helpful in early stages of their development not because support was not offered later on, but because they benefited from a steep learning curve at a stage when their business skills were limited. In addition, they required access to a specific lab infrastructure that a spin-off in the first year of inception would not normally afford to set up. Since the founders explicitly mentioned the TU Wien ecosystem had developed significantly over the past five years into a tech-focused ecosystem that nurtures spin-offs and founders from TUW, offers an extensive network, and facilitates the transition of technology from academia, we can consider "Hypothesis 2: We believe TU Wien has already started its transition towards the new model of an entrepreneurial university because there is already a community of spin-offs existing at the university. " also validated. Similarly, we can consider Hypothesis 3 -5 validated through the study as it revealed the importance of the power of example. Sharing clear examples about what to expect when spinning out with the community and colleagues makes the spin-off process more tangible and relatable and raises awareness among the new generations of scientists about the possibility of an alternative career track. The founders found the power of example enlightening for pursuing a spin-off. They spoke highly about learning from other founders from TU Wien about the journey they are likely to experience and how hard it was, but at the same time, personally rewarding. Exchanges happened at all levels: during lectures, public talks, or more closed communities like the TUW i2ncubator or even locally at the faculty level where founders still employed at the university were sharing their startup journey. Moreover, the interaction with the industry was, for the majority of interviewees, spin-offs, the catalyst that pushed them towards the entrepreneurial path. The factors that determined the founders to spin off varied from personal determination to meet the right people at the right time to extremely encouraging feedback from the industry, testers, or even from grant institutions in Austria. Multiple founders explicitly mentioned presenting their research at conferences and trade fairs and being approached by the industry with much interest.

The founders were fully aware of the nascent stage of their research results and the long path to market. This led them to dismiss alternative commercialization avenues such as licensing. Motivated by the potential of their research and their practical approach, they have been committed to advancing their technology into a market-ready product. They acknowledge that academic impact often remains confined to publications and peer reviews, with complex research proving challenging to replicate and distant from practical application. Transitioning from academia to entrepreneurship requires a significant shift in both mindsets and responsibilities, with a change toward managerial tasks and a steep learning curve in navigating university policies and strategies for fostering an entrepreneurial culture. Despite their enthusiasm, the founders expressed a collective concern over the university's lack of clear guidelines, which poses barriers to academic personnel considering venturing into alternative paths. It only contributes to the many uncertainties they face in their new role. Multiple findings backed the validation of hypotheses 4 and 5. One founder, inspired by an entrepreneurial path since high school, viewed the TU Wien technical education as a means to this end, with a lecturer encouraging the founder and, later, the whole founder team to identify market gaps and pursue their ideas. Among the seven founders, only one had a strong inclination toward entrepreneurship initially. In contrast, others needed convincing. One founder mentioned this career track was only possible due to a hard personal choice to leave a tenured track position at another university and move to Vienna, so the founder had "nothing else to lose ."Despite challenges, founders find fulfillment in spinning off their research, enjoying the freedom and rewards it brings but also seeing it as a duty to give back to society, thus fully embracing the new "hybrid role" cited in the literature. They perceive spin-off development as akin to research, offering more freedom and fewer constraints. However, they wrestle with a culture clash between their scientific and founder personas, facing internal conflicts between curiosity and pressure to deliver within constraints.

Lastly, we cannot validate or invalidate "Hypothesis 6 as a result of the study, and therefore, further research needs to be addressed. We believe scientists have already embraced patenting and invention disclosure activities but perceive going one step further towards setting up a spin-off as a distraction from their primary goal: to pursue science. Therefore, they employ different techniques to ensure the primacy of their academic role identity."

Overall, the proposed framework serves as a strategic tool for driving, managing, and evaluating institutional transformation by providing a roadmap, fostering collaboration, and enabling adaptive decision-making in the pursuit of creating vibrant STEM entrepreneurial ecosystems within universities.

5.2 Further Research

Considering the intricate complexities, limitations, and nuances that were meticulously explored in this thesis, it becomes evident that certain topics, due to their depth, could not be fully addressed in the research journey. This chapter, therefore, serves as a reference for future research directions building upon the foundations laid by the conducted study.

Incentive system While the study has successfully identified a range of personal (problem-solving and the challenge of building something for the real world, with impact in the real world), professional (entrepreneurial education and support, the flexible work policy of the department, and the option to reduce working time to be able to focus on the spin-off), and a mix of professional and personal incentives (technical knowledge, capacity, and willingness to contribute to product development) that drive research commercialization, there is a need for further exploration. The discovery of additional incentives is crucial to fostering innovation and research commercialization.

Deep dive: evaluation pillar of the proposed framework The KPIs considered in the quantitative study are just a "brush of the iceberg". While researching the topic, it was very quickly evident that the quantitative evaluation would itself be a research topic for a master's thesis. The metrics initially identified required access to information a student would typically not have access to and would only be able to quantify with access rights. Examples of such metrics would be research income (per nature of research), industry-sponsored research income (per nature of research), overall research expenditure, volume of scientific articles and publications blending E&I with the specific topic (per nature of research), no. of patents applied for per year, no. of patents granted per year, revenue from the commercialization of patents per year, expenditure for IP per year, no. of invention disclosures per year, no. of invention disclosures protected per year, income/revenue from licenses per year, no. of licenses granted to small businesses, no. of academic staff with business/entrepreneurial experience per specialization, etc.

A comparative study across multiple universities To overcome the limitation that the framework was only tested on spin-offs affiliated with the TU Wien, a comparative study across different technical universities from various geographical regions should be performed as a next step.

A longitudinal study It would be very interesting to track the changes and developments of the subjects participating in the study repeatedly over some time and how their perception of the entrepreneurial ecosystem has changed over time.

Policy impact analysis The research clearly identified that at the moment the study was conducted, there was minimal information about the policies and guidelines for research commercialization at TU Wien. Considering that this aspect will change as a result of the study, it would be interesting to conduct the study again at least half a year after the policies have been openly communicated to the scientific personnel.

Extending the study to student entrepreneurship Students are a vibrant part of the university's ecosystem, and student entrepreneurship has yet to be tackled in this research. It is an interesting step to evaluate and, if needed, expand and improve the proposed framework to encompass a student's entrepreneurial journey perspective.

As we draw this chapter to a close, and with it as well this master thesis paper, it becomes evident that this research topic can be yet further explored, and new meaningful contributions to the research topic can arise from diving deeper into its complexities. We invite fellow students and researchers to embark on this journey of further exploration.

APPENDIX A

Appendix A: Formats for entrepreneurship and sciencepreneurship at TU Wien

194.068 Fachspezifische Lehrveranstaltungen in Data Science

015.100 Creativity Engineering

015.110 Unternehmerisches Denken und Handeln in innovativen Unternehmen und High-tech Start-ups

015.664 Unternehmensgründung

060.008 Einführung in Management und Leadership für Techniker_innen

060.027 Kreatives und nachhaltiges Produkt-, Service- und Prozess-Engineering

061.006 Collaboration and Co-Creation

105.760 Internationale Rechnungslegung

163.207 Green Chemistry: Recent Trends and Innovations (TUW, BOKU, UniW)

184.004 Kommunikationstechnik

188.427 E-Commerce

188.517 Geschäftsprozessmodellierung

188.915 Innovation

193.132 Design und Fertigung

194.082 Technik für Menschen 2040 (Analysis of Megatrends)

194.152 Enterprise & Process Engineering

199.111 Designing Differently, Imagining Collaboratively: The Need for Socio-Technical Alternatives

253.179 Sustainability Challenge, Interuniversitäre Lehrveranstaltung

307.439 Produktentwicklung, Innovation und ECO-Design

325.037 Advanced Business Management and Culture

330.001 Grundlagen der Betriebs- und Unternehmensführung

330.130 Strategic Management

330.131 International Negotiations

330.177 Automobillogistik

330.181 Projekt- und Prozessmanagement

330.190 Managing People and Organizations

330.206 Strategien der Automobilindustrie

330.214 Project and Enterprise Financing

330.222 Investition und Finanzierung 2

330.230 Entrepreneurship and Innovation

330.236 Advanced Financial Planning and Control

330.240 Controlling

330.250 Innovationslabor - Smart Innovation

330.255 E&I Garage - Business Model Development

330.258 Innovation Theory

330.260 Inspirational Leadership im 21. Jahrhundert

330.287 Technologie, Arbeit und Organisation

330.297 Strategy

330.304 Circular Economy Management

330.311 Robot Challenge

330.312 Nachhaltige Wertschöpfungssysteme

352.031 Präsentations- und Verhandlungstechnik

Appendix B: List of Abbreviations

AIR - Advisor in Residence

DACH - the three German-speaking countries in Europe: Germany (D), Austria (A), and Switzerland (CH)

EIC - European Innovation Council

EIR - Entrepreneur in Residence

E&I - Entrepreneurship and Innovation

ERA - European Research Area

ERIC - European Research Infrastructure

GDP - Gross Domestic Product

HEI - Higher Education Institution

IP - Intellectual Property

KPI - Key Performance Indicators

MVP - Minimum Viable Product

OECD - Organization of Economic Co-operation and Development

POC - Proof of Concept

RBI - Research-Based Invention

RBV - Resource-Based View

R&D - Research and Development

RRI - responsible Research and Innovation

SME - Small and Medium-sized Enterprises

STEM - Science, Technology, Engineering, and Mathematics

TRL - Technology Readiness Level

TTO - Technology Transfer Office

UVC - University Affiliated Venture Capital

VC - Venture Capital

WIPO - World Intellectual Property Organization

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