Fostering academic entrepreneurship

A practitioner-oriented review of the literature on academic entrepreneurship, with a particular focus on the digital sciences

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Preface

Entrepreneurship and innovation are central to the mission of Danish universities, which successfully support these goals through a wide range of activities. Best practice and skills for fostering honed on a daily basis, and numerous professional initiatives are being implemented. To support these efforts, we initiated a project to identify and distill state-of-the-art knowledge from academic research and from practice on how to effectively support university entrepreneurship and innovation.

On the initiative of the Department of Applied Mathematics and Computer Science (DTU Compute) at the Technical University of Denmark (DTU) and the Department of Computer Science (DIKU) at the University of Copenhagen (UCPH), our project synthesized insights in the characteristics of entrepreneurship and innovation at Danish universities, with a special focus on digitalization and computer science.

Equally important, the project has gathered valuable knowledge and experiences from researchers and innovation specialists on how to translate scientific knowledge into commercial and societal solutions.

The outcomes of the project include this report based on a literature review of academic entrepreneurship and innovation and their impact, and a set of guidelines aimed at respectively researchers and innovation specialists in the field of computer science. The guidelines can be accessed from [INDSÆT LINK E.L.].

We would like to extend our thanks to the Center for Technology Entrepreneurship at DTU (DTU Entrepreneurship) for writing the report and the guidelines and for great collaboration.

Special thanks also to the researchers and innovation specialists who shared their insights and experiences in two workshops, providing critical inputs for the project. Finally, we are grateful to the Digital Research Centre, DIREC, for funding the project.

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1. Introduction and summary

1.1. Background and aims

This report presents a practitioner-oriented overview of academic literature on how higher education institutions can support academic entrepreneurship. The main target group of the report consists of university managers and innovation specialists, that is, professional staff who support innovation and entrepreneurship.

Academic entrepreneurship is here defined in a broad sense as encompassing all activities that contribute to the translation and commercialization of research-derived knowledge and technology, including patenting, technology transfer (e.g. licensing or sale of patents and other forms of IPR on university research outputs), formation of spin-offs, contract research, consultancy and other forms of collaboration with industry and other research users.

As described in the preface, the report has been developed as part of a larger project on Digital Entrepreneurship, aimed at gathering and disseminating knowledge about opportunities and best practice for supporting academic entrepreneurship within digital research. Consequently, the review focuses on insights relevant to supporting technology-based entrepreneurship in general, with a specific emphasis on entrepreneurship rooted in digital research where applicable.

This report has been produced by two researchers at the Centre for Technology Entrepreneurship, Technical University of Denmark (DTU Entrepreneurship). The larger project on Digital Entrepreneurship is undertaken in a collaboration between DTU Entrepreneurship, the Department of Computer Science (DIKU), University of Copenhagen, and the Department of Applied Mathematics and Computer Science, Technical University of Denmark (DTU COMPUTE). The project is funded by Digital Research Centre Denmark (DIREC).

Key takeaways from this review and the larger project have been distilled in a guide, which is available separately.

We would like to thank the participants at a workshop held at the University of Copenhagen in November 2023 as well as the participants of a session at the D3A conference in Nyborg in February 2024 for their valuable inputs to the development of this review and the accompanying guide.

1.2. Approach

The report presents findings from a narrative literature review of selected academic literature. The aim was to undertake a comprehensive but not exhaustive review of relevant literature to draw out insights and recommendations relevant for university managers and professional staff who provide support for innovation and entrepreneurship in universities.

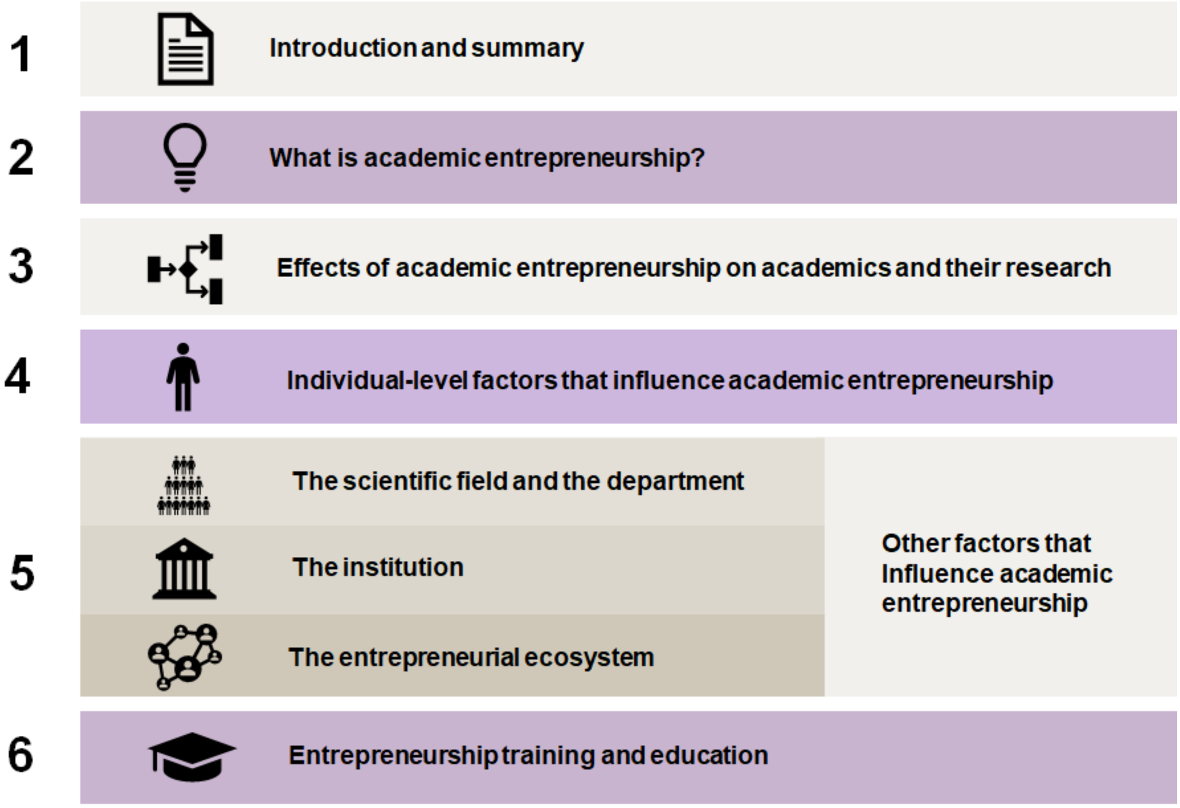
The review presented here builds on a prior review developed by one of the authors (Norn 2016), supplemented with additional literature searches in established academic databases. Given the vastness of literature on the topic of this review, emphasis was placed on publications in peer-reviewed outlets published within the past fifteen years. Key earlier work has however been included where relevant. Moreover, the search focused on empirical studies from Europe and North America given that the project and its main intended audience is based in Denmark.

The review was undertaken in winter 2023/2024. Emphasis was placed on studies of entrepreneurship activity among academic researchers (but not students) and, where possible, digital academic entrepreneurship in particular. The literature on digital entrepreneurship however represents only a fraction of the total body of work on technology-based entrepreneurship; as such most of the report focuses on general insights on academic entrepreneurship. Key themes included in the literature search included: academic researchers' motivations for academic entrepreneurship; other factors that shape academics' propensity to engage in academic entrepreneurship; effects of academic entrepreneurship on researchers' scientific performance and careers; factors that can foster academic entrepreneurship; and effects of training and education in entrepreneurship.

As this is a practitioner-oriented review, and not a systematic literature review, the report does not include an assessment of data, methods or the validity of conclusions in the literature, but focuses on condensing and communicating key insights from the literature to the target audience.

The report consists of six chapters, as summarized in Figure 1, and including this first, introductory chapter. Chapter 2 sets the stage for the rest of the report by presenting a definition of academic entrepreneurship as the concept is applied in this report. Given the focus of the report on digital academic entrepreneurship, the second chapter also reflects on the particularities of academic entrepreneurship in the digital sciences. As the number of studies that focus explicitly on digital academic entrepreneurship is limited, the remainder of the report will synthesize insights from the broader literature on academic entrepreneurship.

Figure 1. Overview of the structure of the report, by chapter



1.3. Summary

Chapter 2. What is academic entrepreneurship?

2.1. Defining academic entrepreneurship. In this report, academic entrepreneurship is defined broadly to include a wide range of activities that contribute to the translation and commercialization of research-derived knowledge and technology, including patenting, technology transfer, formation of spin-offs, as well as consultancy, contract research and other forms of collaboration with industry and other research users. While much of the literature focuses on visible, formal mechanisms, a broader view acknowledges the value of knowledge exchange through informal channels, which often play a significant role in the economic and societal impact of research. Researchers may engage in different entrepreneurial activities based on their capacities and career paths

2.2. What is particular about digital academic entrepreneurship?

Digital academic entrepreneurship leverages digital technologies to transform traditional entrepreneurship and academic knowledge transfer. Digital entrepreneurship, distinct in its reliance on IT, can serve as a facilitator, mediator, outcome, or be integral to a business model, offering efficiency, scalability, and global reach. Innovations in areas like fintech, AI, and blockchain lower traditional barriers to entry, reduce development times, and attract investors. However, digital entrepreneurs face challenges such as rapid market changes and high competition. Digital academic entrepreneurship, an emerging concept, applies these technologies to research commercialization, with digital artifacts, infrastructures, and platforms playing pivotal roles. As academia increasingly adopts digital tools, new opportunities for academic entrepreneurs are being created, reshaping the processes and outcomes of university-driven entrepreneurship.

3. Effects of academic entrepreneurship on participating academics and their research

3.1. The relationship between academic entrepreneurship and scientific performance. Research indicates a positive relationship between academic entrepreneurship and scientific performance, with scholars who engage in entrepreneurial activities often demonstrating strong research productivity. Various forms of academic entrepreneurship, such as industry funding, consulting, patenting, and spin-off creation, generally correlate with higher scientific output. Entrepreneurial activities also relate to scientific impact. While academic entrepreneurship and traditional research pursuits thus appear largely complementary, excessive entrepreneurial engagement can be associated with diminishing returns on research performance. Thus, there may be an optimal level of entrepreneurial engagement that maximizes scientific productivity without sacrificing scientific performance.

3.2. On the relationship between academic entrepreneurship and research. The relationship between academic entrepreneurship and research is complex, with evidence suggesting a positive correlation between the two, but questions remain about the direction of causality. Researchers may achieve strong scientific performance due to entrepreneurial activities that provide cognitive inputs or resources, or they may be better positioned to engage in entrepreneurship because of their prior success in research. Studies show that entrepreneurial activities can enhance research by opening new exploratory paths and supporting both basic and applied research. Academics often balance entrepreneurship with their research careers, benefiting from cross-fertilization between industry and academia. While concerns have been raised that commercialization might shift focus from fundamental research to short-term gains, most evidence suggests this is unfounded. However, some studies indicate that entrepreneurial activities may be associated with secrecy or delays in publication. Overall, however, academic entrepreneurship appears to complement and enhance research.

3.3. Some “star” scientists shine brighter than others. The relationship between academic entrepreneurship and scientific performance is likely not equally strong for all researchers, with significant differences in their ability to balance both pursuits. Much of this disparity can be attributed to the "Matthew effect," where already successful scientists, sometimes referred to as "star scientists," receive more recognition, resources, and opportunities, amplifying their performance. These star scientists often excel in both academic and entrepreneurial pursuits. Studies suggest that the positive correlation between academic performance and entrepreneurial activity is largely driven by these high-performing individuals, indicating that not all researchers will exhibit similar success. Caution is thus needed when generalizing these findings to the broader academic population.

Chapter 4. Individual-level factors

4.1. Personal choice plays a key role in academic entrepreneurship. Individual factors play a more significant role than institutional or departmental factors in determining university researchers' engagement in academic entrepreneurship. While institutional policies matter, researchers' autonomy and personal decisions drive their involvement in "third mission" activities like entrepreneurship, which are optional and often aligned with individual motivations and values. The decision to engage, especially in founding or joining startups, involves adapting professional identity and managing potential role conflicts, which can be mitigated by gaining entrepreneurial experience. Thus, fostering academic entrepreneurship requires initiatives that focus on individual motivation, skill development, and enhancing success in these activities.

4.2. The role of researchers’ perceptions and attitudes. Researchers' decisions to engage in academic entrepreneurship, including collaboration and commercialization, are influenced by their perceptions of the costs, benefits, and alignment with academic values. Positive attitudes towards knowledge dissemination and academic entrepreneurship increase the likelihood of participation, especially if they do not perceive such activities as threatening academic freedom. However, favorable perceptions do not always lead to entrepreneurial action, as researchers may still find the associated costs and difficulties outweigh the benefits. Studies highlight that informal factors, such as attitudes and role models, are often more influential than formal institutional support. Additionally, researchers' engagement varies based on their scientific performance, career stage, and motivations, suggesting that policy initiatives should be tailored to different researcher profiles.

4.3. Researchers’ motivations to engage in academic entrepreneurship. Motivations significantly influence academic researchers' decisions regarding collaboration and commercialization, with researchers in academia typically driven by values such as the dissemination of publicly funded knowledge and the pursuit of peer recognition rather than personal financial gain. While financial incentives, such as royalty sharing from patents, are often implemented to encourage entrepreneurial activities, studies suggest these may not be the primary motivators for most researchers, who are more influenced by non-monetary benefits like enhancing their reputation or gaining access to resources. Additionally, motivations can vary based on researchers' experiences, academic positions, and fields, indicating that a one-size-fits-all incentive approach may be ineffective. Researchers often respond better to a combination of incentives, balancing financial rewards with opportunities for academic freedom and recognition. Ultimately, understanding the complex motivations of researchers is crucial for universities and policymakers in designing effective incentive structures that promote academic entrepreneurship and collaboration.

4.4. Other individual-level factors. Several additional characteristics tied to individual researchers are associated with an increased likelihood that a researcher will engage in academic entrepreneurship.

Age and academic position. Research indicates that the likelihood of starting a spin-off decreases with age, as older academics are generally less inclined to launch new ventures, while younger researchers tend to be more entrepreneurial. However, the relationship between age and collaboration with industry is less straightforward; while some studies find that older researchers may collaborate less, others suggest that increased age or academic rank correlates with greater engagement in collaborative efforts. Overall, while both age and academic position influence entrepreneurial behavior, academic rank appears to play a more significant role in fostering collaboration and commercialization activities.

Position within a research group. The role of principal investigators (PIs) is crucial in driving entrepreneurial activities within research groups. PIs often take on diverse responsibilities, functioning as project managers, negotiators, and resource acquirers, which positions them uniquely as boundary spanners between academia and industry. Their practices as "scientific entrepreneurs" involve not only conducting research but also acquiring resources and building legitimacy through collaboration with various stakeholders, thereby facilitating the translation of scientific knowledge into practical applications and market opportunities.

Gender. Research indicates that male researchers are more likely than female researchers to engage in patenting, commercialization, and industry collaboration, even after accounting for seniority and discipline. Possible explanations that have been proposed in the literature include women's heavier domestic workloads, less industry experience, and greater risk aversion. However, studies also suggest that the social context, including institutional support and the presence of women in the workplace, can mitigate these differences, and some research indicates that when controlling for various factors, women may actually have more collaborators than men, highlighting the complexity of the relationship between gender and research collaboration.

Prior entrepreneurial experience, industry experience and networks to the private sector. Researchers with personal experience in entrepreneurship or industry are significantly more likely to engage in patenting and start new firms, as such experiences provide valuable insights into market applications and increase industry funding and patent productivity. Additionally, established networks within the business community enhance researchers' likelihood of commercializing their work and forming startups, while diverse skill sets and balanced working time are critical for fostering entrepreneurial intentions.

International mobility. Research indicates that international mobility can enhance academic entrepreneurship, as foreign-born and foreign-educated scientists often possess broader skills and social networks that facilitate company formation, and they may have a higher propensity for entrepreneurship.

Chapter 5. The role of the field, the department, the institution and the ecosystem

5.1. The scientific field and the department

Academic engagement and entrepreneurship are more prevalent in some ***scientific fields*** than in others. The ***department*** where a researcher is employed plays a key role in influencing their scientific performance, career development, and entrepreneurial engagement. Departmental prestige and an entrepreneurial orientation are positively associated with academic entrepreneurship, while supportive policies and initial backing from department leadership and colleagues can significantly impact the success of spin-outs. Conversely, a lack of departmental support can hinder entrepreneurial efforts, regardless of broader university policies.Peer influence, especially from entrepreneurial colleagues, plays a key role in shaping researchers' decisions to engage with industry, particularly for early-career and lower-ranked researchers. Role models in the immediate environment are more impactful on entrepreneurial behavior than university-wide policies.

5.2. The institution

University-level commitment, strategies and policies. University-level strategies and policies play a significant role in fostering academic entrepreneurship, with clear missions, patent regulations, and reward structures (such as royalty sharing and access to resources) positively influencing researchers' entrepreneurial intentions. Universities that explicitly promote entrepreneurship tend to see higher levels of patenting and spinout creation, particularly when they offer direct support like funding for early-stage ventures. However, the effectiveness of such policies varies depending on institutional focus, researcher motivations, and departmental norms, and can sometimes result in symbolic rather than meaningful compliance.

Research quality, external funding and reputation of the institution. Several studies demonstrate a positive relationship between the quality of research at universities and their engagement with the private sector. Higher faculty quality and research reputation are associated with greater invention disclosures, successful cooperative projects, and higher technology transfer performance. Institutions with a strong research reputation, particularly in technology-oriented disciplines, are more likely to attract industry collaborations and external funding, creating a virtuous cycle of increased entrepreneurial activity and further funding opportunities. In addition, universities known for generating spinouts benefit from a "halo effect," which can attract more resources for core academic activities.

The role of the TTO/KTO. Technology Transfer Offices (TTOs) and Knowledge Transfer Offices (KTOs) play a crucial role in supporting academic entrepreneurship by managing intellectual property (IP), identifying commercial opportunities, providing access to external networks, and fostering spinout formation. They serve as boundary spanners between universities, the private sector, and internal stakeholders, facilitating both IP-related activities and broader innovation strategies. Effective TTOs rely on experience, resources, and skilled staff with research, marketing, and legal capabilities to support commercialization efforts. However, their performance varies, and while larger, more established TTOs may create more spinouts, the quality of research and regional factors also significantly influence entrepreneurial outcomes.

Striking a balance between centralized and decentralized support mechanisms. Decentralized models, where technology transfer responsibilities are close to researchers, tend to improve patenting, licensing, and externally funded research. Centralized support, such as administrative and commercialization assistance, benefits from economies of scale and specialized expertise but may overlook non-linear technologies and struggle to engage researchers effectively. In contrast, decentralized support fosters responsiveness, autonomy, and in-depth knowledge of the research environment, enhancing researchers’ incentives and reducing conflicts between academic and entrepreneurial missions. Finding the right balance is essential for effective knowledge transfer and commercialization.

Structured programs to facilitate and support spinout formation. Universities can act as incubators for new firms by supporting connections between faculty, researchers, students, and external experts, reducing risk for spinout teams and aiding the early development of startups. Programs aimed at bolstering research commercialization can focus on e.g. education and traning in technology commercialization, mentoring, accelerators, incubators, business plan competitions, etc. which provide a supportive environment for faculty and students to experiment before launching ventures.

5.3. The entrepreneurial ecosystem

The role of the ecosystem. The success of university spinouts is closely tied to the characteristics of the local entrepreneurial ecosystem, including the region's economic performance, access to venture capital, business community, and quality of social ties. Studies have increasingly emphasized the role of external ecosystem actors—such as incubators, accelerators, science parks, and networks of investors and experienced entrepreneurs—in supporting academic entrepreneurship. Universities in well-developed ecosystems tend to produce more spinouts, and their own support mechanisms must complement local offerings. Efforts to replicate successful entrepreneurial models from one region to another often fail due to the unique, slow-to-develop qualities of local ecosystems, underscoring the need for tailored approaches to academic entrepreneurship initiatives.

Academic entrepreneurship in collaboration with experienced entrepreneurs. Academic researchers often possess strong academic capabilities but lack essential commercial and entrepreneurial skills, insights, and networks, which can hinder the success of their startups. To address this gap, collaborating with experienced entrepreneurs and industry professionals can be beneficial, as these individuals bring valuable market insights and business acumen essential for early-stage ventures. Research indicates that academic spinouts tend to perform better when their founding teams include external entrepreneurs, referred to as "surrogate entrepreneurs." This model allows academic inventors to maintain their research careers while leveraging the expertise of seasoned professionals. However, the success of such collaborations often depends on the active involvement of the academic inventor, as they provide critical scientific insights and legitimacy. Despite the advantages of working with surrogate entrepreneurs, researchers may struggle to connect with them due to homogeneous networks, highlighting the need for university-based intermediaries to facilitate access to diverse entrepreneurial networks.

Different models for engaging with experienced entrepreneurs and early career researchers. Academic entrepreneurs can engage with experienced entrepreneurs and early career researchers, such as PhD students and postdocs, to enhance the development of university spinouts. Research indicates that while these early career researchers often lack business insight, they possess deep knowledge of the underlying science and technology, making them valuable contributors to startup efforts. Students and early career researchers can play a critical role in academic entrepreneurship, though they may face conflicts with faculty advisors regarding academic and intellectual property issues.

University approaches to developing and mobilizing the entrepreneurial ecosystem. Universities vary in their approaches to developing entrepreneurial ecosystems, with some adopting a laissez-faire strategy that leverages their strong entrepreneurial cultures and regional ecosystems, while others take a more structured approach. In either approach, it is crucial to ensure alignment of the objectives of the institution, TTOs/KTOs and faculty to ensure clarity on expected outcomes, as well as to bolster university initiatives and activities through external resources and expertise.

Chapter 6. Entrepreneurship education and training

Entrepreneurship education and training (EET) is an emerging field that began to gain traction in the 1970s, with over 1,600 colleges and universities offering programs by 2005. Since then, growth has continued globally as various institutions invest in EET initiatives. A movement in the 1990s sought to broaden entrepreneurship education beyond business disciplines, yet the field is still evolving, struggling to reach maturity in its conceptual and methodological foundations, as disagreements persist over definitions, teaching methods, and assessment of learning outcomes. Central to the debate are two main approaches: the causal approach, which emphasizes strategic planning for business development, and the effectuation approach, which encourages leveraging available resources in uncertain environments. Learning outcomes – what students can demonstrate after completing a program – are crucial for assessing the effectiveness of EET, especially given the field's inconsistent pedagogical practices, underscoring the need for clear evidence of the skills and knowledge gained by students.

6.1. Education and training in entrepreneurship. The debate on whether entrepreneurship can be learned highlights differing views in EET, with some scholars advocating that specific business skills can be taught while others argue that innate qualities like creativity are best developed through experience. Research shows that EET can raise awareness of entrepreneurship as a career and equip students with essential skills, leading to a rise in programs globally driven by job creation and student interest. However, the effectiveness and content of these programs vary, necessitating a balance between theoretical and practical components for effective learning. EET has been linked to increased entrepreneurial self-efficacy (ESE), which correlates with higher entrepreneurial intentions and behaviors; however, there is concern that focusing solely on venture intentions may neglect the broader aim of providing students with versatile entrepreneurial skills. Ultimately, EET should combine both the "art" and "science" of entrepreneurship, fostering an entrepreneurial mindset that recognizes opportunities and promotes entrepreneurship as a viable career option, while accepting that not all entrepreneurial attributes can be formally taught.

6.2. Objectives of EET. Entrepreneurship education programs aim to develop entrepreneurial motivation, equip students with skills for business setup, and enhance their ability to identify and exploit opportunities, with organizations like the European Commission and the World Bank advocating for the instillation of entrepreneurial mindsets to encourage participation in entrepreneurial activities. Recognizing entrepreneurship as a key driver of economic growth, educational institutions are increasingly shaped by governmental policies focused on venture creation and job creation. However, the relationship between entrepreneurship education and actual venture creation is complex, necessitating more longitudinal research to clarify direct impacts. While experiential and practice-oriented pedagogies are shown to enhance learning outcomes, many scholars argue for a balanced approach that also fosters entrepreneurial attitudes and supports existing entrepreneurs alongside venture creation. This ongoing debate highlights the need for clearer frameworks to evaluate the effectiveness of entrepreneurship education in meeting its diverse objectives.

6.3. Purpose and objectives of EET. Entrepreneurship education programs are designed with multiple objectives, which can be categorized into three main areas: educating for, about, and in entrepreneurship. "Educating for entrepreneurship" focuses on preparing individuals to start new ventures by instilling entrepreneurial attitudes, skills, and fostering venture creation, which policymakers see as a key driver of economic growth and job creation. "Teaching about entrepreneurship" aims to cultivate a general understanding of entrepreneurial concepts, helping non-entrepreneurs appreciate the challenges and opportunities within the entrepreneurial landscape, thus supporting policy formulation and funding decisions. Lastly, "educating in entrepreneurship" emphasizes the application of entrepreneurial traits within existing organizations, encouraging individuals to embrace responsibilities for their learning and careers, and fostering intrapreneurship. This approach is increasingly seen as essential in equipping individuals with skills like creativity and risk tolerance, which are valuable in various professional contexts. While a related concept, "educating through entrepreneurship", emphasizes experiential learning through the creation of ventures, it functions more as a pedagogical method than a distinct objective.

6.4. Societal and economic impact of EET. The primary objective of entrepreneurship education and training (EET) remains to cultivate graduates with heightened venture intention, ultimately leading to economic and social value through new ventures, job creation, and technological advancement. This perspective aligns with the views of scholars and policymakers, advocating for government support for entrepreneurship education. Recent reports from e.g. the European Commission and the Danish government indicate a shift towards recognizing broader benefits of EET, including fostering creativity, self-confidence, and an understanding of innovation processes. While traditional views emphasize immediate economic impacts, evidence suggests that the benefits of EET often manifest over time, typically five years or more post-education. Notably, experiential learning approaches have shown to enhance learning outcomes and spur entrepreneurial action. Furthermore, there is growing recognition of alternative forms of entrepreneurship, such as social and sustainable entrepreneurship, which prioritize societal value over profit, thus broadening the objectives and definitions within the field. However, the lack of consensus on these definitions and educational outcomes poses challenges in developing effective entrepreneurship education programs.

6.5. Effects on the individual. Entrepreneurship education equips students with a range of transferable skills and knowledge applicable beyond venture creation, including general business acumen in areas such as strategy, finance, and marketing, as well as decision-making, problem-solving, and interpersonal communication skills. Students develop competencies like initiative-taking, strategic thinking, and creativity, which are valuable across various professions. These learning outcomes not only enhance employability but also help students assess their suitability for entrepreneurial careers, ultimately aiding in the identification and development of their career goals. While creating tailored educational programs could optimize this, the broad applicability of skills gained through entrepreneurship education underscores its multifaceted benefits.

2. What is academic entrepreneurship?

2.1. Defining academic entrepreneurship

Academic entrepreneurship is defined broadly to include a wide range of activities that contribute to the translation and commercialization of research-derived knowledge and technology, including patenting, technology transfer, formation of spin-offs, as well as consultancy, contract research and other forms of collaboration with industry and other research users.

Academic entrepreneurship increases the direct economic impact of public investments in universities and facilitates the translation and diffusion of university-derived science and technology (Rasmussen and Wright 2015).

Narrowly defined, academic entrepreneurship refers to efforts by academic scientists to commercialize knowledge and technology produced through scientific research, typically through IPR-based technology transfer. Literature on this topic has focused on activities such as invention disclosures, patenting, licensing and spinout formation, all of which represent common conceptions of entrepreneurship and are relatively visible and easily measurable activities.

The translation and application of academic discoveries and inventions occurs, however, through a much broader range of commercial as well as non-commercial and formal as well as informal mechanisms (Debackere and Veugelers 2005; D'Este and Patel 2007; Llopis et al. 2018). All of these mechanisms can be described as “entrepreneurial in nature” (Abreu and Grinevich 2013, pg. 408). They include for instance consultancy and contract research, joint research activities, training of researchers or staff, and sitting on advisory boards (Klofsten and Jones-Evans 2000).

A narrow focus on IPR-based, formal mechanisms for academic entrepreneurship promotes a focus on patentable inventions, to the detriment of providing adequate support for other mechanisms for research utilization and commercialization, leading to potential losses of both financial rewards and societal value (Fini, Lacetera, and Shane 2010; Abreu and Grinevich 2013). Indeed, several studies have documented the economic and broader value of consultancy, contract research and various forms of informal interaction for both academics and their external partners (Agrawal and Henderson 2002; Cohen, Nelson, and Walsh 2002; D’Este and Patel 2007; Abreu and Grinevich 2013).

Moreover, many firms started by academic researchers are based on inventions that have not been disclosed to or patented by their university (Fini, Lacetera, and Shane 2010), and many technology and knowledge transfer activities out of universities either involve no IPR or only involve IPR in a minor role (Link and Scott 2005). These findings again underline the importance of acknowledging a broad knowledge exchange perspective – rather than a narrow technology transfer perspective – on academic entrepreneurship.

Abreu and Grinevich (2013, pg. 408) therefore define academic entrepreneurship as “any activity that occurs beyond the traditional academic roles of teaching and/or research, is innovative, carries an element of risk, and leads to financial rewards for the individual academic or his/her institution. These financial rewards can occur directly or indirectly via an increase in reputation, prestige, influence or societal benefits.” In line with other prior research (e.g. Neves and Brito 2020, Secundo, Rippa, and Cerchione 2020), for the purposes of this report, we therefore define academic entrepreneurship in broad sense, as encompassing all activities that contribute to the translation and commercialization of research-derived knowledge and technology, including patenting, technology transfer (e.g. licensing or sale of patents and other forms of IPR on university research outputs), formation of spin-offs, contract research, consultancy and other forms of collaboration with industry and other research users. This broad definition thus encompasses all activities described in the literature as for instance 'knowledge exchange' (Llopis et al. 2018) or 'academic engagement' (Perkmann et al. 2013; 2019).

It is worth noting that academic researchers tend to pursue different mechanisms for knowledge transfer, knowledge exchange and entrepreneurship. Landry et al. (2010) found that academics tend to pursue different combinations, or portfolios, of entrepreneurial activities which are interdependent and mutually reinforcing. Ding and Choi (2011) examined the entrepreneurial activities of university researchers in the life sciences and found that academics tended to either become academic entrepreneurs or to act as scientific advisors to established firms, to the point even that taking on the role of a scientific advisor decreased the likelihood that a researcher would later become an academic entrepreneur. On a related note, Llopis et al. (2018) found that several individual-level antecedents can predict which types of entrepreneurial activities academics engage in, including their individual capacities (including their capacity to engage in multidisciplinary research and their ability to juggle multiple, simultaneous tasks) and career trajectories (including having work experience from outside academia).

2.2. What is particular about digital academic entrepreneurship?

As mentioned in the introduction, this report pays particular attention to academic entrepreneurship within the digital sciences and technologies. In this section, we briefly review some of the distinguishing features of digital academic entrepreneurship.

Digital advances come with new entrepreneurial opportunities and challenges

Rippa and Secundo (2019, p. 901) argue that digital entrepreneurship constitutes a distinct form of entrepreneurship, which they define as "the leveraging of digital technologies to shift the traditional mode of creating and doing business in the digital era".

Steininger (2019) identified four roles that digital technologies can play in entrepreneurship. First, they can serve as a *facilitator*, by taking over and often increasing the efficiency of operations in a startup that had previously been undertaken without the use of IT. Second, they can serve as a *mediator*, or a mechanism that connects a startup to its customers. Third, they can be an *outcome* of entrepreneurial operations, when firms develop physical or digital products or services based on IT. Finally, they can be *ubiquitous*, referring to cases where IT is central to all key elements of the startup's business model, from the nature of the products to the mechanisms by which the company engages with its customers.

Digital innovations within e.g. fintech, data analytics, mobility, mobile business apps, robotics, space, artificial intelligence, virtual reality, cryptocurrencies, the internet of things, cloud computing and blockchain have been argued to create new opportunities for entrepreneurs and lower barriers to new venture creation by mitigating traditional obstacles such as e.g. high barriers to entry, high resource intensity, long lead times and high external dependencies (Von Briel, Davidsson, and Recker 2018; Lamine et al. 2023). Short development- and product-cycle times mean that digital technologies can be tested and improved quickly, reducing time and costs needed for experimentation and development and potentially making such technologies more attractive to venture capital investors (Fini et al. 2023). Moreover, compared to hardware technologies, digital technologies are relatively easy to edit, re-program and scale (Sahut, Iandoli, and Teulon 2021; Troise et al. 2022; Evertsen and Rasmussen 2023) and often associated with easy access to resources, investors, markets and customers beyond the domestic market and even globally (Nambisan 2017; Zahra 2021; Evertsen and Rasmussen 2023).

Digital technologies are not only associated with opportunities for entrepreneurs, but also challenges. The speed and relative ease with which new iterations and functions can be added to digital products and services, and the speed with which new innovations emerge, entail a high velocity of change, market unpredictability and high levels of competition (Evertsen and Rasmussen 2023; Fini et al. 2023). Digital entrepreneurs generally face high levels of both technical and market uncertainty (Nambisan 2017; Troise et al. 2022; Evertsen and Rasmussen 2023; Chen and Tian 2022), though (Fini et al. 2023) argued, with reference to (Arora, Fosfuri, and Roende 2022), that digital technologies primarily face market uncertainty, but not technological uncertainty, at least not to the same extent as, for instance, deep tech, as digital products and services tend to be more rapidly imitable. Given the interdependencies typically seen between digital innovations and broader ecosystems of customers, suppliers, competitors and complementary innovators, the ability to develop effective business models plays a crucial role in the successful commercialization of digital technologies (Fini et al. 2023, with reference to McDonald and Gao 2019).

Digital academic entrepreneurship leverages digital innovations in the translation of research

Advancements in digital technologies are also affecting academic entrepreneurship. Digital academic entrepreneurship is an emerging concept in the academic literature (Rippa and Secundo 2019; Secundo, Rippa, and Cerchione 2020). The higher education sector has also seen an increase in the use of digital technologies (Nambisan et al. 2017), which not only affects how traditional research and teaching activities are undertaken, but also creates new opportunities for academic entrepreneurs (Yoo, Henfridsson, and Lyytinen 2010; Cohen, Amorós, and Lundy 2017; Olan et al. 2024).

Rippa and Secundo (2019) argue that “digital technologies could leverage the way academia in which pursues the entrepreneurship process with a pervasive effect on the rationale, processes and forms of academic entrepreneurship as well as on the stakeholders involved in the achievement of university entrepreneurship goals” (Ibid., pg. 901).

In developing the concept of digital academic entrepreneurship, Rippa and Secundo (2019) invoke Nambisan's (2017) distinction between three distinct but related elements of digital technologies. The first, *digital artifacts,* refers to digital components, applications, or media content that is incorporated into a new product or service and provides functionality and/or value for end users. The second, *digital infrastructure*, refers to digital technology tools and systems that offer communication, collaboration, and/or computing capabilities (e.g. AI or 3D printing) and which necessitate and are affected by the actors that design and use them. Finally, *digital platforms*, refer to shared, common sets of services and architecture that hosts complementary offerings, including digital artifacts (i.e. software-based platforms such as Apple's iOS), and which are closely related to the modules developed as add-ons to a given platform (e.g. iPhone apps). Rippa and Secundo (2019) argue that academia is increasingly leveraging all these types of digital technologies in the transfer of university-developed knowledge and technology and in the development of new, digital products and startups.

3. Effects of academic entrepreneurship on academics and their research

Concern is often expressed that engaging external collaboration and commercialization activities can have a negative impact on participating researchers' performance or careers. Engaging in collaboration or starting a spin-off company takes up time and resources that could otherwise be available for research and other university tasks (e.g. Buenstorf 2009; Jain, George, and Maltarich 2009). Moreover, concerns have been raised that engaging in collaboration and commercialization activities can lead to delays or secrecy that limits the accessibility of research, or that commercial interests will result in more applied, and less fundamental, research (as reviewed in e.g. Larsen 2011; Perkmann et al. 2013). In this chapter, we review evidence on these concerns, synthesizing key insights from prior studies of how engaging in academic entrepreneurship affects participating scientists as well as their research.

3.1. The relationship between academic entrepreneurship and scientific performance

Prior work indicates that collaboration and commercialization activities are, by and large, positively related to indicators of traditional research performance. In other words, researchers who engage in academic entrepreneurship activities tend to have strong scientific performance also. This literature has been reviewed and discussed in detail by e.g. Larsen (2011) and Perkmann et al. (2013; 2019), and this review will therefore only highlight key findings and selected studies.

A number of studies examine the relationship between scientific performance and various indicators and types of academic entrepreneurship, including receiving industry funding (e.g. Blumenthal et al. 1996; Gulbrandsen and Smeby 2005), research collaboration and co-publication (e.g. Landry, Traore, and Godin 1996; Hicks and Hamilton 1999; Godin and Gingras 2000; Bikard et al 2019), contract research (e.g. Van Looy et al. 2004), consulting (e.g. Rentocchini et al. 2014), academic patenting (e.g. Agrawal and Henderson 2002; Meyer 2006; Van Looy, Callaert, and Debackere 2006; Azoulay, Ding, and Stuart 2007; Carayol 2007; Stephan et al. 2007; Fabrizio and Di Minin 2008; Buenstorf 2009; Grimm and Jaenicke 2015), and academic licensing and/or spinout creation (e.g. Lowe and Gonzalez-Brambila 2007; Buenstorf 2009; Fini, Perkmann, and Ross 2021).

These studies generally find that academic entrepreneurship is positively related to *scientific productivity* (that is, the number of scientific publications that researchers produce). There are some nuances to this finding, however. For instance, based on a study of scientists from the Max Planck Society in Germany, Buenstorf (2009) found a positive relationship between academics' scientific performance and licensing inventions to their own spin-offs, but a negative relationship between scientific performance and being actively involved in a spin-off. On a similar note, based on data on US-based academic scientists in the life sciences, Toole and Czarnitzki (2010) found a negative relationship between scientific performance and spin-off activity, though this reflected scientists who had left their university employment to work in a spin-off and therefore discontinued or at least invested less in scientific publications. However, as we will discuss later in this review, most scientists remain fully or partially employed in academia while engaged in a startup.

To some extent, the literature also indicates that academic entrepreneurship is positively related to *scientific impact* (that is, to how many citations academics' publications receive). The literature however adds important nuances to this finding. For example, while Fabrizio and Di Minin (2008) found evidence that publication and patenting are complementary activities, they also found that average citations to publications declined for repeat patenters. This finding, they argued, suggested either a decrease in the scientific quality of repeat patenters' publications, or that repeat patenters impose restrictions on the use of their research findings.

Overall, prior work indicates that academic entrepreneurship and traditional academic pursuits should be seen as complementary rather than as competing activities.

Do these findings imply that more academic entrepreneurship is always better? Not necessarily. In fact, several academic studies have found evidence of diminishing returns on individual researchers' scientific productivity from collaboration with industry, or activities related to the patenting of research findings (e.g. Blumenthal et al. 1996; Fabrizio and Di Minin 2008) or consulting (Rentocchini et al. 2014). These findings suggest that there may be some optimum level of entrepreneurial activity. In other words, academic entrepreneurship may be associated with strong research performance, but high levels of engagement and entrepreneurial activity are associated with diminished or even negative developments in their scientific performance.

Based on an extensive and detailed review of studies of academics' engagement with external actors, Perkmann et al. (2013) concluded that evidence on the impact of such collaboration on research and teaching (which is vastly understudied compared to the effects on research) is too limited to assume that collaboration is always beneficial.

3.2. On the relationship between academic entrepreneurship and research

Perkmann et al. (2013) also called for further research into the direction of the causal relationship between collaboration and scientific performance, to allow for effective interventions to be designed. This is because evidence of a positive relationship between research performance and entrepreneurship does not provide information on the direction of causality: do researchers who engage in academic entrepreneurship have high scientific performance because of cognitive inputs or resources derived from their entrepreneurial activities, or are they more likely to be contacted by firms and engage in entrepreneurship because they are high-performing researchers? Both directions of causality probably play some role in explaining the positive relationship between academic entrepreneurship and scientific performance (Larsen 2011). Moreover, in some cases, it is possible that neither is a consequence of the other, and that they are instead both related to other, unobserved factors such as e.g. personal characteristics of the researcher or characteristics of the types of research problems that the researchers work on (Ibid.).

For instance, studies show that science can support academic entrepreneurship. Azoulay, Ding, and Stuart (2007) examined patenting behavior in a panel dataset covering almost 4,000 academic life scientists in the U.S. While prior studies had shown that researchers who patent tend, on average, to be more scientifically accomplished than their peers who do not patent, Azoulay and colleagues found that patenting events are preceded by a flurry of publications, suggesting that patenting behavior is a function of scientific opportunities.

Several studies have shed further light on the relationship between scientific achievements and entrepreneurial activities. For example, D'Este and Perkmann (2011, p. 332) argued that academics' motivations for engaging with industry may influence how that engagement affects their research: "When academics work with industry primarily to further their research, negative impacts on the direction of their research or on their research productivity will be arguably less likely. This holds particularly when academics are motivated by learning and access to resources. Our data suggest that this type of collaboration is less likely to result in immediately commercially relevant outputs, such as patents and spin-offs. At the same time, however, in the longer term, engagement in relationship-intensive collaboration with companies might enhance academic research output and generate university benefits via better research evaluations and higher levels of funding."

Studies indicate that not just basic but also applied research collaborations can benefit scientific research. For instance, Perkmann and Walsh (2009) investigated university-industry collaboration in engineering and found that even applied research projects can enable academics to engage in exploratory learning, which in turn can open up new research paths and projects.

On a related note, D'Este & Perkmann (2011) stressed that academic researchers place great emphasis on retaining their autonomy and ensuring that their interaction with industry is at minimum compatible with and preferably conducive to their research activities, for example by providing inspiration for research problems and avenues. The authors therefore suggest that universities seeking to increase staff incentives to engage with industry should focus on promoting cross-fertilization that creates value for both academic research and industry applications.

Indeed, academic researchers often pursue commercial ventures that are closely linked to their ongoing research activities and continue to stay in and promote their academic career (Nicolaou and Birley 2003b; Jain, George, and Maltarich 2009; Lacetera 2009; Hmieleski and Powell 2018), which is likely to increase the likelihood of beneficial impacts.

Fini, Perkmann, and Ross (2021) provided the strongest evidence so far that engaging in research commercialization activities can have a beneficial impact on scientists' core academic tasks, by spurring subsequent advances in scientists' research. Using panel data on all scientists at Imperial College London over a ten-year period, they examined how starting a company affects academic scientists' research. They found that scientists who started a company while remaining in full-time employment had higher scientific impact and argued that engaging in entrepreneurship shift scientists' attention away from topics and questions within the discipline in which they are specialized and toward new, more exploratory topics and questions inspired by new knowledge gained from working with technology application and development. This increases search and exploration, the authors argued, creates opportunities for research in fields that are novel to the researcher, allowing them to translate and adjust concepts and ideas from the technological domain into (new) scientific domains, and ultimately increasing the likelihood that they will produce research with high scientific impact.

More recently, Kuckertz & Scheu (2024) confirmed that entrepreneurial activity boosts the academic performance of entrepreneurial researchers, based on a study of just under 800 entrepreneurial researchers in the US and Europe. They found that entrepreneurship was synergistic with scientific performance, though this relationship was strongest when researchers were based in high-performing university entrepreneurial ecosystems.

These findings lend support to the argument that academic entrepreneurship and basic research go hand in hand. Though concerns have been raised that researchers who engage with the private sector will shift their attention away from disinterested, long-term fundamental research towards commercially-oriented pursuits and more applied research that is easier to patent and/or has greater short-term commercial potential (Blumenthal et al. 1996; Lee 1996; Stephan et al. 2007; Fabrizio and Di Minin 2008), the evidence described in the literature suggests that these concerns are, at least generally speaking, unfounded (Larsen 2011; Perkmann et al. 2013). A handful of studies suggest, however, that scientists who engage in entrepreneurial activities may be more prone to secrecy or to delay dissemination of research findings (Perkmann et al. 2013).

3.3. Some “star” scientists shine brighter than others

It is also relevant to ask if the relationship between academic performance and academic entrepreneurship is equally strong for all researchers. The short answer to this question, based on insights from the literature, is: probably not. There are likely to be significant differences in researchers’ ability to combine entrepreneurial and scientific pursuits, as most performance measures in science are skewed. For example, a small number of researchers have a high number of publications, receive many citations and attract large amounts of external funding, while the vast majority of researchers have fewer publications and citations and secure smaller amounts of funding.

This may be partly explained by the “Matthew effect” in science and/or the existence of “star scientists”. Merton (1968) argued that scientists who are already successful and recognized are more likely to get credit for their contributions to science than lesser-known scientists, even if their contributions are similar. He called this the “Matthew effect”[1] to describe a mechanism by which “the rich get richer and the poor get poorer.” This is in line with the idea of “accumulative advantage” in academic science (Cole and Cole 1973; Allison and Stewart 1974), namely the idea that the skewness in productivity among scientists can be at least partly explained by beneficial feedbacks on prior performance in the form of for instance recognition and resources.

A series of papers by Lynn Zucker, Michael Darby and colleagues (e.g. Zucker & Darby 1996, 1997; Zucker et al. 1997, 1998, 2002) introduced the notion of “star scientists”, or top scientists that seem to bring a “Midas touch” to everything they work on. For example, Zucker and Darby’s work has shown that star scientists exhibit both superior scientific performance *and* entrepreneurial performance and therefore play a key role in both the development of science and in its successful commercialization, particularly within emerging fields of technology such as biotechnology and nanotechnology. These star scientists, while valuable assets to their departments, are not representative of the general population of academic researchers.

On a related note, Breschi, Lissoni, and Montobbio (2007) proposed the existence of an “individual productivity effect”, whereby both publications and patents may be seen as proxies for individual scientists’ abilities. According to this line of thought, a highly accomplished scientist would be likely to exhibit both higher publishing and patenting activity than less accomplished peers. Similar phenomena have been described by Azoulay, Ding, and Stuart (2007) as “within-scientist economies of scope” and by Stephan et al. (2007) simply as “the right stuff.”

It is likely that the positive relationship found in many studies between academic performance and academic entrepreneurship is driven as least partly by the presence in the data of some particularly successful, visible and/or well-networked researchers. As such, we cannot expect that all researchers who engage in non-academic collaboration will show strong research performances. This indicates that caution should be exercised in extrapolating findings from the studies mentioned above to the entire population of academic researchers.

[1] Merton (1968, p. 58) coined the term with reference to the Gospel According to St. Matthew, citing the passage "For unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken away even that which he hath".

4. Individual-level factors that influence academic entrepreneurship

4.1. Personal choice plays a key role in academic entrepreneurship

Individual factors play a greater role in explaining university researchers' propensity to engage in academic entrepreneurship than university or department-level factors (D'Este and Patel 2007; D'Este and Perkmann 2011; Perkmann et al. 2013; Thune et al. 2016; Al-Tabbaa and Ankrah 2019; Neves and Brito 2020). Put differently, although institutional policies and initiatives do matter, as will be described in Chapter 5, individual characteristics and decisions about whether to engage in academic entrepreneurship matter more.

This is not surprising given how the academic research system is organized. Academic researchers enjoy considerable autonomy, which extends to decisions about which activities to partake in with a view to achieving the goals of the organization (D'Este and Perkmann 2011). This is especially true for "third mission"-type activities such as academic entrepreneurship which, unlike research and education, are generally not mandatory but encouraged and therefore ultimately a question of personal choice (Y. S. Lee 2000; Thursby and Thursby 2003; Azagra-Caro 2007).

This is not always an easy choice. The decision to found or join a startup in particular is far from trivial for academic researchers, as it requires them to adapt their role identity (Jain, George, and Maltarich 2009), which involves altering their values and beliefs (for instance their beliefs about their professional identity and how they find value or meaning in their work) as well as the day-to-day activities they perform (Galati et al. 2020).

Zhang, Mo, and Wang (2021) found that entrepreneurial experience mitigates role conflict. The authors therefore argued that academic researchers can deal with role conflict by building entrepreneurial experience and, at least to some extent, simply by increasing their knowledge of entrepreneurship, for instance by collaborating with private sector actors or participating in entrepreneurial education (a topic which we return to in Chapter 6).

Given the importance of individual factors for researchers' decision about whether to engage in academic entrepreneurship, initiatives aimed at fostering entrepreneurial behavior should be focused on the individual researcher (Perkmann et al. 2013).

Academics are motivated to engage and persist in academic entrepreneurship by an expectation that they will be able to realize benefits that are of value to them (Y. S. Lee 2000; Owen-Smith and Powell 2001), and that these benefits will outweigh the associated costs and risks (Tartari and Breschi 2012).

The key to boosting university-industry collaboration and research commercialization among public researchers therefore lies in motivating more researchers to voluntarily engage in such activities – and to help them do so in a productive fashion. This includes for instance helping researchers build engagement and entrepreneurial competences but also supporting them in increasing the likelihood of success of the activities they participate in (Perkmann et al. 2013).

In this chapter, we therefore examine individual-level factors that shape academic researchers' propensity to engage in academic entrepreneurship, starting with their perceptions and attitudes towards entrepreneurship and their motivations, before examining the role of other, individual-level factors in shaping scientists' entrepreneurial intentions and behavior.

4.2. The role of researchers' perceptions and attitudes

Researchers' decisions about whether to engage in collaboration, commercialization and other forms of academic entrepreneurship are shaped by their perceptions and attitudes towards such activities. For instance, scientists' participation in patenting activity has been shown to depend on their perception of the costs and benefits of patenting and thus their willingness to disclose inventions (Louis et al. 1989; Van Dierdonck, Debackere, and Engelen 1990; Blumenthal et al. 1996; 1997; Lee 1996; 2000; (Campbell et al. 2002; Owen-Smith and Powell 2001; Baldini, Grimaldi, and Sobrero 2007; Magnus Gulbrandsen and Smeby 2005; Renault 2006; Bercovitz and Feldman 2008; Haeussler and Colyvas 2011; Davis, Larsen, and Lotz 2011; Brettel, Mauer, and Walter 2013). Researchers are more likely to engage in academic entrepreneurship if they believe that the dissemination of knowledge is an important mission for universities (Renault 2006), and if they do not believe such activities to pose a threat to academic freedom (Tartari and Breschi 2012) .

The importance of scientists' perceptions for their decision to engage in academic entrepreneurship was underlined in a study of entrepreneurial activity in 102 universities in 12 European countries, where Guerrero, Urbano, and Fayolle (2016) found that informal factors such as researchers' attitudes and the availability of role models were more important in shaping entrepreneurial activity than formal factors such as institutional support measures, education and training.

However, positive attitudes towards academic entrepreneurship are no guarantee that researchers will actually engage in entrepreneurial activities. For example, a study of Portuguese researchers in the life sciences and biotechnology showed that even though most had no ethical objections to disclosing their inventions or to the commercial exploitation thereof, the respondents still showed a low propensity to engage in patenting and licensing (Moutinho, Fontes, and Godinho 2007). According to the authors of the study, this reflected that researchers believed the costs and difficulty associated with such activities to outweigh the expected personal benefits (Ibid.). This indicates that attention must be paid not only to researchers' attitudes to academic entrepreneurship but also to the incentives, obstacles and costs associated with it.

Also, the literature indicates that researchers have different perceptions of industry engagement and entrepreneurial activities based on e.g. their scientific performance, academic position, age and motivations to engage with industry, suggesting the need to carefully consider how new policy initiatives are likely to impact different subsets of researchers in different ways.

4.3. Researchers' motivations to engage in academic entrepreneurship

Motivations are a key factor in human decision making. Prior work indicates that academic researchers tend to be motivated by different values and goals than researchers working in industry.

For instance, academic researchers tend to believe that knowledge and discoveries generated through publicly funded research should be placed in the public domain (Merton 1973), and to be motivated to produce and disseminate research through scientific publications by rewards in the form of promotions and funding for research and recognition from their academic peers, rather than, say, the possibility to achieve personal financial gain (Merton 1973; Dasgupta and David 1994). Academics are typically driven more by the desire to obtain the recognition of their academic peers than by the possibility to achieve personal financial gain (Ibid.).

Nonetheless, many of the incentive mechanisms aimed at stimulating researchers to engage in collaboration and especially commercialization of their research are based on financial rewards. This includes for example many universities' policies for sharing royalties from licensing of university-owned patents with the researchers listed as inventors on the patents (Bercovitz and Feldman 2008; D'Este and Perkmann 2011). Such incentives are based on an assumption that academic researchers are at least to some extent motivated by financial rewards tied to collaboration and commercialization activities (Jensen and Thursby 2001; Lach and Schankerman 2008).

With reference to prior work, Sandström et al. (2018) argued that financial incentives may have a positive effect on entrepreneurial activity and that a stream of revenues from such activities is crucial to maintain entrepreneurial activities. The potential of financial rewards to incentivize academic entrepreneurship has also been underlined by e.g. Galati et al. (2020), who argued that royalty sharing policies can strengthen researchers' incentives to disclose inventions and start new ventures.

On a related note, Owen-Smith and Powell (2001) found that the higher potential monetary value of university patents in the life sciences in the US might lead at least some researchers to engage in patenting with a view to increasing their income, while the lower pay-off from patents in the physical sciences meant that researchers who engaged in patenting did so for other reasons, notably to develop relationships with firms, access equipment or exploit other research-related opportunities.

In a more recent study of researchers from 67 institutes of the German Max Planck Society, Göktepe-Hulten and Mahagaonkar (2010) found that engagement in patenting not was motivated not by a desire to generate personal income but rather to signal achievements and strengthen reputation among both academic peers and industry stakeholders. Similar findings have been presented by e.g. Baldini, Grimaldi, and Sobrero (2007) and Azagra-Caro, Aznar-Márqez, and Blanco (2008). The latter study found that academic researchers are motivated to collaborate with industry not by the prospect of increasing their income but rather by non-monetary incentives, which – perhaps unfortunately for university managers and policymakers – are harder to cater to.

D'Este and Perkmann (2011) concluded that managers and policymakers should refrain from relying on monetary incentives to promote engagement and instead consider how to stimulate other incentives among academic researchers. This seems a sensible path forward, given that there is relatively little money to be made for most researchers: Åstebro, Braunerhjelm, and Broström (2013) examined total earnings for 478 individuals working at Swedish universities who quit to become full-time entrepreneurs between 1999 and 2008. They found entrepreneurship to be a gradual process and episodic for academics. Moreover, their earnings were similar before and after becoming an entrepreneur, and there were no dividends or capital gains to speak of. In view of the fact that the income risk is more than three times higher in entrepreneurship, financial incentives do not appear to offer a strong motivation to engage in academic entrepreneurship.

Even where financial motivations are salient to consider, there are many challenges to ensuring adequate financial compensation for academic contributors to commercialized inventions, particularly when the invention is at an early stage of development and its ultimate commercial value therefore particularly difficult to ascertain, and when the invention was developed through the collaborative effort of a larger team of researchers where it may be difficult or impossible to attribute efforts and outcomes to individual team members (Brettel, Mauer, and Walter 2013). A study of what motivates researchers in German technical universities to disclose their inventions found that financial incentives had large influence on researchers' behaviors but that universities must improve the financial incentives they offer researchers in order for them to be effective; based on their findings, the authors of the study argued in favor of flexible compensation schemes including one-off payments for granted patents and voluntary top-ups of mandatory revenue (Walter et al. 2018).

Aside from the mixed evidence on the effect of financial motivations, what are other factors that motivate researchers to engage in third mission activities? Prior work indicates that academic researchers who engage in collaboration and commercialization-oriented activities primarily do so because they expect to realize benefits for their research and/or teaching activities. Key motivations include the desire to access research funding; enhance their visibility, reputation or academic position or careers; learn and gain new insights for their research; access industry knowledge or valuable infrastructure, technology, materials or other research resources; demonstrate the value of their research or test its practical applications; or access contacts or insight for use in teaching (Meyer-Krahmer and Schmoch 1998; Lee 2000; Owen-Smith and Powell 2001; Baldini, Grimaldi, and Sobrero 2007; Lam 2007; 2011; Welsh et al. 2008; Yusuf 2008; Fini, Grimaldi, and Sobrero 2009; Göktepe-Hulten and Mahagaonkar 2010; D'Este and Perkmann 2011; Hayter 2015a; Castillo Holley and Watson 2017).

A systematic literature review by Neves and Brito (2020) identified access to funding for research and for the institution as the main driver for even the most extreme form of academic entrepreneurship, namely the establishment of academic spin-offs. This conclusion is supported by prior work by e.g. Hayter (2011; 2015), arguing that academics often see spin-offs as platforms for accessing research funding, as well as by prior studies by Ankrah et al. (2013), and Bodas Freitas and Verspagen (2017)

But motivations for academic entrepreneurship are complex (Hayter 2011). For instance, D'Este and Perkmann (2011) found that researchers' motivations differ depending on which mechanism for interacting with industry that they engage in. For instance, researchers with a preference for learning were more likely to engage in research collaboration, contract research and consulting, while researchers motivated to see their research commercialized were more likely to engage in participate in patenting, spinout formation and consulting.

Moreover, Lam (2011) and Galati et al. (2020) have argued that different academics are driven by different motivations, and that individual researchers' motivations can change over time. This may for instance occur as researchers build experience with entrepreneurial activity, e.g. recognizing lacking business and management skills and adjusting their entrepreneurial strategies accordingly (Hayter 2015b), or as their role identity changes alongside their entrepreneurial intentions and activity (Jain, George, and Maltarich 2009). These findings suggest that different 'carrots' are needed to motivate different people, and that university managers and support staff must be atuned to possible changes in what motivates researchers.

On a related note, based on a study of incentives to engage in entrepreneurial activity (here operationalized as disclosing inventions to the university) in nine German technical universities, Walter et al. (2018) found that single incentives were typically not sufficient to spur researchers to disclose inventions; instead, researchers responded to bundles of incentives that managed to balance financial gains (which the authors referred to as 'gold') with the freedom to continue to pursue their academic research ('grace') and recognition for their entrepreneurial activity in their performance assessments and career progression ('glory') (Ibid.). Moreover, the study found that scientists' incentives vary across disciplines and academic ranks, as well as with various individual characteristics such as scientists' experience from working in industry, prior experience with patenting, and the type of research they engage in. For instance, applied researchers and engineers in particular were found to be more responsive to disclosure incentives in general and to financial incentives in particular. In addition, researchers with prior patenting experience were more responsive to both financial incentives and incentives related to their opportunities for career progression (incl. both 'grace' and 'glory'), and established (and especially tenured) scientists were less responsive to incentives overall than early career researchers (Ibid.).

Other studies have examined differences between senior and early career academics. In a study of motivations among academic entrepreneurs in an Italian region, Rizzo (2015) found that pecuniary incentives were more likely to be a factor in the entrepreneurial decision for senior academic researchers than for early career researchers. Rizzo (2015) also found that starting an academic spin-off was seen by younger researchers offs as a way to “escape the bottlenecks” of the Italian research system and to continue doing research within their field of expertise, given the constraints on access to research funding and limited options to pursue a career path they would face in an academic career. On a similar note, Abreu and Grinevich (2014) proposed that senior academics can be incentivized to engage in entrepreneurial activities by the opportunity to identify job placements for their students. Their findings were echoed by Galati et al. (2020), who found that established academics may engage in entrepreneurial activities to create possibilities for others, including Ph.D. students but also for other colleagues, their university or other stakeholders.

More generally speaking, academic entrepreneurship can sometimes emerge as a response to resource constraints. Based on a study of academic researchers in Sri Lankan universities, de Silva (2011) found that academic entrepreneurship is best described as a process, where academic researchers begin by engaging in ‘light-touch’ activities, for instance teaching-related entrepreneurial activities, before progressing to research-related entrepreneurial activities (e.g. contract or collaborative research) and spinout formation. De Silva argued that resource constraints can play a key role in motivating researchers to progress from one type of entrepreneurial activity to another. This is not only the case in developing economies: Horta, Meoli, and Vismara (2016) and Vismara and Meoli (2015) showed that the skilled unemployment level and a regional shortage of academic positions, respectively, are associated with a higher propensity of academic spin-off creation.

Finally, some academics may choose an entrepreneurial path out of a desire to be useful to society (Hayter 2011) or a sense of moral duty (Ankrah et al. 2013; Iorio, Labory, and Rentocchini 2017), spurring them to go to extra lengths to ensure that their research is applied to create value and impact in society. Indeed, some academic researchers see spinouts as a way of advancing the dissemination and translation their research (Hayter 2015a), a perspective which is supported by a.o. Jain, George, and Maltarich (2009) who have argued that academic spin-offs can be an effective mechanism for increasing the dissemination of university research and the socio-economic value from investments in research.

The academic literature underlines the importance for universities and other research institutions of designing effective incentive structures for academic researchers (Debackere and Veugelers 2005; Halilem et al. 2017). This includes ensuring adequate shares for academic inventors engaged in licensing or spinout formation, in the form of royalties or equity. A similar point was stressed by Lach and Schankerman (2008) who, based on 1990s panel data from 102 US universities, found that universities that gave higher royalty shares to academic researchers generated both more inventions and higher licensing income (particularly in private as compared to public universities), after controlling for other salient factors such as the size, performance and research funding of the university.

4.4. Other individual-level factors

Several additional characteristics tied to individual researchers are associated with an increased likelihood that a researcher will engage in academic entrepreneurship.

Age and academic position

According to several studies, the propensity to start a spin-off appears to decrease with age (Neves and Brito 2020). For instance, based on a large study of Swedish university researchers, Karlsson and Wigren (2012) found that older academics were less likely to start a firm. Similarly, Fini, Lacetera, and Shane (2010) found that researchers who establish a company based on a patent tend to be younger than those who start a non-IP based (e.g. consultancy) firm. It is however worth noting that Bercovitz & Feldman (2008) found that academics who had not been involved in entrepreneurial activities at the start of their academic career were less likely to do so at a later stage.

Findings are less clear with regards to the relationship between researchers' age/seniority and collaboration with industry. Some studies find no relationship (Neves and Brito 2020), and some conclude that older researchers are less likely to engage in collaboration (D'Este and Patel 2007; Tartari and Breschi 2012). Most studies tend to find that engagement with non-academic partners becomes more likely with age or increasing academic rank (see e.g. Levin and Stephan 1991; Carayol 2007; Link, Siegel, and Bozeman 2007; Stephan et al. 2007; Abreu and Grinevich 2013; Hayter et al. 2018). Studies underline the pressure on younger researchers to demonstrate their academic worth and to build a strong publication list, incentivizing them to focus on research and teaching tasks. In contrast, more established academics are likely to have more time to engage with the non-academic community (Abreu and Grinevich 2013). They are also likely to have more established publication track records and better personal networks to companies and other non-academic actors, which increases the likelihood of engaging in collaboration and commercialization activities (Link, Siegel, and Bozeman 2007; Fini, Lacetera, and Shane 2010; Abreu and Grinevich 2013).

While age and rank are correlated, their effects are not always similar. D'Este & Patel (2007) found that age had a negative impact on the variety of collaboration mechanisms that researchers engage in, while academic position was associated with a higher degree of variety. This suggests that when age and career advancement do not move hand in hand, academic position is more important in understanding the propensity of researchers to engage with the non-academic world.

Position within a research group

Individual researchers' position *within* a research group can also matter for their participating in engagement and entrepreneurial activities. For instance, Boehm and Hogan (2014) draw attention to the role of the principal investigator, or PI, in driving collaborations with industry. The authors found that PIs play a lead role in establishing and managing these complex multi-stakeholder research projects, and that they have to be 'jacks of all trades', able to take on the roles of project manager, negotiator, and resource acquirer as well as traditional academic roles of Ph.D. supervision and mentoring. The authors argued that PIs are often better placed than TTO managers to function as boundary spanners between academia and industry and should therefore be considered explicitly in university policies and strategies for collaboration with firms. Similar points were echoed by Dolmans et al. (2022).

Casati and Genet (2014) also took a closer look at principal investigators, focusing on the everyday practices which allow them to act as 'scientific entrepreneurs', that is, "scientists with entrepreneurial capabilities, but who work within academia who not only perform research, but are also involved in acquiring resources from different sources (funding agencies, firms, professional associations, etc.), in combining internal and external resources to shape scientific avenues, and in gaining legitimacy for these new avenues by organizing workshops, conferences, special issues or setting up new journals, building on their scientific reputation to transfer it to other networks (economic, business, policy makers)." (p. 24) PI practices identified including 'innovating and problem solving,' defined as "developing outcomes and exploiting solutions for existing markets or industries," and 'brokering,' which as defined as "animating and influencing their scientific communities" (Ibid. p. 11). The authors argued that some PIs move beyond their scientific careers to engage with policymakers, private firms and other societal actors, where these practices help them to generate novel knowledge and inventions and craft their paths to the market.

Gender

Several studies have found that male researchers are more likely than their female counterparts to engage in patenting, commercialization activities and collaboration with industry, even when controlling for seniority and scientific discipline (e.g. Thursby and Thursby 2005; Whittington and Smith-Doerr 2005; Ding, Murray, and Stuart 2006; Link, Siegel, and Bozeman 2007; Abreu and Grinevich 2013; Tartari and Salter 2015; Goel, Göktepe-Hultén, and Ram 2015; Hayter et al. 2018).

Some of the possible explanations that have been put forth in the literature include that women carry a heavier workload at home, are less likely to have industry experience and network relations to firms, and may be more risk averse than male researchers (W. W. Ding, Murray, and Stuart 2006; P. Stephan and El-Ganainy 2007). Moreover, based on a study of Spanish 1,178 academics, Miranda et al. (2017) concluded that female academics have less of an entrepreneurial intention than their male colleagues and that this can be explained by the presence of implicit barriers that affect female researchers' entrepreneurial intentions.

However, drawing on a large scale study of UK physical and engineering scientists, Tartari and Salter (2015) argued that gender differences in collaboration activity can be tempered by the social context in which female scientists work, notably by factors such as the presence of women in the local work setting and/or the scientific discipline and institutional support for women scientists' careers.

Colyvas et al. (2012) questioned the assertion that female scientists are less involved in formal technology transfer, and highlighted prior research showing that gender differences disappear when personal characteristics and resources are included as variables in the analysis (Xie and Shauman 2003). Based on a study of US medical school data, Colyvas et al. (2012) found no significant gender differences in the likelihood of reporting inventions or successfully commercializing them, though women in their study tended to disclose fewer inventions than male scientists. They argued that these finding may indicate that female scientists are an untapped source of entrepreneurial talent.

Ultimately, the question of whether and, if so, to what extent male and female scientists differ in their research collaboration "does not lend itself to a straightforward answer" (Bozeman and Gaughan 2011, p. 1393). Bozeman and Gaughan (2011) pointed out that many gender-correlated variables could mitigate the relationship between gender and collaboration. For example, they argued, gender-correlated differences in the number of collaborators could be explained either by something intrinsic to men's and women's work strategies and preferences or to their different positions in work structures and hierarchies. The authors examined questionnaire data from the US National Survey of

Academic Scientists and found, counter to prior research, that in a model that takes into account such factors as tenure, discipline, family status and doctoral cohort, women actually have somewhat more collaborators on average than do men. Both male and female scientists with more industrial interactions and those who were affiliated with university research centers had more collaborators.

Prior entrepreneurial experience, industry experience and networks to the private sector

Unsurprisingly, perhaps, researchers who have personal experience in starting a business or who are closely related to entrepreneurs are more likely to engage in patenting and to start a new firm (Klofsten and Jones-Evans 2000; Shane and Khurana 2003; Abreu and Grinevich 2013; Gulbrandsen and Thune 2017). Similarly, researchers who have been employed in industry (for a substantial part of their career) are likely to have both more industry funding and higher patent productivity than colleagues without such experience (Dietz and Bozeman 2005; Abreu and Grinevich 2013). Research also shows that academic researchers with a record of past interaction are more likely to want to collaborate with industry (Abreu and Grinevich 2013; M. Gulbrandsen and Thune 2017), to be involved in a greater variety of interactions with industry, and also to engage more frequently across a wider set of interaction channels (P. D'Este and Patel 2007).

Why does experience matter? For one, many scientists lack knowledge of the possible applications and potential market value of their research (Hellmann 2005; Macho-Stadler, Pérez-Castrillo, and Veugelers 2007), particularly when that research is very fundamental in nature and may therefore have multiple and diverse applications. Insight into particular industries or firms increases the likelihood that academic scientists will be able to see potential uses or users of their research.

Prior entrepreneurial and/or industry experience can be a valuable for academic entrepreneurs, as most academics lack networks to people with such commercial experience, which acts as a barrier to commercialization activities (Mosey and Wright 2007; Sandström et al. 2018); indeed researchers with networks to the business community have been shown to be more likely to start their own firm (Karlsson and Wigren 2012; Neves and Brito 2020).

Non-academic experience, including for instance experience with joint research collaboration or having worked in a corporate setting, has been linked to a higher likelihood of startup formation (Krabel and Mueller 2009; Wennberg, Wiklund, and Wright 2011; Hayter et al. 2018), emphasizing the importance for academic entrepreneurship of building experience in working at the intersection between academia and industry (Rasmussen and Wright 2015). Experience with patenting or prior spinout formation has also been linked in several studies to a higher likelihood of starting a company, emphasizing the role of prior experience in strengthening scientists' ability to identify and effectively act on new commercial opportunities (Hayter et al. 2018).

Diverse skill sets have also been shown to matter for entrepreneurial activities, which is not surprising given that new entrepreneurs need to possess or build a broad range of entrepreneurial skills (Gümüsay and Bohné 2018). Moog et al. (2015) examined the impact of skills, working time and peer effects on scientists' entrepreneurial intentions. They found, using data collected from life sciences researchers in Germany and Switzerland, that scientists are more likely to have higher entrepreneurial intentions if they have a more diverse and balanced skill set (i.e. are "Jacks-of-all-trades" rather than highly specialized), but only if they also balance their working time and are in contact with entrepreneurial peers. The authors therefore underscored the importance for promoting entrepreneurship of ensuring that scientists, among other things, have balanced working time allocations across different activities and that they work with entrepreneurial peers, i.e. scientists who have experience starting spinouts.

International mobility

Finally, Krabel, Siegel, and Slavtchev (2012) examined whether scientists employed in foreign countries and foreign-educated native researchers are more ‘‘entrepreneurial’’ than their ‘‘domestic’’ counterparts. Based on data from researchers at the Max Planck Society in Germany, they found that academic entrepreneurship can indeed be stimulated by facilitating the mobility of scientists across countries, and suggest this may be explained by foreign-born and foreign-educated scientists possessing broader scientific skills and social capital, which increases the likelihood that they will start a company. On a related note, Wright (2014) argued that scientists may specifically choose to move to universities and ecosystems that are more conducive to their research and their efforts to commercialize that research.

More recently, Choi et al. (2023) found that foreign-born scientists in the US are more adept at managing role conflicts and adopting an entrepreneurial identify, indicating that they may have a higher propensity to engage in academic entrepreneurship. Based on a survey of scientists in Denmark, however, Uhlbach, Tartari, and Kongsted (2022) distinguished between “stayers” (who remained employed in the Danish system), “returnees” (who returned to the Danish system after a period abroad) and “immigrants” and how that while returnees were substantially more likely to become academic entrepreneurs than stayers, immigrants, were significantly less likely to start a firm than returnees, indicating that the effect of international experience is not straightforward.

5. The role of the field, the department, the institution and the ecosystem

While understanding individual researchers' motivations and decisions is crucial to understanding their engagement in academic entrepreneurship, as shown in the previous chapter, researchers do not exist in a vacuum. They are a part of an international research community within their field of research, which also affects their propensity to engage in academic entrepreneurship. They are also employed at a research department (or center, or similar unit) with local norms and practices that will also affect when and how researchers engage in entrepreneurial activities.

Researchers are also employed by universities or other institutions – these institutions, their strategies and their actions can also shape academic entrepreneurship. Finally, universities are embedded in a wider entrepreneurial ecosystem, which can provide talent, know-how and resources for research institutions and their spinouts.

In this chapter, we therefore examine the role of the scientific field, the university department, the institution and in shaping researchers' entrepreneurial behavior.

5.1. The scientific field and the department

The role of the scientific field

Academic engagement and entrepreneurship are more prevalent in some scientific fields than in others. This includes for instance the life sciences, engineering, technical sciences and – according to some studies – parts of the natural sciences and social sciences e.g. economics and management studies (Y. S. Lee 1996; Bozeman 2000; Schartinger et al. 2002; Azagra-Caro, Carayol, and Llerena 2006; Arvanitis, Kubli, and Woerter 2008; Abreu and Grinevich 2013).

The propensity of academic researchers from a given field to engage in entrepreneurial activities is affected, among other things, by the types of knowledge that characterize the field (including, for instance, how readily applicable that knowledge is in industry, the public sector or other parts of society), and to how effective IP is in protecting inventions (Abreu and Grinevich 2013). For instance, patents are commonly used to protect and commercialize research outputs in the life sciences. More applied research fields, e.g. engineering, tend to be have higher levels of entrepreneurial activity (Iorio, Labory, and Rentocchini 2017; M. Gulbrandsen and Thune 2017).

In contrast, research in the humanities is generally disseminated via public talks and books targeted a non-academic audience, and the social sciences often disseminated via contract research and consultancy for public and third sector organizations, meaning that such activities are seen as entrepreneurial within these fields (Abreu and Grinevich 2013).

The role of the department

The international scientific field may overlap in part with the researcher's department, but the extent to which it does depends on how the department is organized. Some departments are closely associated with a given field, while others may have a broader focus including researchers from multiple related or unrelated scientific fields. Both are therefore relevant to consider.

The department that an academic researcher is trained or employed in is known to affect their scientific performance and careers (e.g. Agrawal, McHale, and Oettl 2017; Broström 2019).

It can also affect their propensity to engage in entrepreneurial activities. For instance, the prestige of a university department is positively associated with scientists' propensity to engage in academic entrepreneurship (Perkmann, King, and Pavelin 2011). On a related note, based on a survey of academics at four European universities, Kalar and Antoncic (2015) found that academics who perceived their department as being highly entrepreneurially oriented were more likely to engage in entrepreneurial activities, and also less likely to be concerned about potential harmful effects of entrepreneurship on science,

The department can also play a role specifically with regards to spinout formation. Both university and department policies for academic entrepreneurship can play a role in promoting and supporting entrepreneurial activity by researchers (Neves and Brito 2020). Rasmussen, Mosey, and Wright (2014) examined entrepreneurial competencies in different departments at the same universities and found that even small differences in the initial support provided to early-stage academic entrepreneurs from departmental management and senior colleagues – for instance allowing them to build entrepreneurial experience and explore commercial opportunities – could have a substantial effect on the later development of these entrepreneurs' spinouts. The authors also found that lacking support from the department inhibited the development of spinouts, regardless of what university-level policies and practices were in place and therefore emphasized the role of the department in understanding differences in scientists' entrepreneurial behavior.

Peer effects

Kenney and Goe (2004) compared entrepreneurial activity among faculty members in two leading American electrical engineering and computer science departments. Both cases were focused on departments and disciplines that value and provide support for entrepreneurial activities and both cases exhibited substantial engagement in collaboration with industry and formation of spinouts. The authors concluded that academic departments and disciplines that have cultures which are supportive of entrepreneurship can mitigate the typical disincentives and barriers to entrepreneurial activities seen in academic environments.

Generally speaking, the behavior and values of peers in the scientific community or in one's home department tend to influence academic researchers' decisions about whether and how to engage with industry (Perkmann et al. 2013; Aschhoff and Grimpe 2014; Moog et al. 2015).

Based on data on researchers in the UK, for example, Tartari, Perkmann, and Salter (2014) found evidence of peer effects in researchers' decisions engage with industry. In particular, they found that lower-ranked and younger researchers are influenced by the collaboration behavior of peers in their immediate social environment.

Other studies have also emphasized the particular influence of entrepreneurial peers on early career researchers (Bercovitz and Feldman 2008; Houweling and Wolff 2020). Indeed, entrepreneurial role models in the local environment are likely to have a stronger effect on propensities to engage in academic entrepreneurship than, say, university-level strategies and policies (Huyghe and Knockaert 2014; Houweling and Wolff 2020).

A study of scientists at Swedish and German universities showed that the presence of university role models was found to positively affect research scientists' propensity to engage in entrepreneurial activities (Huyghe and Knockaert 2014).

Moog et al. (2015) found, using data collected from life sciences researchers in Germany and Switzerland, that scientists are more likely to have entrepreneurial intentions if they are in contact with entrepreneurial peers, that is, scientists who have experience starting spinouts.

5.2. The institution

University-level commitment, strategies and policies

University culture and policies matter for academic entrepreneurship (Carlsson and Fridh 2002; Di Gregorio and Shane 2003; Goldfarb and Henrekson 2003; Neves and Brito 2020). Based on a study of scientists from Swedish and German universities, Huyghe and Knockaert (2014) found that the extent to which universities explicitly present entrepreneurship as a key element of their mission was positively related to scientists' intentions to engage in patenting and spin-off creation (but not related to their propensity to engage in collaboration with industry). As evidenced by a study of 62 Italian universities, clear strategies and policies are also associated with higher levels of entrepreneurial outcomes (Muscio, Quaglione, and Ramaciotti 2016).

To be effective, such policies should promote a wide range of entrepreneurial activities (Bercovitz and Feldman 2008). They should also consider the personal motivations, preferences and level of entrepreneurial experience of individual researchers (Lam 2011; Neves and Brito 2020).

Universities can support entrepreneurship in many ways, in addition to signaling its importance and value for the institution. For instance, patent regulations at the university-level can reduce obstacles to patenting as perceived by researchers, by signaling organizational commitment to patenting activities (Baldini, Grimaldi, and Sobrero 2007). Policies and strategies can also address rewards for academics who engage in entrepreneurial activities, incl. financial rewards (e.g. royalty sharing, equity) but also access to various resources such as research facilities and incubators (Muscio, Quaglione, and Ramaciotti 2016). The aforementioned study by Huyghe and Knockaert (2014) also showed that explicit rewards for entrepreneurial activities were associated with higher levels of patenting, licensing and spinout activity.

Rewards matter not only at the individual level but also at the department level: Markman, Gianiodis, and Phan (2008) found, based on data from 54 US universities, that scientists are less likely to bypass their TTO when faculty departments receive greater shares of the royalties from the licensing of their discoveries and inventions.

Universities can also provide direct funding, for instance to their spinouts. Academic spinouts tend to be based on early-stage, uncertain technologies, which banks and investors may be reluctant to invest in (Rasmussen and Sørheim 2012). Yet funding for early-stage research and development is crucial to enable the necessary and often long-term development of academic inventions and technologies (Munari and Toschi 2021), and some such funding is provided directly by universities (Munari, Sobrero, and Toschi 2017), through e.g. proof-of-concept, pre-seed or seed funding.

All in all, universities' role in fostering entrepreneurship is complex, and its strategies and policies should be seen in connection with reward structure and other actions taken. Di Gregorio and Shane (2003) sought to explain why some US universities generate more startups than others, and pointed to multiple factors, including the research performance of the institution (which we will address in the next section), whether the institution made equity investments in its startups (for more on this topic, see Ulrichsen et al. 2022), but also policies regarding royalties and equity.

How to design effective university policies is not, however, straightforward. While royalty sharing policies can strengthen researchers' incentives to disclose inventions and start new ventures (Galati et al. 2020), for example, some studies find that higher royalty shares and higher licensing income can strengthen scientists' entrepreneurial motivations (e.g. Lach and Schankerman 2008), other have argued that low royalties from licensing could simulate scientists' incentives to start spinouts with greater earning potential (e.g. Di Gregorio and Shane 2003).

Universities' strategies and policies should also reflect their entrepreneurial focus. In a study of UK universities, Sánchez-Barrioluengo, Uyarra, and Kitagawa (2019) found that different universities have different entrepreneurial (or "third mission") profiles. For instance, large, established universities tended to either focus on research-oriented collaborations with large firms and other organizations or engage in a broad variety of knowledge exchange activities. Meanwhile, younger, less research-intensive universities emphasized consultancy and spinout activities.

It should also be kept in mind that while developing adequate incentives for academic entrepreneurship can strengthen universities' entrepreneurial activity and performance (Debackere and Veugelers 2005; Huyghe and Knockaert 2014), the results of institutional policies are far from guaranteed. For instance, Fini, Grimaldi, and Sobrero (2009) found that universities investments in mechanisms to support spinout-formation did not strengthen researchers' incentives to start a company; instead, such decisions were driven by the expectation of personal benefits, notably an improved academic position. In addition, official policies may also lead to symbolic rather than actual changes to behavior: Bercovitz and Feldman (2008) argued that researchers' may engage in symbolic, or superficial, compliance with local policies regarding entrepreneurial behavior, pretending to live up to expectations or requirements instead of actually altering their behavior. Actual entrepreneurial behavior, the authors argue, requires certain conditions to be met, e.g. that local entrepreneurial norms exist within the faculty group.

Research quality, external funding and reputation of the institution

A number of studies have examined the relationship between quality of research undertaken at a university and researchers' engagement with the private sector. For instance, Friedman and Silberman (2003) found that the number of invention disclosures at American universities was positively related to the quality of universities' faculty. Several other studies have echoed the finding that the prestige and quality of research and faculty is positively related to universities' entrepreneurial performance (Hayter et al. 2018).

In a study on data from Austrian university departments, Schartinger, Schibany, and Gassler (2001) found that research characteristics such as the number of international scientific publications per researcher were significantly related to participation in joint research with industry. Volume of publications is not an indicator of research quality, but can at least serve as a proxy for some level of scientific activity that meets academic standards, provided that the publications were in peer reviewed journals.

In a study of 800 cooperative agreements between Spanish firms and research organizations, Mora-Valentin, Montoro-Sanchez, and Guerras-Martin (2004) found that even the perceived reputation of public research organizations was positively and significantly associated with the perceived success of cooperative projects. Moreover, Lee and Stuen (2016) argued that universities' reputation can also play a role in the success of their technology transfer activities. Using data on researchers from the nanosciences, the authors found evidence of a strong positive relationship between the university's reputation in nanosciences and the number of patents assigned to the university (rather than to firms).

They also found that the share of license revenue offered upfront to researchers was positively associated with university-assigned patents, but negatively related to firm-assigned patents. All in all, their findings suggest that improving universities' research reputation through support for basic research may improve technology transfer performance.

On a related note, using a dataset covering all UK universities, Perkmann, King, and Pavelin (2011) found that the relationship between departmental faculty quality and industry involvement differed. For example, they found a positive relationship in the technology-oriented disciplines. They also showed faculty quality and industry involvement to be positively related in the medical and biological sciences, but not for star scientists. In the social sciences, they found some support for the existence of a negative relationship between faculty quality and particularly the more applied forms of industry involvement.

Not surprisingly, several studies show that collaboration tends to be correlated with higher levels of external funding, particularly from private sources. Institutions that succeed in attracting external funding are likely to have a high quality of research and good networks to external funders and collaborators, which in turn increases the likelihood of attracting more funding. For example, Friedman and Silberman (2003) studied invention disclosures at 83 American universities and found that the number of invention disclosures was positively associated with, among other things, the volume of external funds awarded to universities (both from public, federal sources and from industry).

Based on a survey of university-industry interaction in 241 scientific institutes in Switzerland, Arvanitis, Kubli, and Woerter (2008) found a significant and positive relationship between a high share of external funding and higher propensity to partake in knowledge and technology transfer activities.

Finally, Pitsakis, Souitaris, and Nicolaou (2015) found that entrepreneurial activity can also strengthen an institution’s access to external funding, not only through royalties and equity, but also indirectly through reputational benefits: having a strong reputation for being entrepreneurial and generating spinouts can have a “halo effect” by attracting additional funding for core activities at universities.

The role of the TTO/KTO

Technology Transfer Offices (TTOs) and Knowledge Transfer Offices (KTOs) – which in the following will be referred to collectively as TTOs – are generally tasked with administrative and legal responsibilities associated with research commercialization and academic entrepreneurship, focused in particular on IP-related activities (such as assessing invention disclosures, patenting, marketing inventions to potential licensees, licensing, and supporting spinout formation) (e.g. Boh, De-Haan, and Strom 2016) but also e.g. post-deal management (Hockaday and Piccaluga 2021).

TTOs can also play a role in identifying commercial opportunities in the institution (Lockett, Wright, and Franklin 2003), for instance through scouting, and they can provide access to networks of external stakeholders, particularly those who can provide nascent firms with vital competences (e.g. mentors, co-founders, talent to hire) or financing (e.g. soft funding providers, investors etc.) (Shane 2004).

TTO/KTOs have been described as “boundary spanners”, or gatekeepers, between the institution, spinouts, and the rest of the university ecosystem (Alexander and Martin 2013; Chau, Gilman, and Serbanica 2017). Their boundary spanning function can build bridges not only between the institution and the wider ecosystem, but also *within* the institution where they can help mobilize both commercial competences and context-specific knowledge in internal entrepreneurial processes as well as communicate changes in entrepreneurial priorities and policies from the upper university management throughout the organization (Huyghe et al. 2014).

TTOs also often play a broader role in shaping strategies and initiatives regarding IP, innovation and research commercialization in their organization (Siegel, Veugelers, and Wright 2007). Increasingly, they're also expected to support not just technology transfer to individual companies but also the development of solutions to grand challenges, which represents a broader and more complex role for universities and TTOs in knowledge translation and application (Borrás et al. 2024; Menter 2023; Siegel and Wright 2015).

Having an effective TTO/KTO is a critical component in universities' efforts to foster academic entrepreneurship (Vohora, Wright, and Lockett 2004; Sandström et al. 2018; Neves and Brito 2020). TTOs can support successful academic entrepreneurship (Macho-Stadler, Pérez-Castrillo, and Veugelers 2007), though not all TTOs are equally efficient or effective (Chapple et al. 2005; Iacobucci, Micozzi, and Piccaluga 2021) and they sometimes play only a marginal or indirect role in the research commercialization process (Clarysse, Tartari, and Salter 2011; Siegel and Wright 2015). Some studies paint a critical picture of TTOs, pointing e.g. to misalignment between researcher and TTO incentives or to lacking capabilities in TTOs (Kenney and Patton 2009; Sandström et al. 2018)

The majority of US university spinouts are not based on university-owned IP, i.e. either they do not involve IP at all, or they are based on IP which has not involve the university (Fini, Lacetera, and Shane 2010). Sometimes academic researchers choose not to disclose inventions to the university TTO (Siegel, Waldman, and Link 2003; Markman et al. 2005), and sometimes they bypass the TTO unintentionally, because they are not aware of the TTO and what it does (Huyghe et al. 2016).

An effective TTO is therefore crucial. TTO performance is dependent on its experience base and capacity, as indicated by its age, as well as on the depth and quality of its interaction with the surrounding business community (Carlsson and Fridh 2002). More developed and larger TTOs tend to yield higher numbers of startups, commercialized patents and licensing income (Carlsson and Fridh 2002; Iacobucci, Micozzi, and Piccaluga 2021), presumably because of the additional resources available to older, larger TTOs as well as their ability to capitalize on the experience they have accumulated over time (O'Shea et al. 2005; Markman et al. 2005; Algieri, Aquino, and Succurro 2013).

A higher volume of entrepreneurial activities does not necessarily, however, translate into better entrepreneurial outcomes: Iacobucci, Micozzi, and Piccaluga (2021) investigated the importance of resources (as in the number of employees) of university TTOs for the creation and performance of academic spin-offs from Italian universities during the period 2002-2011. In the initial years of their study, they found no effect of universities, which they argued could be explained by the long time it took Italian universities to respond to a legislative change and establish effective TTOs. In the 2006-2011 period, however, and controlling for university-specific factors, local context and TTO age (i.e. experience), they found that TTO size was positively associated with the *number* of new academic spinouts created, but not their *performance.* Performance was instead shaped by other factors, such as the quality of the underlying research, the level of economic development of the regional ecosystem, and the local availability of incubators or similar intermediaries.

TTOs can pursue very different strategies and approaches (Alexander and Martin 2013; Traoré, Amara, and Rhaiem 2021), and show large variation in their performance (Perkmann et al. 2013). It is difficult to point to any clear-cut best practices in TTOs (Geuna and Muscio 2009).

Regardless of the approach a TTO takes, it needs skilled staff. Soares and Torkomian (2021) highlighted the importance of the competence profiles of TTO staff, distinguishing between research-oriented capabilities (i.e. the ability to understand and assess scientific results and outputs), marketing-oriented (i.e. the ability to effectively identify and pursue commercial opportunities), and legal-oriented capabilities. More specifically, based on a study of Brazilian universities, they found that TTO employees that had research-oriented capabilities had a positive impact on both the number of new invention disclosures as well as licensing agreements, while TTO employees that had marketing-oriented capabilities had a positive impact on licensing agreements only. Research-oriented staff, the authors also argued, could hold additional benefits, including for instance in being able to more easily build trust with academic researchers and help align TTO and researcher objectives and interests. However, the authors also pointed out that the complementary capabilities of TTO staff with marketing-oriented capabilities may encourage academic researchers to disclose their inventions and collaborate with the TTO (Ibid.).

Striking a balance between centralized and decentralized support mechanisms

Bercovitz et al. (2001) pointed to the importance of organizational structures in explaining universities' performance with regards to patenting, licensing and externally funded research. They found that universities with high performance on these activities tended to have a decentralized technology transfer model, meaning that responsibility for technology transfer was allocated to decentral units or personnel in close proximity to researchers.

Debackere and Veugelers (2005) argued that finding the right balance between specialized, decentralized entrepreneurial support and centralized support is crucial for universities' overall entrepreneurial performance.

Centralized support includes e.g. administrative support on activities related to entrepreneurial activities (e.g. legal and financial issues) but also specialized support for commercializing research outputs (e.g. commercial and marketing issues) (Debackere and Veugelers 2005). This allows departments and researchers to focus on knowledge exchange and transfer activities rather than administration (Ibid).

Central units can have an advantage in building expertise and competences, increasing efficiency in entrepreneurial processes, and in identifying opportunities for synergies and collaboration within and beyond the institution (Carlsson et al. 2008). They can benefit from economies of scale and scope: by handling a larger volume of cases, they have resources and opportunity to build expertise in matters such as selecting high-potential inventions (Siegel, Waldman, and Link 2003; Debackere and Veugelers 2005). This is especially valuable as TTOs that are too small often lack the critical mass necessary to be effective (Polt 2001). However, centralized TTOs risk emphasizing inventions that suit the practices and skills they have honed, and deselecting technologies that although promising are not well-suited for IP-based tech transfer and/or require long-term, non-linear development and commercialization (Litan, Mitchell, and Reedy 2007). Central units can also have difficulties engaging with researchers and incentivizing them to e.g. disclose activities and inventions (Jensen and Thursby 2001; Debackere and Veugelers 2005).

Decentralized, specialized support fosters responsiveness and provides research institutes and similar units with autonomy in deciding how to pursue entrepreneurial activities, mitigating the risk of disagreements or conflicts of interest between a centralized unit and local research and teaching activities in the research environment (Debackere and Veugelers 2005). It provides departments with autonomy in their engagement with funders, investors and patent attorneys etc., which may facilitate effective engagement (Ibid.) as well as greater responsivity and speed (Carlsson et al. 2008).

Close proximity to researchers can increase TTO effectiveness (Polt 2001). Decentralizing responsibility for and influence over entrepreneurial activities can also increase researchers' incentives to actively engage in the development of entrepreneurial activities and help reduce the risk of conflicts of interest between the three missions of the university (Debackere and Veugelers 2005). It also promotes specialization, understood as in-depth knowledge of the field of the research environment and how the characteristics of the field and department shape opportunities and processes for entrepreneurial activities (Ibid.).

Structured programs to facilitate and support spinout formation

Boh, De-Haan, and Strom (2016) found, based on detailed case studies of spinouts from eight US universities, that universities can act as incubators for new firms, supporting the formation of connections between faculty members, early career researchers, students and external experts and facilitating the early development of startups based on university research. They further argued that universities' support in this period reduces risk for the spinout team (as, for instance, early career researchers and students can postpone the decision about whether to dedicate themselves full-time to the company) while providing a supportive environment for their efforts to bring down the market risk and technological risk of the venture. This requires that universities provide suitable programs and support opportunities for early stage startups.

By studying spin-off formation at eight US universities, Boh, De-Haan, and Strom (2016) identified the following types of university programs and practices that were conducive to the formation and development of academic spinouts, in addition to services provided by the TTO/KTO:

- *Education and training in technology commercialization,* typically involving interdisciplinary teams working on actual business ideas and how to commercialize them. In addition to strengthening entrepreneurial insight and skills, such training was found useful in locating new members for the entrepreneurial founding team (see Chapter 5 for more information on this).
- *Mentoring programs and access to ecosystem actors.* The study also underlined the value of mentoring in providing support and advice for potential or early-stage entrepreneurs, which included facilitating connections to relevant experts (e.g. legal or commercial experts) as well as potential investors, licensees or customers.
- *Accelerator and incubator programs.* These provide focused support for startups, typically concentrated over a short period of time and focused on providing both infrastructure (e.g. office space) and support (e.g. financing, mentoring, access to ecosystem networks etc.). They may also strengthen the visibility of the startup vis-à-vis relevant actors in the ecosystem.
- *Business plan competitions* which can provide a starting point for founding team formation and for the development of a business plan and strategic roadmap. Like accelerator and incubator programs, they may also strengthen the visibility of the startup vis-à-vis relevant actors in the ecosystem.

These practices may not, on their own, ensure successful spinoffs for universities, but they provide rich ground for faculty and students to experiment in a relatively safe environment before they launch new ventures. And they allow universities to use their resources, both inside and outside the school, strategically. Universities seeking to improve their technology transfer must examine their ecosystem more broadly, creating programs to ensure that faculty and students interested in commercializing technologies are able to access and leverage university resources both inside and outside the school.

5.3. The entrepreneurial ecosystem

The role of the ecosystem

The economic and innovative performance of regions, and their access to venture capital, have been tied to the success of university spinouts (Chapple et al. 2005; Audretsch, Hülsbeck, and Lehmann 2012). Similarly, the characteristics of the local business community (Fini, Lacetera, and Shane 2010) as well as the quality of social ties within a region (Casper 2013) have been shown to matter for universities' entrepreneurial performance.

In recent years, studies have therefore expanded their focus from the role of the institution and the TTO to also highlight the importance of the wider ecosystem in which universities are embedded. The ecosystem includes actors such as university internal or external incubators, accelerators, science parks, but also networks of investors and experienced entrepreneurs. Ecosystem actors can contribute not only to specific spinouts but also to various university programs aimed at supporting academic entrepreneurship, for instance as mentors, expert advisers, co-founders or investors (Boh, De-Haan, and Strom 2016).

Prokop (2022) examined 160 institutions of higher education in the UK, which had formed a total of 784 academic spinoffs and found that institutions anchored in better developed university entrepreneurial ecosystems tended to produce a higher number of academic spinouts.

Ecosystem actors may provide incubators, accelerators or other support offerings to university spinouts. Fini et al. (2011) found that universities' own support mechanisms may either have a positive or negative marginal effect on universities' spin-off productivity, depending on how well they complement offerings in the local ecosystem.

The role of the ecosystem also helps explain why attempts to emulate the success of entrepreneurial universities in, for instance, the US and reproduce it in European universities tend to fall short of expectations. Successes in one context build on particular qualities of the local entrepreneurial ecosystem, which can take decades to evolve (Feldman and Desrochers 2003; Mowery and Sampat 2004) and be difficult if not impossible to recreate in other contexts (Sandström et al. 2018).

Moreover, the varied nature of universities' entrepreneurial ecosystems require universities to tailor their initiatives and practices to the particular characteristics of the ecosystem in which they are embedded (Bergek and Norrman 2008; Miner et al. 2012; Sandström et al. 2018).

The efficiency and effectiveness of academic entrepreneurship policies and initiatives will depend on how well the many factors described in this review fit together in a coherent whole, from the characteristics of the local entrepreneurial ecosystem to the organization, activities and incentive structures of the institution (Sandström et al. 2018). Research has shown that there is no particular combination of antecedents in a university ecosystem that yields more spinouts than others; rather, there are multiple combinations of antecedents and strategies that can lead to success for a university (Berbegal-Mirabent et al. 2015). However, often, initiatives to promote and support academic entrepreneurship are not successful, because they rely on conditions that are not fulfilled (Sandström et al. 2018). It has also been shown that initiatives to increase the number of academic spinoffs can bear fruit in the form of increased numbers of new ventures formed (Fini et al. 2017, 2020), but that this volume increase may come at the expense of the quality of these firms (Fini et al. 2017).

Academic entrepreneurship in collaboration with experienced entrepreneurs

Academic researchers, not surprisingly, have academic capabilities but lack commercial and entrepreneurial insight, capabilities and networks (Vohora, Wright, and Lockett 2004; Clarysse and Moray 2004; Mosey and Wright 2007; Rizzo 2015; Messina et al. 2022), including skills to identify and develop commercial opportunities, drive the startup development process, and acquire the technical, human and financial resources needed to needed to manage and grow the company (Rasmussen, Mosey, and Wright 2011; 2014). Given that academic researchers do not tend to be strongly motivated by the potential for personal financial gain (Fini, Grimaldi, and Sobrero 2009), and because they associate strongly with their academic role identity (Clarysse et al. 2023), they often lack growth ambitions for their startup (Meyer 2003; Hayter 2011; Clarysse et al. 2023). Indeed, academic inventors can hamper the commercial potential and development of the company (Hayter et al. 2018). Moreover, many academic inventors entirely lose interest in the research commercialization process once their research results have been successfully patented (Aydemir, Huang, and Welch 2022).

Academics can compensate for this lack of entrepreneurial skills and/or interest by collaborating with experienced entrepreneurs and industry professionals to commercialize research. Several studies highlight the value of seasoned commercial profiles in the development of academic startups (Lockett, Wright, and Franklin 2003; Nicolaou and Birley 2003a; Siegel and Phan 2005; Politis, Gabrielsson, and Shveykina 2012; Visintin and Pittino 2014; Prokop, Huggins, and Bristow 2019).

Effective and timely engagement with experienced commercial profiles is important (Wennberg, Wiklund, and Wright 2011; Prokop 2022). There is a great need for market insight and business skills in the early stages of a startup (Djokovic and Souitaris 2008; Messina et al. 2022), where key decisions and composition of the founding/management team can greatly affect the survival chances and subsequent growth of the company (Huynh et al. 2017). For instance, academic spinoffs are more likely to form when the founding or management team includes external entrepreneurs (Hayter 2013), and they are then also likely to exhibit better performance in the early stages of venture development (Visintin and Pittino 2014)

Prior work has therefore pointed to the value of so-called “surrogate entrepreneurs” with commercial experience who take on the task of bringing research-based inventions to the market, showing for instance that Swedish, technology-based university startups performed significantly better when they included a surrogate entrepreneur (Lundqvist 2014).

Franklin, Wright, and Lockett (2001) found that the universities that produce most startups were more likely to be favorably inclined towards surrogate entrepreneurs, and a related paper by Lockett, Wright, and Franklin (2003) showed that universities that generate most startups had both access to commercial networks and explicit strategies for using surrogate entrepreneurs.

This raises the question for academic entrepreneurs of *how* and *how much* they wish to, and should be, engaged in their startup. Researchers differ in the extent to which the want to be involved in a startup, and the extent to which they wish to retain their ability to pursue academic tasks (Stern 2004; Vohora, Wright, and Lockett 2004; Berggren 2011; Würmseher 2017). As Würmseher (2017) pointed out, there is a full spectrum of possible entrepreneurial models to consider, ranging between the “inventor entrepreneur” model, where the academic entrepreneur starts a company on their own, and the “surrogate entrepreneur” model, where the academic hands over the reins to an experienced entrepreneur. Working together with experienced entrepreneurs can be a very attractive option for academics. While the startup benefits from the experience and insights of the surrogate entrepreneur, this model also allows the researcher to maintain their research career.

Meanwhile, maintaining the involvement of the academic inventor can also be an advantage for the firm. Surrogate entrepreneurs may lack sufficient understanding of the underlying science or technology, or they may lack the legitimacy or capabilities needed to work effectively with scientists (Hayter et al. 2018). Moreover, Braunerhjelm and Svensson (2010) showed that Swedish patents generate more income when they were commercialized by an entrepreneur rather than by the inventor – but also that they generated most income when the inventor remained actively involved in the commercialization of the patent. Indeed, some form of continued involvement of the academic inventor is often critical to the success of a research-based startup (Jensen and Thursby 2001; S. A. Shane 2004; Vohora, Wright, and Lockett 2004) and also increases the speed of commercialization (Markman et al. 2005).

A model which combines the scientific insight of academic inventors and seasoned entrepreneurs is likely to be the most effective (Franklin, Wright, and Lockett 2001; Lockett, Wright, and Franklin 2003; Lundqvist 2014; Würmseher 2017).

Locating appropriate surrogate entrepreneurs is, however, often difficult for researchers (Boh, De-Haan, and Strom 2016). Academic researchers tend to have homogeneous networks (Hayter et al. 2018) and limited opportunities to engage with experienced entrepreneurs (Branscomb & Auerswald 2001). Academic startups are therefore often established by people who knew each other beforehand (Clarysse and Moray 2004; Colombo and Piva 2012). While these initial founding teams are key in the initial development of a spinout, Hayter (2016) showed that they must evolve over time (to develop or access commercial capabilities and networks), or they risk constraining the later development of the spinout.

University-based intermediaries can help by providing researchers with access to networks of experienced entrepreneurs, industry professionals and investors (Rasmussen and Borch 2010; Rasmussen, Mosey, and Wright 2011; Hayter 2016a); however, often universities themselves have limited networks to relevant profiles (Hayter et al. 2018).

Different models for engaging with experienced entrepreneurs and early career researchers

In the previous section, we focused on how academic entrepreneurs can partner with experienced entrepreneurs to develop academic spinouts. Another (and potentially complementary) option to consider is to partner with early career researchers, i.e. PhD students and postdocs (Grimaldi et al. 2011). As mentioned earlier in the report, entrepreneurship can provide access to attractive, alternate career options for early career researchers who are interesting in pursuing a career outside academia.

Based on detailed case studies of spinouts from eight US universities, including Harvard University, MIT, Stanford University and UC Berkeley, Boh, De-Haan, and Strom (2016) concluded that students and early career researchers often play a critical role in university spinoffs. PhD students and postdocs, like their more experienced faculty member colleagues, usually lack business insight and capabilities, but have deep knowledge of the underlying science and/or technology. Other scholars have also emphasized the role of students and postdocs in academic entrepreneurship including e.g. Pirnay, Surlemont, and Nlemvo (2003) and Rasmussen and Wright (2015). On a related note, Åstebro et al. (2012) found that that recently graduated students from universities were more likely to start a business than faculty members and that their startups were not of low quality. And, more recently, Hayter, Lubynsky, and Maroulis (2017) who stressed the understudied nature of the phenomenon of students entrepreneurs in university spinouts. Based on insights from a qualitative of spinouts from MIT, they found that graduate students take on similar roles in spinouts as faculty members. Student entrepreneurs also risked, however, experiencing a variety of conflicts with their faculty advisors, related both to academic tasks and to spinout related IP and ownership conflicts.

Boh, De-Haan, and Strom (2016) identified four different ways in which experienced faculty can engage with early career research but also with business school students and experienced external entrepreneurs to commercialize their research: (1) a principal investigator on the faculty team (PI) partners with an experienced entrepreneur (23% of the cases studied); (2) a PI partners with PhD students/postdocs (41% of cases); (3) a PI partners with PhD students/postdocs and business school students (13% of cases); and (4) the startup is driven purely by student efforts, typically by Master's or PhD students working together with business school students (23% of cases), sometimes aided by structured programs at their university.

University approaches to developing and mobilizing the entrepreneurial ecosystem

A study of eight US universities by Boh, De-Haan, and Strom (2016) revealed that some institutions took a very structured, managed approach to the development of their universities' entrepreneurial ecosystems, while others took a more laissez-faire approach, allowing the ecosystem to develop organically (e.g. Stanford and MIT). The laissez-faire approach was successful, the authors of the study argued, because of the strong entrepreneurial culture in place at these two universities and because they were both embedded in larger, high-performing regional ecosystems. Harvard and UC Berkeley were examples of universities taking a more structured approach, which the authors argued was considered necessary (despite their strong regional ecosystems) because of the long-standing focus of these institutions on basic rather than applied research, which could warrant a more structured focus on nurturing and supporting entrepreneurial activities.

Boh, De-Haan, and Strom (2016) also proposed three guidelines for universities for stimulating technology transfer and spinout formation. The first was aligning objectives of the institution, TTO, faculty members and early career researchers (i.e. PhD students and postdocs), focusing in particular on aligning expectations of intended gains and outcomes of entrepreneurship. The authors referred specifically to aims of generating income for the universities (which several studies have argued is difficult, even for the highest-performing universities, see e.g. Mowery et al. (2001) and Valdivia (2013)), and aims of augmenting the impact of the university's research, arguing that the aims set and the metrics used to track progress along these aims will shape priorities and behavior, and that clarity on intended aims and supporting metrics is therefore crucial to achieve alignment. Secondly, Boh, De-Haan, and Strom (2016) advised universities to leverage all potential university resources to support academic entrepreneurship, meaning that they should develop programs and initiatives that address e.g funding gaps within their local entrepreneurial ecosystem and other sources of public and private funding available for entrepreneurial activities. Leveraging resources could also refer to initiatives aimed at bridging competences and networks, for instance by connecting internal activities to lacking competences and networks available in the ecosystem, through entrepreneurship courses and training, business competitions, access to commercial external expertise etc. Finally, the authors recommended encouraging PhD students and postdocs to actively consider spinout formation as a career option, for instance through courses and training programs, given the importance of early career researchers and students in the development of university spinouts.

6. Entrepreneurship education and training

Entrepreneurship education and training (EET) is described as a relatively new field. In the 1970s a few business schools started teaching entrepreneurship courses. By 2005 over 1600 colleges and universities have entrepreneurship programs, with these numbers only continuing to grow (Fellnhofer 2019; Kuratko 2005). In the 1990s, a movement started that aimed to expand entrepreneurship education and move it to other disciplines than just business, with the academic interest following (Duval-Couetil 2013). However, the research into the discipline is still growing and it is suggested that as an academic field it is still striving for more maturity as a field of study, with a consensus on its conceptual and methodological principles (Brazeal and Herbert 1999; Duval-Couetil 2013; Neck and Greene 2011; Solomon et al. 2008).

As recent as 2021, a review on learning outcomes in entrepreneurship education concluded that there is a lack of agreement as to the definition of entrepreneurship education, and how it should be taught and assessed (Wong and Chans 2021). The core of this debate would be the understanding of whether entrepreneurship education is supposed to teach the skills to be able to create a venture or to instil a mindset of opportunism, proactiveness, innovation, and risk tolerance (Caird 1991; Duval-Couetil 2013; Henry et al. 2005; Kirby 2004). This has resulted in a lack of consistency in course design across programs when it comes to pedagogical approaches, learning objectives, and learning outcomes (Rideout and Gray 2013).

The two main schools of thought about entrepreneurship have been the causal and effectuation approach (Fayolle and Gailly 2008). The causal approach views entrepreneurship being more related to economic plans and strategies as it focuses on how education impacts business development rates. The effectuation approach considers uncertain environments by suggesting entrepreneurs use available resources in terms of what is available to them (Gertz Huang and Cyr 2018; Sarasvathy 2001). Effectuation as a learning method can be helpful to understand how ideas can be developed then delivered into the marketplace (Ilonen and Heinonen 2018).

Learning outcomes can be defined as what the learners know or can do after completing a specific program (Allan1996; Wong and Chans 2021). In other words, these learning outcomes show what the program has achieved in terms of its educational goals and are essential when it comes to demonstrating the value created (Duval-Couetil 2013). Assessing this value or impact of a program is important in all educational fields, but with the limited consistency and diversity in approach in the field of entrepreneurship it is even more essential to be able to provide evidence of the obtained knowledge and skills by its students (Duval-Couetil 2013). Regardless of the direction the program design takes, the assessment of the learning outcomes will allow determination and demonstration of the value created.

6.1. Entrepreneurship education and training (EET)

The question of whether entrepreneurship can be learned is a longstanding and complex debate in the field of EET. While some argue that entrepreneurship skills can indeed be taught, others contend that key aspects of entrepreneurship are innate and cannot be learned through traditional educational approaches. For instance, Isaacs et al. (2007) highlight ongoing discussions about this issue, and several scholars agree that certain components of entrepreneurship, particularly those relating to business and management, are teachable (Timmons and Spinelli 2004; Henry Hill and Leitch 2005; Kuratko 2005). On the other hand, Haase and Lautenschläger (2011) present arguments that challenge this notion, pointing out that certain entrepreneurial qualities, such as creativity and innovative thinking, cannot be easily transferred through formal education. This view is further supported by Poikkijoki (2006), who distinguished between the "art" and "science" of entrepreneurship, suggesting that while business and management skills can be taught (the “science”), the creative aspects of entrepreneurship are best learned through practical experience (the “art”).

Entrepreneurship education programs often operate on the assumption that entrepreneurial intentions and skills can be fostered in a classroom setting, further accentuating the creative aspects of EET. Research by Clark et al. (1984), Gorman et al. (1997), Peterman and Kennedy (2003), and Pittaway and Cope (2007) supports the notion that these programs can raise students’ awareness of entrepreneurship as a viable career path and equip them with the skills necessary to launch and manage their own ventures. The growing global interest in EET is reflected in the increasing number of entrepreneurship courses being offered by educational institutions (Kuratko 2003) and its recognition in international initiatives like the European Commission’s Oslo Agenda and the Global Entrepreneurship Monitor. Mwasalwiba (2010) attributes this rise in EET partly to the self-interests of key stakeholders, including policymakers driven by the need for job creation, students seeking alternative career options, and educational institutions responding to market demand. This suggests that education and training systems are becoming central to broader efforts to promote entrepreneurship.

Despite the growing popularity of EET, there is considerable variation in the content and delivery of these programs. Some scholars argue that entrepreneurship education should include a balance between theoretical and practical elements. Bygrave (1993) warns against purely practical or purely theoretical approaches, arguing that neither should be pursued in isolation. Similarly, Fiet (2000) advocates for the teaching of theory in entrepreneurship education, viewing it as a crucial component of effective learning. He draws on Kuhn's (1970) work, suggesting that correct theory is one of the most practical things educators can offer to students, even though our theoretical understanding of entrepreneurship remains incomplete. This raises the question of what constitutes entrepreneurship theory and what its role should be in education.

In terms of the broader effects of entrepreneurship education, research has shown a positive correlation between higher levels of education and improved entrepreneurial performance, including higher rates of business formation (van der Sluis van Praag and Vijverberg 2005; Isaacs et al. 2007). However, measuring the impact of entrepreneurship education remains challenging due to the intangible nature of many performance outcomes. Furthermore, there is potential for selection bias, as individuals with a pre-existing inclination towards entrepreneurship may be more likely to pursue entrepreneurship education. Beyond formal education, training programs—both for aspiring entrepreneurs and practicing entrepreneurs—offer additional pathways for entrepreneurial development. There is evidence that practicing entrepreneurs benefit more from business training, which helps them improve the success of existing ventures. In contrast, potential entrepreneurs may benefit more from programs that help develop their entrepreneurial mindset, making them more likely to pursue entrepreneurship in the first place. This reflects a broader distinction between enhancing an existing business and encouraging someone to enter the field of entrepreneurship.

Entrepreneurial self-efficacy (ESE) can show the influence entrepreneurial education has on the students’ entrepreneurial behavior. Multiple studies indicate that a person with high ESE has higher entrepreneurial intentions and behaviors than someone with low ESE (Barbosa et al. 2007; Mauer et al. 2017; McGee et al. 2009; Zhao et al. 2005). ESE shows an individual’s perceived behavioral control, which is an indicator for their intention to perform a certain behavior, following the theory of planned behaviour (Newman et al. 2019). This makes it a fitting assessment method to indicate the effectiveness of a particular program in increasing the venture intention of its students (Newman et al. 2019). It has also been specifically suggested that performing a pre- and post-measurement with ESE can give educators better insights into how to improve their programs' effectiveness (McGee et al. 2009). The most widely used ESE measurement tools is a 22-item scale developed by (Chen et al. 1998). This scale consists of questions within 5 sub-dimensions that are supposed to measure the self-efficacy in terms of entrepreneurship tasks: marketing, innovation, management, risk-taking and financial control. However, a comment on this scale is that it is relatively general within the field of management, not specific to entrepreneurship (Bandura 1986; Newman et al. 2019). The following often used scale tried to develop a more domain specific tool. The scale of DeNoble, Jung, and Ehrlich (1999) is supposed to capture "*the entrepreneurial skills that are uniquely different from managerial skills*", covering six sub-dimensions: developing new product and market opportunities, building an innovative environment, initiating investor relationships, defining core purpose, coping with unexpected challenges, and developing critical human resources. The most recent version is developed by McGee, Peterson, Mueller and Sequeira (2009). This was developed as it was argued that "*there remain inconsistencies in the definition, dimensionality, and measurement of ESE*". The scale takes different phases of the startup process into account and is aimed for both nascent as experienced entrepreneurs, resulting in the following four sub-dimensions: searching, planning, marshalling, and implementing (McGee et al. 2009). Rasmussen et al. (2011, 2014) emphasize three essential skills needed for entrepreneurial success. First, the *opportunity development competency* focuses on identifying and shaping viable business opportunities, a critical aspect of innovation and market relevance. Second, the *championing competency* highlights the importance of leadership and motivation, as entrepreneurs must inspire others to believe in and support their vision. Finally, the *resource acquisition competency* addresses the need to secure financial, human, and material resources to transform an idea into a sustainable business, ensuring that entrepreneurs can execute and scale their ventures.

These scales and frameworks all have different perspectives on what the essential dimensions of entrepreneurship are, but all use the ESE to evaluate the entrepreneurship education in terms of venture intention (Markman et al. 2002; McGee et al. 2009). However, it is argued that venture intention should not be of concern for university education. Their main purpose should be to enhance knowledge and equip students with relevant skills, not to enhance intentions (Biggs et al. 2022; Karlsson and Moberg 2013). Researchers argue that with societal changes in the last decade, entrepreneurial skills are a necessary ability for all individuals, having a growing influence on career development and vocational behavior. These skills are necessary both when they choose to be self-employed, but also as employees. For example when working on corporate entrepreneurship and innovation or in the social sector (Charney and Libecap, 2000; Newman et al. 2019). There is universal use for individuals with qualities taught when educating in the entrepreneurial mindset, such as creativity, proactivity, and risk-tolerance (European Commission: Enterprise and Industry, 2008). These qualities would currently not be measured effectively by a scale that focusses on venture intention.

Ultimately, entrepreneurship education and training must address both the "art" and the "science" of entrepreneurship. While business skills can be taught similarly to traditional management training, the creative and innovative aspects of entrepreneurship remain difficult to formalize. Instead, fostering an entrepreneurial mindset—particularly in potential entrepreneurs—may be more about unlocking latent potential rather than creating it from scratch (Henry et al. 2005; Kirby 2004). In this way, EET plays a crucial role in helping individuals identify opportunities and consider entrepreneurship as a possible career path, even though not all aspects of entrepreneurship can be directly taught.

6.2. Objectives of EET

Entrepreneurship education programs can have different objectives. The European Committee names the following as examples: "*developing entrepreneurial motivation among students, training students to set up a business (planning, networking, selling, finding resources, etc.), developing the entrepreneurial skills needed to identify and exploit opportunities*" (European Commission: Enterprise and Industry, 2008). The World Bank offer a similar definition: "EET… *represents academic education or formal training interventions that share the broad objective of providing individuals with the entrepreneurial mindsets and skills to support participation and performance in a range of entrepreneurial activities*." The overlap between these objectives would be that they have to do with preparing and motivating students to set up a company. Entrepreneurship has been identified as a large driver in economic growth (Almodóvar-González et al. 2020; Pradhan et al. 2020; Prasetyo and Kistanti, 2020) and the European Union has included raising the level of entrepreneurship and innovation in their Europe 2020 Strategy for economic growth (Pradhan et al. 2020) through new ventures and job creation (Mwasalwiba, 2010). This perspective explains that, from a governmental policy point of view, the increase in venture creation is one of the main objectives of entrepreneurship education, which heavily influences universities and other educational institutions (Aboobaker, 2020; Estrin et al. 2016). The educational objective that would lead to an increase in entrepreneurial activity is mentioned as venture intention. Venture intention indicates the likeliness of the student to create a venture or engage in entrepreneurial activity after they have completed the educational program.

This objective relies on the positive correlation between entrepreneurship education and entrepreneurial activity, which multiple studies have indicated (Aboobaker 2020; Barba-Sánchez and Atienza-Sahuquillo 2018; Unger et al. 2011). Research results have been indicated as being mixed, inconsistent, and inconclusive (Duval-Couetil 2013; Gorman et al. 1997; Matlay 2005; Solomon et al. 2008). Problems include the need for more longitudinal studies, a lack of control groups in the research design, and an inherent bias in the samples chosen (von Graevenitz et al. 2010), with the latter representing a significant challenge to the field as many students self-select into EET (Rideout and Gray 2013).

In their systematic review, Carpenter and Wilson (2022) examined the effects of entrepreneurship education and training (EET) in higher education, focusing on learning, venture, and economic outcomes. Their findings align with a growing body of research that highlights the importance of experiential and practice-oriented pedagogy in entrepreneurship education. Several studies, including Costa et al. (2018), Hahn et al. (2017), and Klapper and Faber (2016), consistently report positive learning outcomes when students are actively engaged through experiential learning approaches. Hahn et al. (2017, p. 963) emphasize that learning outcomes "are always higher when a practice-oriented entrepreneurial teaching pedagogy is used." This type of pedagogy encourages students to construct knowledge through hands-on experience, placing the responsibility for learning on the student themselves (Gielnik et al. 2015). In addition to learning outcomes, experiential education has been linked to practical entrepreneurial action. Gielnik et al. (2016) found that entrepreneurship education can stimulate entrepreneurial action, which leads to job creation and the development of income-generating activities. These findings support Fayolle, Gailly, and Lassas-Clerc's (2006, p. 702) definition of entrepreneurship education as "any pedagogical program or process of education for entrepreneurial attitudes and skills," reinforcing the potential for EE to cultivate essential entrepreneurial capacities. Greene and Saridakis (2008) also point to the potential for entrepreneurship education to enhance students' venture creation skills, knowledge, and attitudes, which, in turn, can contribute to business startups and job creation (Greene, Katz, & Johannisson, 2004; Rideout & Gray, 2013). These outcomes have broader implications for economic growth and development, as suggested by Bosma et al. (2008).

However, the impact of entrepreneurship education on venture creation and economic outcomes is less clear-cut. While Gielnik et al. (2016) emphasize the role of entrepreneurship education in fostering entrepreneurial action that can drive job creation, Slavtchev, Laspita, and Patzelt (2012) caution that the effects of EET may not be immediate. Their research suggests that the positive outcomes of entrepreneurship education, such as new venture formation, often take five or more years to materialize. This delayed impact highlights the challenges of measuring the short-term effectiveness of EET, particularly regarding venture creation and economic growth. Moreover, the relationship between entrepreneurship education and venture intention remains inconclusive due to potential selection bias. While many entrepreneurship programs are designed to increase venture intentions, there is no irrefutable evidence of a direct causal link (Mwasalwiba 2010). Nevertheless, venture intention remains a key metric for evaluating the success of entrepreneurship programs, even as scholars suggest that entrepreneurship education can yield other valuable outcomes beyond startup creation (Gibb 2002a; Hannon 2005; Sarasvathy and Venkataraman 2011).

Mwasalwiba (2010), in his evaluation of 108 articles on EET, revealed a diverse range of objectives associated with entrepreneurship education. While 34% of scholars view the primary goal as fostering entrepreneurial attitudes and culture, 27% see the aim as promoting venture creation and job growth. Additionally, 24% link entrepreneurship education to supporting local entrepreneurs, and only 15% emphasize the transmission of entrepreneurial skills to students. This indicates that the creation of new ventures is relatively less important for educators compared to policy-driven objectives. However, this focus appears to be shifting, particularly considering the European Commission's Expert Group report on 'Entrepreneurship in Higher Education, Especially in Non-Business Studies' (European Commission: Enterprise and Industry, 2008). The report stresses the importance of not only supporting graduate startups but also fostering the skills needed to manage the growth phase of a business—an area that is often neglected in current entrepreneurship programs, which tend to focus heavily on startup activities.

Even though most scholars seem to see an emphasis on teaching attitudes, skills and helping existing entrepreneurs improve, most programs still seem to focus on venture creation (Mwasalwiba 2010). This is followed by growth management, entrepreneurial financing, and other programs with business model creation at its core (Gibb 2002b; Küttim et al. 2014). This makes sense, as the governmental perspective and the money connected to it will probably have a big influence on policy- making within educational institutions (Mwasalwiba 2010). That venture creation is a big objective can also be found in the assessment methods that have been reviewed (Kolvereid and Isaksen 2006). With cognitive psychology becoming a bigger influence in how entrepreneurship programs are evaluated, the main topic again has been how entrepreneurship education can raise students' intention to create new ventures (Kolvereid and Isaksen 2006). Though without long-term impact research it is complicated to evaluate the effect of a program on the actual venture creation.

6.3. Purpose and objectives of EET

When designing an entrepreneurship education, program multiple objectives co-exist. This includes creating or increasing entrepreneurial attitudes, spirit or culture; venture and job creation; helping local entrepreneurs grow and improve; and passing entrepreneurial skills on to students (Mwasalwiba 2010). These are general terms, and difficult to translate to practical contributions, particularly when attempting to influence mindset, passion or intentions of the individual. Based on the intent of the educators, these differing objectives can be divided into three categories: Educating for, about, and in entrepreneurship (Co and Mitchell 2006; Hytti and O'Gorman 2004; Kirby 2004; Mwasalwiba 2010).

Educating for entrepreneurship would aim to create an entrepreneur, or in other words to prepare someone to start a new venture. It is aimed at both current and nascent entrepreneurs (Co and Mitchell 2006; Hytti and O'Gorman 2004; Kirby 2004; Mwasalwiba 2010) and the objective is to provide them with the skills and attitude to start a business (von Graevenitz et al. 2010). Therefore, this category covers all general objectives mentioned prior: creating or increasing entrepreneurial attitudes or mindset, helping existing entrepreneurs grow, passing on skills and most of all, venture creation. As discussed before, this is considered by policy makers the most desired outcome and has the potential of creating economic growth and technological progress(Acs and Szerb 2007; Stel et al. 2005; Sternberg and Wennekers 2005; von Graevenitz et al. 2010; P. K. Wong et al. 2005), through, for example, job creation, high investment readiness of founders and a better performance of university spin- offs (Dietrich 1999; Harhoff 1999; Reynolds et al. 1994; Shane 2004; von Graevenitz et al. 2010).

Programs focused on teaching about entrepreneurship aim to create a general understanding of the concept of entrepreneurship (Hytti and O'Gorman 2004; Mwasalwiba 2010). This is aimed to make students have a better understanding of what entrepreneurship entails, which would be in line with understanding the entrepreneurial spirit or culture. Therefore, this objective would be adjacent to the first one mentioned in the initial categories: creating or increasing entrepreneurial attitudes, spirit or culture. The potential benefit of this would be to make non-entrepreneurs more understanding to the challenges and opportunities of entrepreneurship. The World Bank states that these people will be able to influence both an entrepreneur's opportunities as their ability to effectively use their skills and resources (Mwasalwiba 2010). In practice, this would mean policy makers being able to make more fitting grant-policies for example, or financers being better able to understand business proposals. On its own it might not have a large impact, but it is a supporting function to the ones being educated for entrepreneurship and would potentially expediate the entrepreneurial process for some founders.

The aim of educating in entrepreneurship would be to use some of the positive traits of entrepreneurs within an existing organization (Dreisler et al. 2003; Henry et al. 2005; Hytti and O'Gorman 2004; Kirby 2004; Mwasalwiba 2010). It takes the objectives of passing on entrepreneurial skills and the increasing of entrepreneurial attitudes and culture and applies it to jobs that are already in place in their organization. The benefit of this would be that individuals take more responsibility of their learning and career life (Charney and Libecap 2000; Hytti and O'Gorman 2004; Newman et al. 2019). This would include attitudes such as creativity, pro-activity and risk-tolerance and skills including product development and marketing (Mwasalwiba 2010). This fits the argument of other researchers that entrepreneurial skills are becoming a necessary ability for all individuals (Charney and Libecap 2000; Newman et al. 2019). This also could be a way to create intrapreneurs: entrepreneurs who are not self-employed but work within a larger organization. Ultimately, having these skills as an employee might open options throughout their career, and according to Hytti and O'Gorman (2004) makes individuals take more responsibility of their learning and career life (Mwasalwiba 2010). Another term was suggested by Kirby (2004), educating through entrepreneurship. This describes the process where students acquire the necessary skills and understanding of the entrepreneurship process through the creation of a new venture (Mwasalwiba 2010). However, this is less of an objective as it seems to be a teaching method, therefore it is not often used in the same group.

6.4. Societal and economic impact of EET

The main objective of EET continues to be graduates with higher venture intention, who then go on to create economic and social value through new ventures, job creation and technological development (Ndou et al. 2019; Wong and Chans 2021). This contributing to society then has a positive effect on national development, which would be why governments should support entrepreneurship education and influence its learning objectives (Wong and Chans 2021). For long this has been the view of a lot of scholars and policy makers. However, recent reports from the European Commission and local governments such as the Danish ‘the Strategy for Education in Entrepreneurship’ suggest that this perspective is changing.

In 2008 the European Commission presented a final report from their expert group titled: Entrepreneurship in higher education, especially in non-business studies (European Commission: Enterprise and Industry, 2008). This report advises that boosting startups is not the only benefit to be had from entrepreneurship education. It helps students become more creative and boosts overall self-confidence, which is in line with what the principle of self-efficacy suggests. Developing entrepreneurial capacities and mindsets would then help them successfully enter the labor market.

The Danish government agrees with this and takes this vision one step further. It aims to develop students' knowledge of entrepreneurship and their ability to act entrepreneurially (Danish Ministry of Science 2010), with a broad definition of what entrepreneurship entails. It is rooted in the principle of value creation, whether it is economic or not. The aim is for more people to understand the process of innovation, that is, where the observation of an opportunity leads to the development of an idea, implementation and ultimately value creation. Ultimately, the Danish Government works from the perspective that “*Our future competitiveness is strengthened by the fact that through the education system we stimulate young people's ability to think innovatively, see opportunities and translate ideas into value*” (Uddannelses- og Forskningsministeriet 2013).

This can happen in the form of starting one’s own business, or in an existing company by creating new processes or products that can be of value to the organization (Danish Ministry of Science 2010). This change in perspective might also signal an opportunity for change in the focus of most programs, or at least allow for other objectives to get more opportunities. When most focus from government and policy makers is on venture creation, creating programs with a different objective would lack support. But change starts with a vision (Gill 2002). With support or even leadership from governmental institutions to define the purpose of new programs with these objectives, there is also the opportunity for more research in these fields. Both into the following objectives, and into how to create effective policy in this regard (Ratten and Usmanij 2021).

In examining the venture and economic outcomes of entrepreneurship education and training (EET), the evidence is less robust compared to learning outcomes. Gielnik et al. (2016) point out that EET positively influences entrepreneurial action (EA), which can lead to job creation and income-generating activities. However, the effects of EET on venture creation and economic outcomes often take time to manifest. Slavtchev, Laspita, and Patzelt (2012) argue that EET shows little to no immediate impact, with the positive effects becoming evident only five or more years after the completion of educational activities. This delay presents a challenge for measuring the short-term effectiveness of EET, particularly in terms of economic impact.

One of the most consistent findings in entrepreneurship education research is the benefit of experiential or practice-oriented pedagogy (Costa et al. 2018; Hahn et al. 2017; Klapper and Faber 2016). This approach to education places the responsibility on students to actively construct learning through their own experiences (Gielnik et al. 2015). Hahn et al. (2017, p. 963) observe that learning outcomes "are always higher when a practice-oriented entrepreneurial teaching pedagogy is used." The engagement and practical experience inherent in this pedagogical style allow students to develop a deeper understanding of entrepreneurial concepts and apply them in real-world contexts. The benefits of experiential education are further supported by research showing its impact on entrepreneurial action. For example, Gielnik et al. (2016) found that entrepreneurship education leads to increased entrepreneurial activities, which in turn create jobs and stimulate business income-generating activities. This aligns with Fayolle, Gailly, and Lassas-Clerc's (2006, p. 702) definition of entrepreneurship education as "any pedagogical program or process of education for entrepreneurial attitudes and skills." The potential for entrepreneurship education to enhance students' venture creation skills, knowledge, and attitudes is well-documented (Greene and Saridakis 2008). Moreover, these educational programs are linked to graduate business startups and job creation, which can contribute to broader economic growth and development (Rideout and Gray 2013; Bosma et al. 2008).

In addition to fostering entrepreneurial action, entrepreneurship education also plays a role in sustaining long-term entrepreneurial passion. Gielnik et al. (2017) suggest that entrepreneurship training can forestall the decline in passion over time, particularly when entrepreneurial self-efficacy is developed. Drawing on theories of passion development (Mageau et al. 2009; Vallerand et al. 2003), they hypothesize that training participants maintain high levels of passion if they simultaneously cultivate a sense of mastery. This sense of mastery is closely tied to self-efficacy beliefs (Bandura 2001, 2012), which serve as a moderator of the positive effects of entrepreneurship training on long-term passion. In this model, entrepreneurial self-efficacy strengthens the enduring impact of entrepreneurship education, helping individuals sustain their motivation and enthusiasm for entrepreneurial activities.

Jones and Matlay (2011) agree that there is an opportunity to broaden the perspective of entrepreneurship education and move beyond economic impact as main objective. New forms of entrepreneurship are starting to be recognized, which include social entrepreneurship and sustainable entrepreneurship. These provide different perspectives on what entrepreneurship means, but all provide positive societal impact. Successful entrepreneurship does not have to be about creating jobs and revenue. Social entrepreneurship can be defined as the field in which entrepreneurs tailor their activities to be directly tied with the goal of creating social value (Abu-Saifan 2012). This is often done without profit being a motive for the organisation. This form of entrepreneurship per definition provides societal value and is getting more attention (Abu-Saifan 2012).

However, as a research topic it lacks consensus on its definition and theoretical framework (Abu-Saifan 2012; Barendsen and Gardner 2004; Bruyat and Julien 2001; Weerawardena and Sullivan Mort 2006). As stated before, without clear consensus on the learning outcome and how students will learn it, it is tough to create an effective educational program (Duval-Couetil 2013; Pittaway et al. 2009). Although there is theoretical overlap between regular entrepreneurship and social entrepreneurship, there are specific topics that are only taught when concerning the latter. For example, management of non-profit organisations, social innovation and what challenges one has to overcome when creating a business model that is not centered around revenue increase (Abu-Saifan 2012). One way to aim for revenue but still create societal value is sustainable entrepreneurship. This is an emerging concept that has been gaining more research attention over the last decade, with scholars connecting traditional entrepreneurship with the needs of society and the environment to establish this new field of study (Cohen and Winn 2007; Terán-Yépez et al. 2020). Sustainable entrepreneurship can be defined as “the discovery, creation, and exploitation of opportunities to create future goods and services that sustain the natural and/or communal environment and provide development gain for others" (Patzelt and Shepherd 2011; Volkmann et al. 2021) although there is no consensus on this definition.

6.5. Effects on the individual

The effects of entrepreneurship education on an individual's development and career potential are the last perspectives to explore when diving into the reasons why different approaches to entrepreneurship education deserve more research. This is done from the perspective of human capital. According to Schultz: "Human capital is the set of skills, knowledge and other attributes that contribute to an individual's capacity to perform productive work" (Aboobaker 2020; Schultz 1980). Human capital can be viewed as a societal thing, where it describes the total economic value of the workforce, or as an individual factor. In this case we look at the individual knowledge and skills created by entrepreneurship education that are not related to venture creation.

There is a lot of knowledge to be gathered from entrepreneurship education that would later be applicable to other career paths. General business knowledge, such as business strategy, risk, marketing, finance, and business idea development (Matlay 2008; Wong and Chans 2021). Students can develop knowledge in a more specific field, such as engineering management or legal knowledge (Pluzhnik et al. 2018; Wang et al. 2019; Wong and Chans 2021). It is also suggested students gather knowledge on decision making and problem-solving techniques, as well as interpersonal communication and negotiation (Rafiei et al. 2019; Tang et al. 2014; Wong and Chans 2021). These would also be reported as skills learned.

Other multi applicable skills include but are not limited to initiative-taking, strategic thinking, negotiation capacity, opportunity identification and opportunity evaluation (Pluzhnik et al. 2018; Wong and Chans 2021). These are identified as entrepreneurial competencies but could be applicable in a number of professions. The same goes for analysing, networking, adaptability, creativity, risk-taking propensity and sense of initiative (Ernest et al. 2015; Wong and Chans 2021). More generic competencies would include creativity, communication skills, teamwork and critical thinking (Wong and Chans 2021).

These lists of knowledge and skills show all the learning outcomes that students can gain from entrepreneurship education which could benefit them in a non-venture creation career. This human capital can be suitable in multiple available career paths, both as described for about entrepreneurship and in entrepreneurship. It shows that the learning outcomes of entrepreneurship education can be beneficial in many ways, even though creating objective specific programs would be a more efficient way to achieve this human capital. There is even a positive influence found of entrepreneurship education on the graduate's employability. There is one more benefit for students who follow entrepreneurial education: Discovering they might not be suited for a life as an entrepreneur after all (von Graevenitz et al. 2010). Successfully matching students with a fitting career and giving them the right tools to start that career is also one of the goals of education. Rae and Woodier-Harris even suggest this offers students an advantage in terms of identifying and developing their career options and goals (Matlay et al. 2012; Wong and Chans 2021).

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