TALLINN UNIVERSITY OF TECHNOLOGY
School of Business and Governance
Department of Business Administration

Jekaterina Mazina-Šinkar

ACADEMIC ENTREPRENEURSHIP: FACILITATING SPIN-OFF VENTURES IN ESTONIAN UNIVERSITIES

Master's thesis
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Supervisor: Martin Toding, MA

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I hereby declare that I have compiled the thesis independently
and all works, important standpoints and data by other authors
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Jekaterina Mazina-Šinkar ……

(signature, date)

Student code: 201441MAEM

Student e-mail address: jekaterina.mazina@gmail.com

Supervisor: Martin Toding, MA:

The paper conforms to requirements in force

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(signature, date)

Chairman of the Defence Committee:

Permitted to the defence

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(name, signature, date)

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ABSTRACT

Nowadays, Estonian academic entrepreneurship is getting increased attention from scientists, students, academic institutes' support and administration structures, policymakers, and citizens. There are different mechanisms proposed at the national and European levels to accelerate the spin-off venture establishment, for instance, the proof-of-the-principal grants, various accelerators, incubation, and public funding programs. Nevertheless, a deep contradiction exists between scientific and entrepreneur beliefs and attitudes toward scientific achievement and breakthrough commercialization. From one side, the research results should be shared with the public, from another side, the commercialization of these research results requires intellectual property protection, limiting access to scientific knowledge. Furthermore, one crucial research topic appears, why academic members should or would like to deal with their science commercialization.

Academic institutes, both universities and public research institutes, are considered fundamental co-actors in the knowledge transfer, along with the service, IT, and manufacturing companies. One of the challenges facing Estonian academic institutes is their ability and capacity to transfer the scientific achievements and results from academia to the market. Even more challenging is to convert this academic innovation into successful industrial and commercial models. This research is dedicated to one of the knowledge commercialization ways, i.e., academic spin-offs, where academic institutes' members adopt directly entrepreneurial roles for effective knowledge transfer of their scientific breakthroughs. The current research aim is to examine Estonian researchers' motivations, drivers and barriers, and ecosystem attributes, facilitating the spin-off venture establishment in Estonian universities.

This research involved academic (professors, researchers, lecturers, etc.) and non-academic members (support and administration structures) from the four largest Estonian universities (Tartu University, Tallinn University of Technology, Tallinn University, and Estonian University of Life Science). The mixed-method was applied, i.e., in-depth semi-structured interviews with professors, researchers, Technology Transfer Offices, and administration members, and an online

survey conducted in April 2022. This study revealed the motivations of Estonian researchers, drivers, and currently existing barriers in Estonian universities that Estonian researchers face in establishing science-based companies. Moreover, the current study is the first study that examines the typology (Lam, 2010) of the Estonian researchers according to their beliefs and attitude toward science and business collaborations and research results commercialization. The current research findings can be used for effective ecosystem creation and as input for spin-off model development to facilitate the spin-off ventures establishment in Estonian universities. Finally, this research identified the potential future directions and opened questions that arose during this study.

Keywords: academic spin-off, academic entrepreneurship, knowledge transfer, entrepreneurial university, motivation

INTRODUCTION

In recent years, there has been increasing pressure on universities, expecting universities to play an important role in economic and social development (Fini et al., 2018). It means that the traditional activities of universities, i.e., education and research, should be broadened, adding the third mission aiming to generate knowledge outside the academic environment to the benefit of social and economic development (Berghaeuser & Hoelscher, 2020; Etzkowitz & Leydesdorff, 2000). Nowadays, more and more universities are going through a transformation from academic to entrepreneurial, transferring to the so-called third generation of universities (Compagnucci & Spigarelli, 2020; Wissema, 2009), where entrepreneurial activities come to the fore in addition to the teaching and research tasks. The entrepreneurial universities are closely connected to the demands of the industry, society, and governments, creating the so-called triple helix (Etzkowitz, 2016). This transformation requires a tremendous mindset change of various university members (researchers, professors, administrative and support structures), private and risk capital investors, and policymakers to succeed.

Nowadays, most European Union (EU) universities depend on public funding, i.e., their primary funding mechanism. Therefore, the drastic cuts to public funding caused by various crises, i.e., the 2008 global financial crisis, COVID-19 crisis, 2021 energy crisis, and 2022 Ukrainian crisis, affect the universities' sustainability, having a long-lasting impact on the European economy and society (Estermann et al., 2020). For instance, it is expected that the COVID-19 pandemic crisis (EU-27 gross domestic product (GDP) -6.4% in 2020 (Eurostat, 2022)) will affect the public funding allocations across the EU, decreasing the volume of funding during the next two to four years as it was during the 2008 finance crisis (EU GDP -4.4% in 2009 due to the global financial crises (EuropeanCommission, 2009)). Furthermore, the impact of the current EU crises, i.e., the energy crisis and war in Ukraine, will even more severely affect the public funding during the following years.

According to the Organisation for Economic Co-operation and Development (henceforth, OECD) report (OECD, 2020) and Eurostat statistics (Eurostat, 2022), Estonia has overall expenditure on

education and research and development (henceforth, R&D) expenditure is relatively low compared to other OECD countries. Both expenditures are lower than EU-28. Therefore, Estonian universities continuously search for additional funding sources, i.e., tuition fees, research contracts, EU program fundings, commercialization of research results via patenting, licensing, joint ventures with private companies, and facilitating spin-off venture establishment. The latest is the main topic of the current research. While tech innovation through research and development is considered as a key factor in economic growth, it requires value creation through a successful transfer of this technology to the market. Nowadays, academic entrepreneurship, i.e., one possible way of commercialization of research and technology, is considered an engine for economic growth and employment (Benneworth & Charles, 2005; Müller-Wieland et al., 2019; Vincett, 2010) as well as additional possible funding source of universities and research institutions. Academic entrepreneurship has different definitions, considering a broad range of knowledge transfer (Fini et al., 2018) or limiting only to establishing university spin-offs and academic startups.

In recent years, various fundings have been committed to facilitating research and technology commercialization to receive a significant return of investment to society. Despite the expected economic impact and long-term post-impact, the focus on financial returns from university spin-offs has been criticized (Siegel & Wright, 2015). The latest published report by European Commission on the H2020 funding program's evaluation claimed that there is still an innovation deficit in Europe. The innovation deficit was supposed to be due to the marginal commercialization activities as after-project activities, not due to the ideas and discoveries generated during the projects. Consequently, European society has not received monetary or social investments back as expected (EuropeanCommission, 2018). Similar to the H2020 funding program's achievements, the evaluation of Estonian Research Funding programs also showed a similar tendency, i.e., the lack of groundbreaking innovation and marginal impact on Estonian economics (Eljas-Taal et al., 2019). Indeed, only 20% of spin-off ventures established so far have remarkable revenue (more than 600,000 euros per year), and only 11 spin-off ventures had annual revenue of more than 1.8 million euros in 2018. More than 65% of the Estonian spin-offs have shown minimal activities (average annual revenue of 26,000 euros), focusing mainly on research in university than spin-off development (Eljas-Taal et al., 2019). The average number of annually established academic spin-offs varies largely depending on the year and financial program available (for instance, SPINNO 2011-2015 (Eljas-Taal et al., 2019). The statistics revealed that 25 companies were established during 2011-2015 (five new companies annually) and only three spin-off ventures were established

during 2016-2019, respectively (Eljas-Taal et al., 2019). Consequently, this presents a ratio of 0.3-1.6 spin-offs per 1,000 researchers annually (3,272.4 full-time equivalents (FTE) researchers in 2018 (Estonian Dean's Board, 2018)). The 1.6 is high ratio by international standards for comparable research organizations(OECD, 2019), but low in comparison to CalTech (California Institute of Technology, USA) and EPFL (École Polytechnique Fédérale de Lausanne, Switzerland) with ratios within 5.3 and 3.8 spin-offs per 1,000 employees during 2017-2019 (Frietsch et al., 2021). The ratio of 0.3 spin-offs per 1,000 employees can be considered as low. When interpreting these numbers, the structural differences and the applied definition of spin-off venture should be considere. Consequently, the Estonian universities' problem is the unstable number of spin-off ventures annually established in Estonian universities and their performance and low impact on society and the economy.

The latest Estonian Research and Development, Innovation and Entrepreneurship (RDIE) strategy plan 2021-2035 has introduced the weaknesses and challenges in the research and development ecosystem and, consequently, the bottlenecks for the successful development of the academic entrepreneurship environment in Estonia. The major bottleneck is the absence of the spin-off ventures policy in Estonia. One of the priority goals of the RDIE strategy plan 2021-2035 is to increase the knowledge transfer capacity of research and higher education institutions.

This research aims to investigate the Estonian researchers' motivations, drivers and barriers, and ecosystem attributes, facilitating the spin-off venture establishment in Estonian universities. The current research findings can be used by policymakers and universities, and other research institutes to develop a spin-off venture policy in Estonia. The current research outcomes can be valuable not only for Estonia but also for similar countries such as Latvia and Lithuania for successful spin-off model development. The issues and problems studied in this research are common in many countries. To understand the challenges and predicaments of the research commercialization through spin-off ventures establishment in Estonia, it is crucial to answering the following research questions:

1. Why do Estonian researchers commercialize their scientific research results?
2. What are the drivers and barriers to a successful spin-off establishment?
3. How can the ecosystem encourage researchers to become academic entrepreneurs?

This master thesis is divided into three chapters. The first chapter gives an overview of the theoretical background and literature review based on the publications from 1995 to 2022 from different peer preview journals (*Research Policy*, *International Journal of Innovation Studies, International Entrepreneurship and Management Journal, The Journal of Technology Transfer*, etc.). The literature presents the latest studies on research and technology commercialization approaches, the theories, models, and research on scientists' motivations, beliefs, success in spin-off establishment, and performance. The methods part describes the qualitative and quantitative methods used in the current research and their design. Results and Discussion chapter is divided into subsectors. First of all, the quantitative research results are described, followed by the results from semi-structured interviews with scientists, academic entrepreneurs, Technology Transfer Organization (henceforth, TTO) specialists, and university administration, followed by a discussion of the results. In conclusion, the findings, recommendations, and limitations of the current research are presented.

1. THEORETICAL BACKGROUND

This chapter will give an overview of the latest research results on academic entrepreneurship, growth drivers, barriers, technology transfer, and the best practices worldwide. More than 1800 peer-reviewed publications were retrieved in the EBSCOhost database from 1972 to 2022. The bibliometric search was designed with the following query: "university spin-off" OR "academic spin-off" OR "academic spin-out" OR "academic entrepreneurship" OR "university spin-off" OR "university spin-out" OR "entrepreneurial university" OR "academic commercialization", OR "university commercialization" OR "university commercialisation". The applied design was previously used in other studies with slight modifications (Meyer et al., 2014; Skute, 2019), helping to retrieve more case studies and technology transfer publications. Moreover, his search was restricted to the following subjects (thesaurus terms): “entrepreneurship”, “university&colleges”, “technology transfer”, “technological innovations”, “academic spin-outs”, “new business enterprises”, “academic-industrial collaborations”, “businesspeople”, “intellectual properties”, and “knowledge management”. All publications were inspected using keywords mentioned above and/or titles and/or abstracts. As a result, only 15 publications were removed (mainly due to the subject “new business enterprises”). The drastic growth and interest in academic entrepreneurship is observed during the last ten years (more than 1200 publications) (Figure 1).

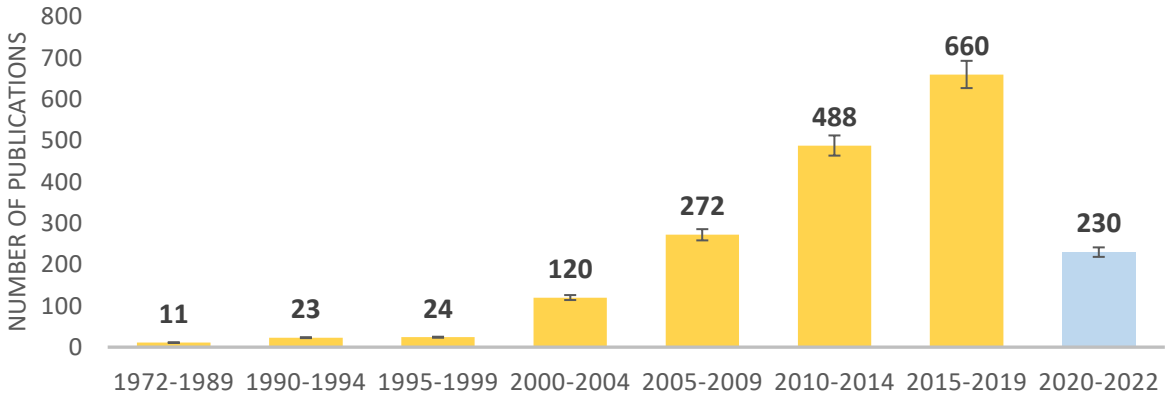

Figure 1. Statistics on published peer-previewed articles on academic entrepreneurship (error 5%, 95% probability)
Source: EBSCOhost (15.04.2022); author's calculations

1.1 University missions and its transformations

Nowadays, academic universities are changing under the pressure of internal developments and external aspects, i.e., shortcuts in funding, increasing social demand, and re-structurization of knowledge. Industrial innovation shifts to a knowledge-based economy driven by government research funding policy and practice (Etzkowitz, 2016), expanding the universities role from teaching and research to an entrepreneur nature. Indeed, the universities went through at least three academic revolutions (Etzkowitz, 1998), i.e., teaching to combining teaching and research, followed by economic and social missions, and finally, embedded in triple-helix relations with government-university-industry (Leydesdorff, 1995; Viale & Etzkowitz, 2005). Etzkowitz and Leydesdorf (2000) have proposed the Triple Helix models of university-industry-government relations, describing the research systems in its social contexts (Figure 2). The theories and concepts behind this progressive transformation are described by

- the entrepreneurial university (Etzkowitz 2003),
- the third mission of universities (Pinheiro et al. 2015; Zomer and Benneworth 2011),
- the Triple-Helix (Etzkowitz & Leydesdorff, 1995), and
- Quadruple Helix (Carayannis & Campbell, 2009), and
- Quintuple Helix (Carayannis & Campbell, 2010) (Miller et al., 2018).

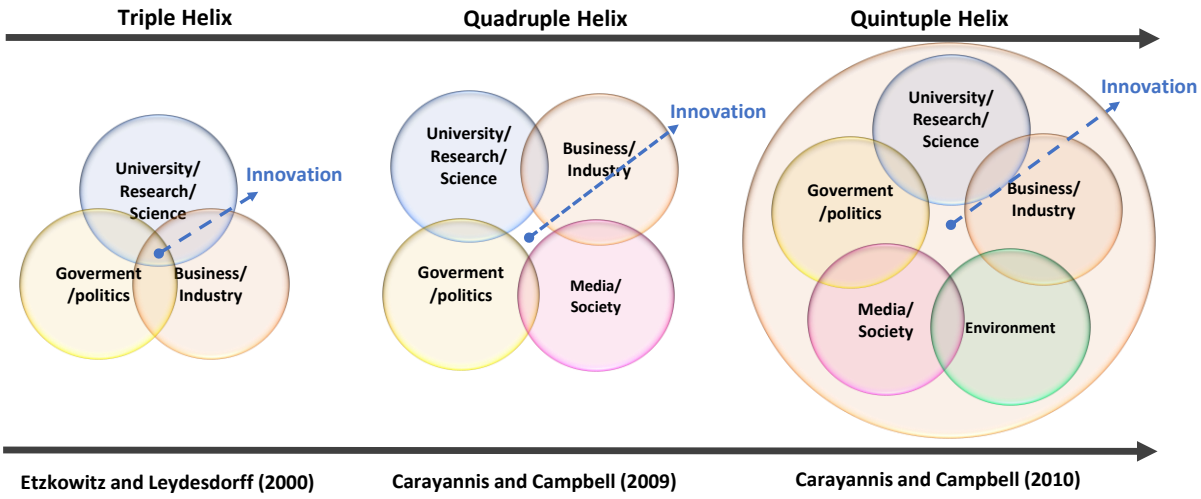

Figure 2. Triple, Quadruple and Quintuple Helixes
Source: Adapted from Carayannis and Campbell (Carayannis & Campbell, 2010) (Miller et al., 2018), (Amry et al., 2021); author's visualization

Innovation is a major pillar in a knowledge economy (Halibas et al., 2017). Historically, the USA Bayh-Dole Act of 1980 and similar legislation in Europe (OECD, 2003) initiated more intensive diffusion of technologies from academic institutes to companies and facilitated public/private partnerships, enabling the creation of entrepreneurial universities. The Triple Helix model stresses the importance of higher education for innovation, emphasizing knowledge production and innovation. Nowadays' university involves even more members additionally to business/industry and government/politics, i.e., a vital part plays media/society and the environment.

1.2 Research and technology commercialization approaches

Parent academic institutions, i.e., universities and public research institutes, play an important role in knowledge translating for economic and social development. The current trend toward scientific achievements' and breakthroughs' commercialization reflects the pressure to maximize the social return on public investment. Therefore, academic institutes are continuously looking for commercialization approaches and developing an ecosystem that effectively supports these activities that will generate additional revenues in the time of funding constraints, enhancing self-sustenance and stability. The rise in technology commercialization raises important managerial and policy issues, triggering universities, corporations, and government changes.

The scientific results commercialization is one of the essential mechanisms for achieving practical value and applying scientific knowledge. The practical application includes developing new products or improving existing products and services and transferring them to the. Different strategies involve internal, quasi-internal, and externalization approaches (Markman et al., 2008). The internal approach includes Technology Transfer Offices (henceforth, TTO) as a boundary spanner between the customer and supplier, i.e., between entrepreneurs/firms and academic scientists, to establish the effective collaborations between two poles that have different norms, standards, and values. The quasi-internal approaches include the business incubators, facilitating companies' growth and success of companies, and offering business assistance services (support, resources, and services) to foster spin-off venture creation. The strategies to incubate the spin-offs can include a small number of companies with world-class innovation and the potential to become global and have high investments return. It can also focus on businesses that already generate the revenue and, finally, on a larger number of smaller companies, with mainly local and regional potential. The university's incubation strategy is generally set individually and depends on

resources and capabilities, considering the universities' field of interest and priorities. The last commercialization approach, or externalization approach, entails university research parks, academic spin-offs, licensing, joint venture spin-offs, corporate venture capital (henceforth, VC), and open science and innovations (Markman et al., 2008).

Indeed, there are different types of research knowledge transfer, and the main ways are patents, licensing, collaborative research (Wit-de Vries et al., 2019), contract research and consulting joint ventures, and academic spin-off (Perkmann et al., 2013). The current research is dedicated to one of the knowledge transfer commercialization ways, i.e., academic spin-offs, where academic institutes' members adopt directly entrepreneurial roles for effective knowledge transfer of their scientific breakthroughs. Therefore, a further literature overview is presented for spin-off ventures.

1.3 Spin-off ventures

The establishment of spin-off ventures is one of the ways to exploit research results (Salvador, 2021). Recently, an increasing number of spin-off ventures have been found in many countries. Nevertheless, there is still no consensus on the definition of the spin-off (Di Fatta et al., 2018; Hogan & Zhou, 2010). A common and accepted definition in the literature is the new companies founded by one or more academics who choose to work in the private sector (Doutriaux, 1987). European Union defines the spin-off as "a company based on the use of scientific results from the public research sector". According to OECD (2001), spin-offs are "companies based by public sector employees in universities and other higher education institutions, including lecturers, professors, and pos-doctoral students". University or public research institute's spin-off, also known as academic spin-off (this terminology is used in the current research), are subgroup of high-tech start-up firms, where one of the founders or co-founders is a university's or public research institute's academic member(s) with the intellectual properties, such as patent or utility models, generated from research in a university or public research institute (Shane, 2004). One of the spin-off's stakeholders can be a university or public research institute (Buenstorf, 2009). Indeed, the spin-off venture might not be exclusively based on the patent but can also be established on scientific expertise and tacit knowledge.

Spin-off venture establishment may be one of the optimal ways to transfer scientific results and knowledge. There are several opportunities why spin-off ventures should be established. For

instance, if the licensing is not possible, or intellectual property as a basis for research product has clear opportunities to create many valuable products and applications, or IP has a potential for "emerging technologies, ensuing that the additional efforts and possible risks will have returns. Finally, the spin-off establishment is also a solution when additional technology and related infrastructure investments are required to reach the market or fulfill the legal (for instance, certifications) or customer requirements.

The spin-offs are generally established through TTO, responsible for managing the spin-off process. However, the publications and statistics showed that many academic spin-off ventures do not have an official spin-off status and are established outside the formal channels. Despite the growing interest, academic entrepreneurship has multiple contradictions and open questions in the academic society. Some of the questions are: why researchers should or would like to create spin-off ventures, what are the phases for spin-off venture creation, what are the policy and regulations, what are the barriers and how to overcome them, and how the university should or should not support the initiatives of academic staff, do the academic entrepreneur should or should not leave the parent organization, keeping their academic position at least as a part-time and many others.

1.4 Motivations

Spin-off creation requires commitment from founders to go through the different development phases of the spin-off ventures. However, what are the prerequisites of the spin-off establishment from the researcher's point of view? One of the prerequisites and driving forces is the researchers' motivation, passion, and entrepreneurial intention to establish science-based companies. Consequently, the researcher that decides to establish a spin-off company, being or becoming a founder or co-founder, must be motivated, passionated or pushed to do it, owning or in the process of developing specific attributes related to entrepreneur (risk-taking, will, competencies, leadership, planning, innovation, and others) (Schaefer & Minello, 2019; Sousa, 2018). According to the theory of Achievement Motivation Theory (McClelland et al., 1958), an individual's motivation is based on three needs: achievement, power, and affiliation. The individual with a stronger need for achievement will likely establish the new venture. The entrepreneurial mindset is a core of entrepreneurship, helping entrepreneurs successfully establish and develop their companies (Lynch & Corbett, 2021). It can be defined as a "constellation of motives, skills, and thought processes that distinguish entrepreneurs from non-entrepreneurs and contribute to

entrepreneurial success" (Davis et al., 2016). According to multiple research studies, the entrepreneurial mindset can be developed or enhanced (Hayter et al., 2021; Lindberg et al., 2017). Different models are available to determine the dimensions of an entrepreneurial mindset (Botha & Taljaard, 2021; Freiling & Schelhowe, 2014). According to one of the latest published models, i.e., the comprehensive entrepreneurship competence model (Venesaar et al., 2022), entrepreneurship competencies can be divided into four main areas of competence: acting upon opportunities and ideas, managing social situations, creative thinking, and self-management. These areas are divided into interconnected 14 sub-competences (Figure 3) (Venesaar et al., 2022). This research handles mainly the self-management dimension, or the process of managing oneself, relating to the initiation and persistence of the activity (Venesaar et al., 2022). The following sub-dimensions are considered important for the decision to become an entrepreneur, affecting the success of the entrepreneur and performance of a newly established venture: autonomous motivation (Deci et al., 2017; Malleus et al., 2018), growth mindset (Burnette et al., 2019; Murphy & Dweck, 2010), high self-efficacy (Chen et al., 1998), high resilience (Evans & Wall, 2020), internal locus of control (Gugnani, 2022) as well metacognition. Metacognition, or the ability to think beyond and re-organize existing knowledge in the face of new and uncertain decisions and tasks, has a significant positive impact on entrepreneurial orientation and venture performance (Cho & Jung, 2014; Haynie et al., 2010). Coping with emotions and high resilience helps individual to handle, manage, overcome and recover from failures and negative emotions faced, being future-orientated (Ahmed et al., 2022; Shepherd et al., 2016).

First of all, individual motivations should be considered. It can be analyzed through the self-determination theory (STD) (Ryan & Deci, 2000), an important concept in psychology that refers to each individual's ability, i.e., the scientist's ability, to make choices and manage their life. The self-determination theory suggests that individuals are motivated to grow by three innate and psychological needs, i.e., competence, relatedness, and autonomy. Fulfilling these needs, the individual becomes self-determined. One part of autonomy is the intrinsic motivation that plays a crucial role in STD. Indeed, research on STD in various fields revealed that autonomously motivated individuals would be more engaged and interested in activities and more stable, solving complicated problems better and quickly acquiring knowledge. For instance, the study on entrepreneurial students showed that the autonomously motivated students that established the company evaluated their self-management, initiative, and creativity skills higher than those externally motivated (i.e., controlled motivation) (Malleus et al., 2018). Consequently, researchers are more likely will establish the spin-off if they are autonomously motivated.

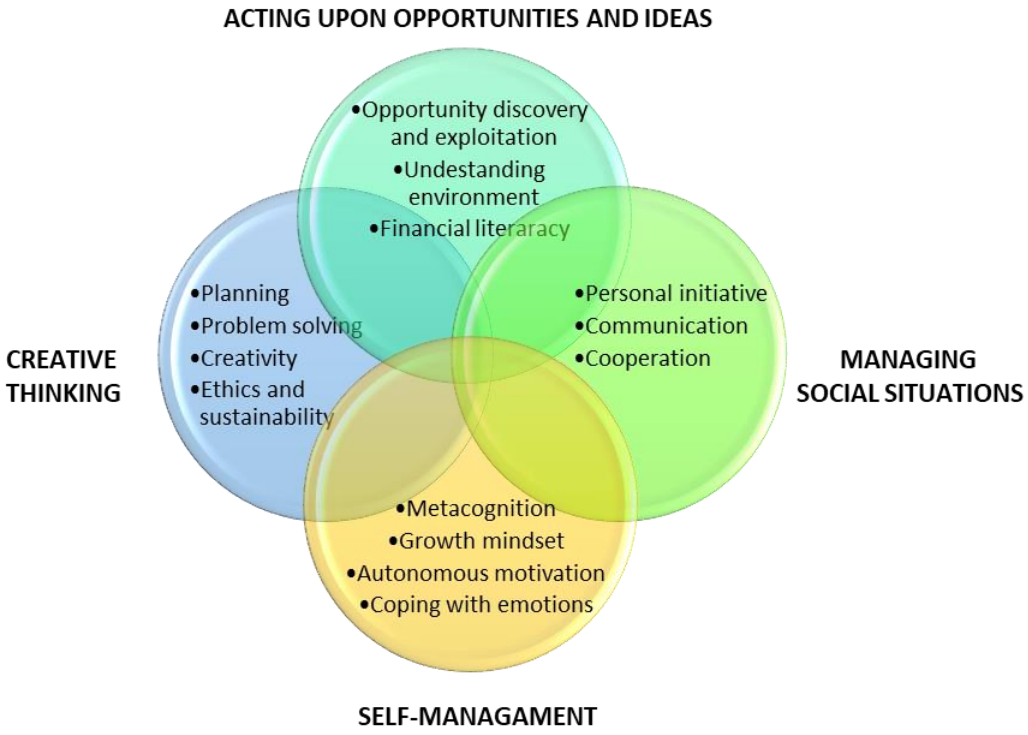

Figure 3. The comprehensive entrepreneurship competence model
Source: (Venesaar et al., 2022); author's adaption

Nevertheless, it is not so simple. Motivation is a symbiosis of various biological, emotional, social, and cognitive forces, activating behavior. Therefore, different patterns should be investigated, explaining why a person or, in this study, the researcher does something or would like to do. According to the Mindset theory (Dweck & Leggett, 1988), initially named Implicit Theories of Intelligence, individuals' beliefs are organized into two groups, i.e., individuals with a fixed mindset and a growth mindset, describing the underlying beliefs that individuals have about learning and intelligence. Dweck (1988) proposed that people with a growth mindset can develop their intelligence through effort, good strategies, input, and mentoring from others, leading to more extended success.

In contrast to the growth set, people's intelligence with the fixed set is unchangeable, i.e., one's competencies and talents are carved in stone (Dweck, 2019). Dweck's research on students has shown that students with a growth mindset are more passionate about learning, growing, and self-improving constantly, most easily overcome challenges, and persist in the face of setbacks. These people learn from mistakes and the challenges they face. Therefore, researchers and teams must learn and transform from a fixed mindset to a growth mindset if they consider establishing a spin-

off venture. This transformation is possible (Ng, 2018) but requires time, effort, and deliberate practice, according to neuroscience discoveries.

Self-efficacy is considered "a key psychological attribute in understanding an individual's decision to be an entrepreneur"(Borchers & Park, 2010). Self-efficacy and entrepreneurial motivation play an important role in improving the performance of employees as well as venture performance and, consequently, sustainability of the venture itself (Srimulyani & Hermanto, 2022). Other sub-dimension, such as internal locus of control, i.e., one of the personality characteristics, is associated with innovativeness, proactiveness, and risk-taking (Dawwas & Al-haddad, 2018). Individuals with an internal locus of control believe that they have control over the events during their life resulting from their efforts. It is also found that there is a significant relationship between self-efficacy and intention to start a business if the external locus of control is low (Borchers & Park, 2010). Research studies have also found that the locus of control could differ by strength and can be developed and enhanced while getting more entrepreneurial experience (Bhushan et al., 2020; Cromie & Johns, 1983).

The researcher's motivations towards science and commercialization should be considered despite the entrepreneurial mindset development or enhancement. According to (Lam, 2011), three factors are related to the researcher's motivations: "gold, ribbon, and puzzle". 'Gold' means financial gains, the 'ribbon' is related to glory, reputation, and career advancement, and the 'puzzle' is associated with satisfaction of creation of new knowledge, i.e., the research itself. The previous studies (Lam, 2010, 2011, 2015) differentiated the researchers according to their professional orientation or typology: 'pure tradition', 'traditional', 'hybrid', and 'entrepreneurial' researcher. These typologies are based on the researchers' motivation, values towards scientific research, attitudes and beliefs towards the commercialization of their research results, and underlying factors towards these motivations, attitudes, and beliefs. The 'pure traditional' researcher mainly focuses on "ribbon" reward, i.e., career advancement and reputation, and believes that the commercialization contradicts scientific values, where the results of research achievements must be freely accessible to all. Conversely, 'entrepreneurial' researchers focus on the commercialization of research results and suggest that science and business collaboration are inherent in science. The entrepreneurial researchers are motivated by the 'puzzle', i.e., the development of new knowledge and possible 'gold' reward.

There are also researchers between two poles, i.e., the combinations of ‘traditional’ and ‘entrepreneurial’ researchers. The hybrid researchers can also be divided into two sub poles, i.e., ‘traditional’ and ‘hybrid’. The first one, the ’traditional’ researcher, also focuses on the academic passion of ‘pure traditional’ researchers but recognizes the need to collaborate with industry to benefit their scientific research. The ’hybrid’ researchers are committed to getting a reputation and advancing their career, i.e., ‘ribbon’, with the desire to solve problems, ‘puzzle’. The ‘hybrid’ researcher emphasizes the importance of collaboration between science and business, protecting his traditional commitment to core scientific values (Lam, 2015; Suominen et al., 2021). Therefore, the typology of researchers and universities’ teams is important to examine and map, understanding what could be the most effective and suitable ways of the knowledge transfer for this researcher and team, i.e., spin-off ventures, joint laboratories, licensing, etc.

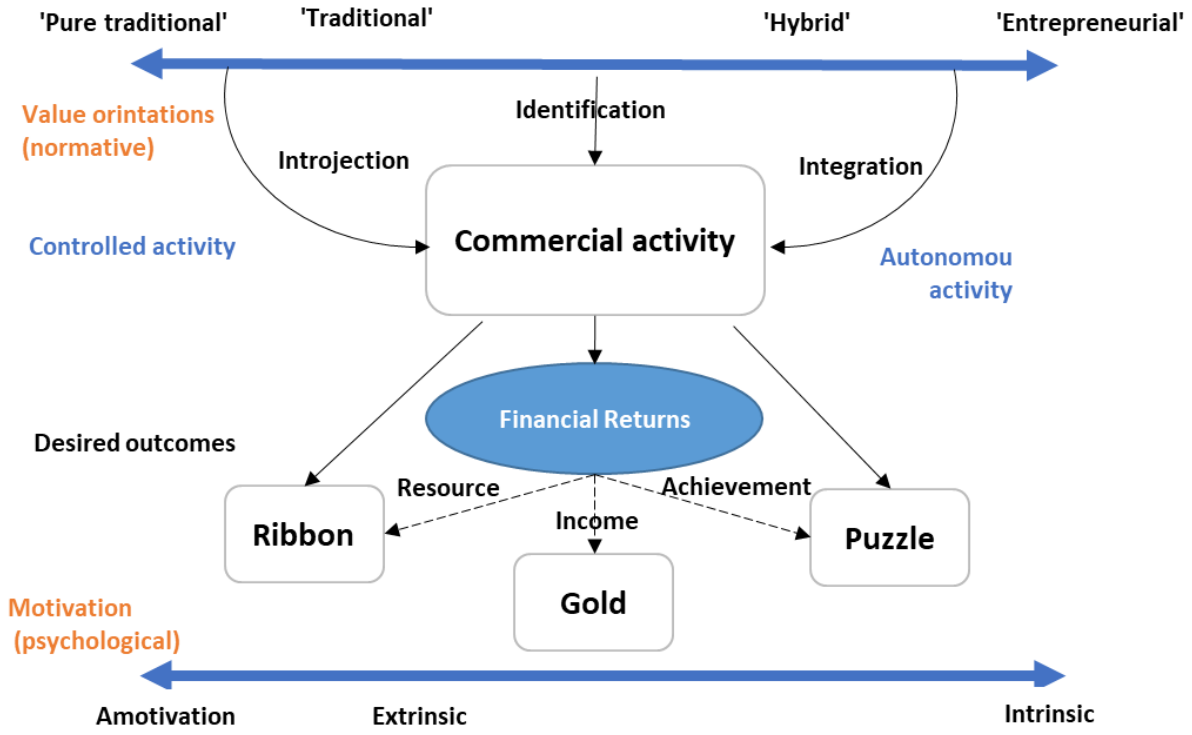

Figure 4. Scientific motivation and commercial engagement
Source: (Lam, 2010); author’s adaption

According to (Lam, 2010), different typologies of researchers are engaged in commercialization activities at different levels. Figure 4 presents the conceptual framework proposed by (Lam, 2010) on how the scientist is motivated to engage in commercial activities and their motivation. The ‘entrepreneurial’ scientists are intrinsically motivated in contrast to ‘pure traditional’ scientists. Taking into account the STD theory, the intrinsically motivated researchers will likely achieve

success in commercialization in the longer perspective that scientists that are in the transition state and might be externally motivated, for instance, by some the awards (reputation, prestige, financial gain, better infrastructure, etc.).

1.4.1 Drivers

Despite the individual motivation, once decided to commercialize the research results, the researcher, team, university administration, and policymakers should consider what kind of drivers and barriers exist at all levels of knowledge transfer. Multiple studies analyzed different possible drivers and barriers. For instance, research on Spanish and Hungarian academics revealed that economic benefit ('gold') is not only important but occupies the first position in the list of possible drivers (Novotny, 2017; Vega-Gomez et al., 2018). The latter contradicts recent study results of the same author on Spanish academics that revealed that the influence of rewards on the researcher's decision to establish the spin-off venture is questionable, but rather the moral desirability ('puzzle') drivers the researchers to transfer their knowledge and contribute to society (Vega-Gomez & Miranda-Gonzalez, 2021). Another study on Italian researchers also confirmed that finding deeper meaning ('puzzle') in their work while getting stuck with bibliometric work drives the scientists to establish spin-off ventures (Parmentola & Ferretti, 2018). The authors also concluded that there is no need to design a policy to motivate entrepreneurship according to the academics segment, gender, or knowledge area when academics want to establish a spin-off venture based on their research results (Vega-Gomez et al., 2018). The same author also concluded that there was no influence of the environmental or contextual factors (opportunity), pointing out that the conclusion may be skewed by the national level of the research conducted.

The research on 2200 German and UK life scientists has found that professional security, advantage, and productivity ('ribbon' and 'puzzle') are strong drivers for participation in academic entrepreneurship. These researchers easily combine science and entrepreneurship, moving from academic pole to entrepreneurs' pole and back. However, it was also found that these scientists perceive the value of patenting differently, possessing a higher commitment to scientific achievements and reputation ('ribbon') compared to entrepreneurial ones (Haeussler & Colyvas, 2011). The productivity, professional security, and advantage were also shown in the previous research conducted in Estonian universities that concluded: "…being a professor, having Science as the primary academic field, and a larger number of publications increase the likelihood of academic ownership while a larger number of grants decreases." (Mõttus et al., 2019). The research on 2604 scientists working for the Max Planck Society in Germany indicated that the

entrepreneurial activities heavily depend on patenting, expertise, personal beliefs, opinions on the commercialization benefits of research, and personal ties to the industry (Krabel & Mueller, 2009).

The research on Italian academic entrepreneurs revealed the external motivations to establish science-based companies, including funding constraints ('gold'), low demand for doctorate holders ('ribbon'), and favorable supporting policy (Rizzo, 2015). The absence of career opportunities, especially for freshly defended Ph.D. candidates, was also shown in another study (Parmentola & Ferretti, 2018). Another study on Italian universities' spin-offs revealed the correlation between the decline in tenured academic positions ('ribbon') within universities and the growth of university spin-offs (Boffo & Cocorullo, 2019). It was suggested that the spin-off might play a role of academy substitution for those academic members that cannot enter a tenured career path ('ribbon').

Table 1. Factors that drive the spin-off ventures' creation and success

Factors	Author(s)
Economic benefit	(Novotny, 2017; Vega-Gomez et al., 2018)
Expertise, previous personal connections with industry	(Krabel & Mueller, 2009)
Entrepreneurial orientation of team	(Ferretti et al., 2020)
Moral desirability to contribute to society	(Vega-Gomez & Miranda-Gonzalez, 2021)
Professional security, advantage, and productivity	(Haeussler & Colyvas, 2011; Krabel & Mueller, 2009; Mõttus et al., 2019)
Low demand for doctorate holders	(Parmentola & Ferretti, 2018; Rizzo, 2015).
A limited number of tenured academic positions	(Boffo & Cocorullo, 2019)
Research-related benefits	(Novotny, 2017)
Deep interest in research outcome	(Parmentola & Ferretti, 2018)
Need for independence	(Novotny, 2017)
Need for achievement	(Novotny, 2017)
Application of knowledge to practical purposes	(Novotny, 2017)
TTO with a good network	(Hayter, 2016)

Source: author's literature review

The study on Hungarian universities concluded that the strongest motivation to start a spin-off company is the necessity (economic benefit or 'gold'), followed by research-related benefits ('puzzle'), the desire to be independent, and the need for achievement ('ribbon') (Novotny, 2017). Other important drivers introduced in the literature are the home universities themselves and their TTOs as the important elements, mainly providing infrastructure, legal, and funding possibilities.

Table 1 summarizes the factors, driving the researchers to establish spin-off ventures found in the literature.

1.4.2 Barriers

To choose the most suitable way of knowledge transfer, developing a supportive and effective ecosystem, and, finally, the policy, drivers should be considered, but also the possible barriers should be thoroughly studied and mechanisms to overcome them developed. According to the literature, the main barriers are the lack of resources, the individualism of business people and researchers, lack of knowledge applicability, lack of awareness, and lack of entrepreneurship training and entrepreneurial orientation, regional and national legislation constraints (Goldstein et al., 2017; Neves & Franco, 2018).

The latest publications shed light on the significant role of entrepreneurial orientation in academic spin-off ventures, being a crucial driver of academic spin-off performance. For instance, the study on 138 Italian academic spin-offs revealed that the driving factor of the early growth performance was the joint efforts of academic members and non-academic representatives as stakeholders and management board representatives (Ferretti et al., 2020). Another study on 107 Spanish spin-offs confirmed the positive influence of entrepreneurial orientation on spin-off performance, showing a positive relationship between the firm's entrepreneurial orientation and academic spin-off performance (Diánez-González et al., 2021). All these studies confirmed that entrepreneurial orientation plays an important role and can be fostered by introducing non-academic team members to the management board. Therefore, the lack of entrepreneurial orientation is considered one of the constraints for successful spin-off development and sustainability. Table 2 presents the summary of the barriers found in the literature.

Another constraint for spin-off creation and development is limited access to a resource (the restrictions on using infrastructure and availability of financial resources, legal support) and missing or an unclear strategy for spin-off creation and infrastructure use (Degroof & Roberts, 2004; Goldstein et al., 2017). The research on French academic spin-offs determined four factors leading to the growth of spin-off ventures, i.e., entrepreneurial orientation, the acquisition of skills in the entrepreneurial process, availability of public and private funds, technological capabilities, and support programs (Bessiere et al., 2017).

Table 2. Factors hindering the spin-off ventures' creation, performance, and success

Factors	Author(s)
Lack of awareness of the commercialization potential of the research	(Goldstein et al., 2017)
Lack of entrepreneurial orientation	(Neves & Franco, 2018)
Lack of knowledge applicability	(Neves & Franco, 2018)
Lack of entrepreneurship training	(Goldstein et al., 2017; Neves & Franco, 2018)
Lack of trust between partners (industrial and scientific)	(Neves & Franco, 2018)
Individualism of business people and researchers	(Neves & Franco, 2018)
Cultural differences (between industry and academia, non-holistic approach to spin-off or university culture is not prone to knowledge transfer)	(Calderón-Hernández et al., 2020; Goldstein et al., 2017)
Various regulatory and the bureaucratic issues	(Fini et al., 2017; Neves & Franco, 2018)
Lack of support in applying for patents, informational gaps	(Goldstein et al., 2017; Neves & Franco, 2018)
Lack of social network of founders and weak networking from TTO	(Diánez-González et al., 2021; Huynh, 2019)
Lack of organizational support (insufficient resources for technology transfer, lack of "seed capital", lack of awards, lack of competency in teams and TTOs)	(Bessiere et al., 2017; Diánez-González et al., 2021; Goldstein et al., 2017)
Absence of a clear strategy from the university	(Degroof & Roberts, 2004; Pérez-Hernández et al., 2021; Woollard, 2010)
Lack of external expertise	(Shutyak, 2016)
Weak entrepreneurial ecosystem of the region, country, geographical location	(Fischer et al., 2019; Goldstein et al., 2017)
Global and/or national macroeconomic conditions (interest rates on borrowing, demand, consumer spending, etc.)	(Goldstein et al., 2017)

Source: author's literature review

Indeed, one of the keys to entrepreneurial success is social networks. The researcher's social networks are limited and considered homophylic, i.e., individuals associated and bonded with similar. Research on 181 Spanish spin-offs (Huynh, 2019) showed that success is hidden in exploiting social networks. Another study on Spanish academics confirmed that the spin-off success relies on academic and non-academic contacts (Hayter, 2016). The survey on the United Kingdom academic institutions revealed that one of the spin-off venture constraints is the limited support from the TTO for academic entrepreneurial activities, focusing mainly on legal requirements and intellectual properties (Irwin et al., 2018). Another constraint introduced in the literature is the limited networking capabilities of TTO to link scientists to possible angel investors, venture capital (VC) firms, or find the appropriate funding opportunities (Diánez-González et al., 2021; Prokop et al., 2019). Therefore, the assistance, expertise, and substantial network availability

of TTO are significant factors helping the spin-off ventures raise money and find the required expertise.

1.5 Spin-off ventures' development phases and policy

The development of academic spin-off ventures as companies producing new products and service innovations has numerous uncertainties, and these companies possess a high risk of failure (Rodeiro-Pazos et al., 2021). The studies revealed that the survival rate of academic spin-offs was higher, i.e., 75% of the European academic spin-offs celebrate six years after establishment (Mustar et al., 2008), in comparison to the general start-ups' companies' survival rates, which survival rates were just above 60% after three years, 50% after five years, and just over 40% after seven years (Calvino et al., 2015). Indeed, most academic spin-off ventures remain small, and only a small number of them really present a return. An even smaller number of spin-off ventures become large technology companies (Hesse & Sternberg, 2017). Understanding why one academic spin-off venture performs better than another is a subject of debate (Mathisen & Rasmussen, 2019; Migliori et al., 2019; Rodeiro-Pazos et al., 2021).

There is a wide gap between the knowledge generated by the researcher and the practical use of this knowledge, creating economic value. This gap can be described as a black box of economic value creation (Ndonzuau et al., 2002) that must bridge the so-called “Valley of Death” (Markham, 2002) (Figure 5). The “Valley of Death” is most commonly described as the gap between resource availability and skills required for research and development and commercialization activities (Markham, 2002). There can be other different factors causing the “Valley of death”: lack of human resources, lack of cooperation, poor understanding of the business environment, high risks, insufficient time, institutional pressures, high initial costs, lack of governmental support, and others (Gbadegeshin et al., 2022).

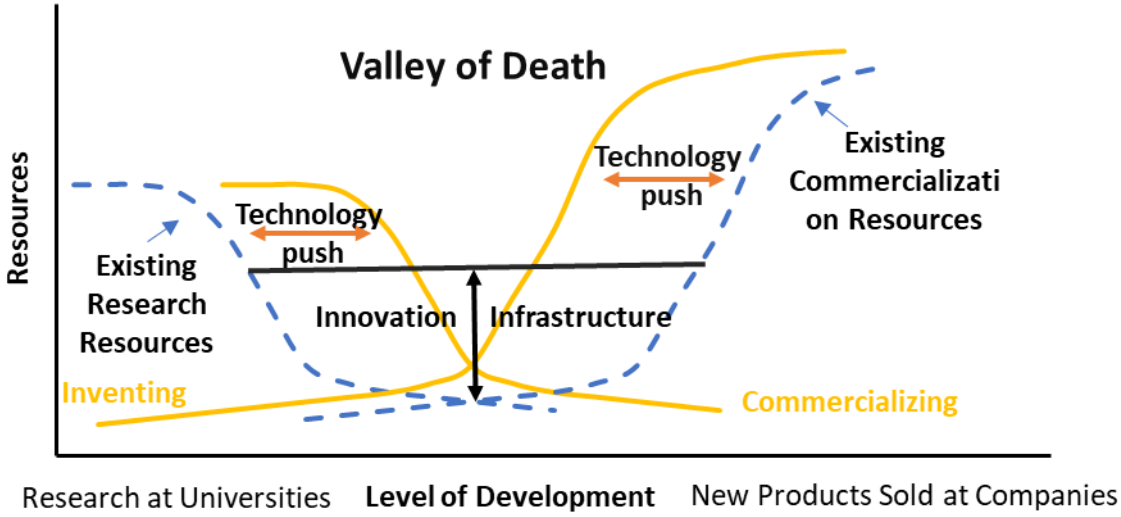

Figure 5. Graphical representation of the "Valley of Death" and strategies to escape
Source: (Gbadegeshin et al., 2022; Rasmussen & Rice, 2012); author's adaption

Therefore, the knowledge should go through a cascade of transformation from the research lab to the market, including multiple phases presented in Figure 6. These phases include the formation of a devoted team, existence of formal and informal development process for the company in general, support from senior management, availability of staff with commercial experience and technical background, availability of networks, appropriate funding, resources, identified target and customers' needs in line with the application of technologies as well as clear vision and mission are considered the critical factors for the success of science-based companies (Baines & Smith, 2019; Ernst, 2002).

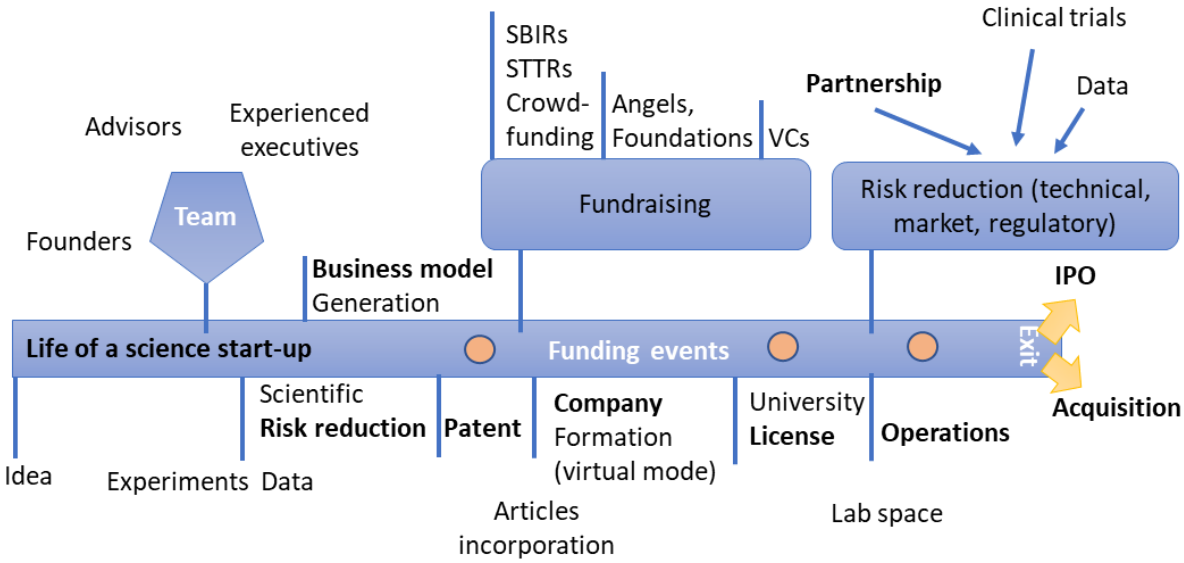

Figure 6. Life of a science startup
Source: (Tajonar, 2014); author's adoption

A spin-off venture's establishment process, performance, and future success depend on multiple factors described in the previous subchapters. Once established, the new companies have a high survival rate and a high possibility of raising seed funding either from an angel investor or a VC or even going to the public (Hayter, 2013). Therefore, policymakers are developing, testing, and implementing different strategies through multiple policies and programs to enable these companies' commercialization success. It is important to consider that a spin-off company goes through different development phases, and each phase has its barriers.

Generally, the knowledge transfer policy must contain a mix of various instruments: financial, regulatory, and "soft" instruments. OECD recommends the following policy instruments for spin-off ventures as the main channel and a researcher as a primary focus group (OECD, 2013, 2019):

- "Awareness-raising (outreach activities) (soft instrument)";
- "Training programs for researchers and TTO staff, covering various aspects of knowledge transfer (soft instrument)";
- "Networking (events, workshops to express the technological needs and presenting research results by scientists) (soft instrument)";
- "IP rights regime (ownership of IP and allocation of IP revenues from publicly funded research) (regulatory instrument)";
- "Regulation of spin-offs founded by researchers and students (conditions, distribution of revenue, implications for academic salaries, etc.) (regulatory instrument)";
- "Career rewards for professors and researchers for mobilizing private research funds, earning income from IP and creating spin-off ventures(regulatory instrument)";
- "Abbaticals and mobility scheme, allowing scientists to join the industry and temporary recruitment od industry researchers (regulatory instrument)";
- "Financial support to academic spin-offs providing proof-of-concept grants, "seed" funding, business plan competitions, etc. (financial instrument)" (OECD, 2019).

Not all policy instruments should be implemented, but instead should be prioritized by each country and university. For instance, the Norwegian Government has established several mechanisms to facilitate Norway's academic spin-off venture establishment. The mechanisms enable to extend the academic research into development, extending the role of commercial actors and investors and supporting the development and engagement of indermediators. This can be

achieved by the proof-of-the principle (POC) grants, providing necessary infrastructure, competence, financial support, pre-seed, the incubation (Rasmussen & Rice, 2012).

Another successful case is Finland's VTT Technical Research Centre with its VTT Venture subsidiary. VTT searches for talented teams and researchers with ambitious and possible scale-up research results, providing a funding program (400-500t €), infrastructure, and support with a project duration of 18 months. The second mechanism implemented by VTT is POC grants. POC grants have been recently implemented in Estonia by the Estonian Research Council POC (up to 100,000 euros with the duration of 12 months), Tallinn University of Technology (up to 75,000 euros), and multiple accelerators (Prototron up to 35,000-50,000 euros, Health Research Accelerator 17,000 euros, etc.). Also, other soft mechanisms, i.e., pitching training and competitions, fundraising support, networks, market validation, etc., are implemented in Estonian universities (Tallinn University of Technology, Tartu University, and Tallinn University). Tartu University has recently implemented a similar approach to VTT Ventures, establishing UniTartu Ventures to scale-up spin-off ventures coming from Tartu University.

Different countries are implementing various policies and a mix of multiple instruments to facilitate the knowledge transfer, paying more attention to the more advanced stages of spin-off life cycles (growth), emphasizing quality and potential to grow high over the quantity of small spin-offs (Fischer et al., 2018). In addition, attention is now turned to the promotion of students and early-stage career researchers' spin-off ventures establishment in addition to researchers’ and professors' ones. The latest has a positive effect on the new employment possibility of the students and the creation of a new connection with industry and university for knowldege transfer (OECD, 2019).

2 RESEARCH METHODOLOGY

The second chapter gives an overview of the research methodologies and statistical approaches applied in the current research. This chapter also describes the current state of the knowledge transfer in Estonia, policy, bottlenecks, and statistics on spin-off ventures in four Estonian universities (Tallinn University of Technology, Tartu University, Tallinn University, and Estonian University of Life Sciences).

2.1 Methods and data collection

In order to examine how the motivations of researchers affect the spin-off ventures' establishment and activities connected, the online questionnaire survey was combined with the in-depth semi-structured individual interviews. The combination of quantitative and qualitative research methods has enhanced the research project's results and led to a deeper understanding of the reasons behind the research questions. Meanwhile, the quantitative research provided the patterns among large populations, the qualitative data gathered participants' beliefs, attitudes, and actions. Moreover, the semi-structured interview revealed the aspects not included in the questionnaire, giving directions for future research.

2.1.1 Quantitative analysis

The data for quantitative analysis was gathered using an online questionnaire. The variables for the questionnaire were derived from the conducted literature review: background, industrial links, nature of involvement in commercialization, motivations, drivers, barriers, and ecosystem on more than 100 publications and used for the analysis of Estonian researchers' attitudes and beliefs towards research results commercialization.

The survey questionnaire contained seven main sections: responder's affiliation, general and scientific background, non-academic experience, professional orientation (typology (Lam, 2011)), spin-off venture experience and performance, commercialization activities, evaluation of spin-off drivers and barriers, ecosystem attributes and finally motivations' section to establish the spin-off

venture. The flow between sections depended on the responders' experience, beliefs, and attitudes toward the commercialization of their research results through the spin-off venture establishment.

The approach used in the current research was proposed by (Lam, 2011) and replicated to map the Estonian researchers' beliefs and attitudes about academic and industrial collaborations, identifying the individual belonging to one of the poles from 'traditional' to 'entrepreneurial' scientists and between these poles. The previously published surveys designs (Ibrahim Saad Darwish, 2022; Novotny, 2017; Rijnsoever & Hessels, 2021; Suominen et al., 2021) on the entrepreneur motivation of scientists conducted on spin-off ventures in Hungarian universities (spring 2014), Egyptian universities and VTT Technical Research Centre of Finland (in late 2019) as well as for researchers from North America and Western Europe (3145 corresponding authors from 1741 institutes (response rate 7.3%, February 2017)) were collocated and adopted for the current research questions. The questionnaire design and the survey questions are presented in Appendix 1 and Appendix 2, respectively.

The questionnaire was sent to the four Estonian universities (Tallinn University of Technology, Tartu University, Tallinn University, and Estonian University of Life Sciences) to collect data from academic staff (professors, leading researchers, researchers, Ph.D. students) as well as non-academic staff (TTO specialists/managers, member of administrative structure) through Google form during April-May 2022. The questionnaire design was tested and discussed with five researchers and a supervisor. The corrections were made, and the additional explanations were introduced throughout the tests (specifically, the terminology explanations were added) before making the questionnaire publicly available.

The respondents were given two weeks to complete the survey. During the first week, the response rate was only 2.0% (44 responders from 2,200 emails in the employers with contracts and guest lecturers' lists at Tallinn University of Technology). Therefore, it was suggested to change the strategy for survey distribution. The background of researchers was screened using the following criteria, i.e., academic position and discipline (Life Sciences, Engineering, Information and Technology) through the universities' and Estonian Research Information Portal websites. The personalized emails with survey invitations were generated and sent to 849 researchers employed in the four Estonian universities (Appendix 3). The response rate was 21.2% (n=184), if taking only personalized emails (26.4% response rate for all received responses, n=225). The survey was constructed to keep the responder's identity anonymous. No personnel data was collected that

could potentially discover the responder. The unprocessed and processed data were stored securely on a Tallinn University of Technology server (Appendix 13).

2.1.2 Qualitative analysis

The thematic analysis was used for qualitative research to find the hidden patterns and themes that were not found in the literature review or confirm the findings in the literature. The defined themes' peculiarities were analyzed and summarized. The data for qualitative research was gathered through the in-depth interviews conducted with seven academic members (professors, researchers) and three TTO specialists/managers (Table 3).

The interviewees were chosen according to their background, achievements, affiliation, and involvement in various commercialization activities (e.g., the consultancy, collaborative research, patenting, licensing, and spin-off creation). Five of eight academic members have already established spin-off ventures or private enterprises (Table 3). The involvement of TTO specialists and managers in the current study was critical to investigating how TTO staff understand academic staff's intrinsic and extrinsic motivations to commercialize their research. It is known that many researchers bypass or completely skip the TTO, bringing their research results to market themselves (Burg et al., 2021; Huyghe et al., 2016). Indeed, TTO is considered the university structure, aiming to transfer knowledge from academia to industry, create collaborations, and motivate the academic staff to commercialize their research ideas through different models (licensing, spin-off, etc.).

Table 3. The interviewers' coding and its position

Interviewer's number	Position
INT1	Founder, TTO manager
INT2	Founder, Researcher
INT3	Founder, Professor
INT4	Founder, Researcher
INT5	Professor
INT6	Administration, Founder, Researcher
INT7	Administration, Researcher
INT8	TTO manager
INT9	Professor
INT10	TTO manager

Source: author's survey; authors' visualization

The interview was divided into sections dedicated to three main research questions, i.e., motivations, drivers and barriers, and ecosystem. The question choice depended on the role of the interviewee in the academic organization. The examples of questions are presented in Appendix 4. The unprocessed and processed data were stored securely on a Tallinn University of Technology server (Appendix 13).

2.2 Main variables and analytical approach

The Estonian reseacrhers belonging to one of the categories defined by (Lam, 2011) and connections to their external and intrinsic motivations, and positions were examined. After that, the hidden connections between motivations, experience, and beliefs were defined using principal components analysis (PCA) combined with cluster analysis.

PCA is a statistical technique used widely in data analysis in life and social sciences (Bro & Smilde, 2014; Suominen et al., 2021). PCA (Figure 7) reduces the dimensions in a dataset, determining the features, and hidden patterns, accounting for the most significant variation, and discarding the noise. Before PCA analysis, the dataset was pre-processed, scaled, or standardized into a comparable range. After that, the covariance matrix was calculated, helping to identify the correlations and dependencies among features in a dataset. The next step was the calculation of eigenvectors and eigenvalues from the previously calculated covariance matrix, helping to determine the largest and smallest eigenvalues of the eigenvectors. Finally, principal components were calculated. The principal component (PC) 1 was the most significant, having the highest eigenvalue. The principal components that are lesser significant were not considered. Consequently, the dimension of the data was reduced. The biplots of scores and loadings are presented, visualizing the hidden patterns and connections.

Cronbach's alpha was used for evaluation of the internal consistency of a questionnaire part contributed to motivation using the Likert scale from 1 to 7, where 1 (one) equals "Strongly disagree" and 7 (seven) equals "Strongly agree", respectively. The Cronbach α was 0.8813, showing that the scale is internally consistent (Cronbach $\alpha>0.5$).

The data was divided into two sets: testing (121 x 20) and validation (104 x 20). The testing set was used for model construction and validation for model testing. The testing model was

constructed using six principal components (PC), describing 72.7% of the dataset pre-processed using autoscaling. The threshold for data explanation was set to at least 70% of the dataset (225x20) and consistency of eigen. The cluster analysis using Ward's method was applied.

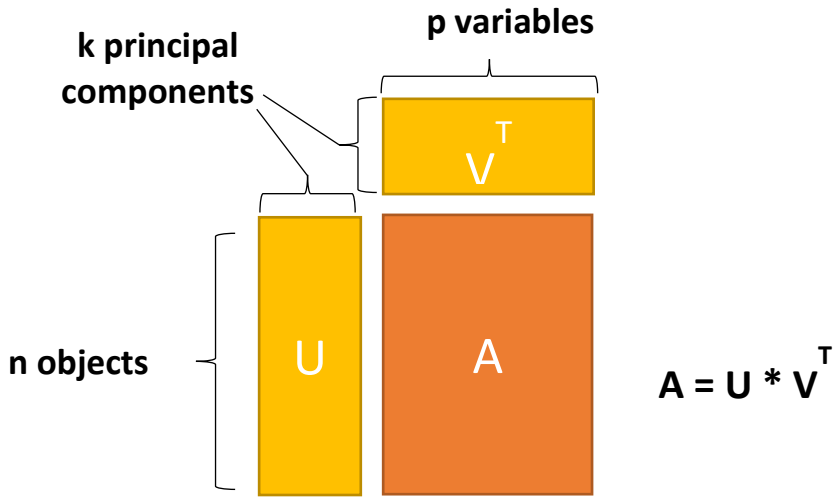

Figure 7. Principal Component Analysis (PCA)
Source: (Bro & Smilde, 2014), author's visualization.

The questionnaire was prepared in Google Forms. The data was pre-processed by MatlabR 2021b (Mathworks, USA), statistical analysis toolbox PLS Toolbox 9.1 (Eigenvector Research, Inc., USA), and Microsoft Excel. The interviews were transcribed using an online advanced rich transcription system for Estonian speech (Alumäe et al., 2019).

2.3 Limitations and ethical considerations

The current research response rate calculation can be distorted by the volume of e-mails in the general lists and possible responses during the duration of the survey. The online survey's invitations were sent through the general email list of university employees and personally. The limitation of this study is the proportion of responders from different universities and disciplines, i.e., 57.3% of the responders took part were from Tallinn University of Technology, 26.2% from Tartu University, 10.2% from Tallinn University, and 5.3% from the University of Life Science and other 0.9%, respectively. 55.1% of responders defined their discipline as Life Science, 19.6% as Engineering and 13.8% as Information and Digital Technologies, 4.4% as Medicine, 4.4% as Business and Governance, and 4.4% as others. Therefore, the results and conclusions can be skewed to the researchers of one predominant discipline, i.e., Life Sciences, and to one

organization, i.e., Tallinn University of Technology, as a major contributor to the current study. Therefore, it was crucial to combine quantitative and qualitative research to study different Estonian universities' ecosystem attributes, barriers, drivers, and motivations.

The identity and affiliation of the interviewers are not disclosed in the current research. The interviewers were provided with the consent form, and the interviewer confirmed the correctness of their citations before making them public. However, the position of interviewers is presented separately as an important source of information.

3 RESULTS & DISCUSSION

The results of the author's survey are presented in the first subchapter of the third chapter. The last subchapter presents a discussion, conclusions, and recommendations for Estonian universities.

3.1 Results

3.1.1 Estonian researchers' typology and motivations

Motivation has been an important research object, driving individuals, including academic and non-academic staff, towards entrepreneurship (Hayter et al., 2021; Huszár et al., 2016). The individual and organizational transformation from purely academic to entrepreneurial can be painful, quite long, and even unacceptable to some members. It can be explained that academic science and academic entrepreneurship motives and beliefs are located at the opposite poles. The norms of science ethos, also known as Merton's norms (Merton, 1942), i.e., communality, universalism, disinterestedness, and organized skepticism (CUDOS), clearly contradict entrepreneurial scientific activities such as scientific research patenting, not publishing the research results, direct economic benefits in conducted research, delivering results with direct commercial value, and focusing on problems and needs instead of expanding the knowledge on the world's understanding. Therefore, if the academic university transforms into an entrepreneurial one, the academic members should also go through the transformation and accept the new mission, established mechanisms, and policy.

According to (Lam, 2011), the typology of researchers' motivation can differ to a large extent from 'pure traditional' to an 'entrepreneurial' one (Figure 4). Prior to author knowledge, the motivational trichotomy of financial, reputational, and intrinsic satisfaction ('gold', 'ribbon', and 'puzzle') was analyzed for Estonian researchers for the first time. Lam (2011) found that the universities with very different types of researchers ('pure traditional' and 'entrepreneurial') can clash with tensions between groups.

This research has found that the predominant part of Estonian researchers placed themselves in the 'hybrid' category (49.8% of the responders by the first priority). 'Hybrid' researchers are passionate about scientific knowledge production, solving 'puzzle', and receiving 'gold' to advance their research. These researchers might share the entrepreneurial researchers' belief that science and business collaborations are important and beneficial for their research while still committed to the core scientific values of traditional researchers. The second large group of Estonian researchers was 'entrepreneurial' (30% of the responders by the first priority). The 'entrepreneurial' researchers believe that the boundary between science and business is permeable and that science and business collaboration is the core. These scientists are more likely involved in commercialization activities and driven by 'gold' (financial award) and 'puzzle'. The third group of Estonian researchers belonged to the 'traditional', pursuing commercial activities only as additional funding for their research and advancing their career using commercial activities as a currency. Only 6.1% of Estonian researchers placed themselves into the 'pure traditional' category of researchers. This group believes that science and business should be distinct and mainly driven by 'ribbon', advancing their career and getting a reputation from the core of scientific values.

The survey showed that the second priority of the Estonian researchers has a similar signature to the first choice. However, the second priority revealed more 'traditional' researchers (24% of the responders by the second priority). In total, twelve responders could not place themselves into only one category by the first priority and 17 responders by the second priority, choosing the multiple categories for the first and the second priorities. These responders were excluded from the statistics for typology examination. Table 4 presents the statistics on Estonian researchers' typology. Since the majority of the responders were self-defined as 'hybrid' or 'entrepreneurial' researchers, it was suggested to examine the groups using both priority answers depending on the first and second priorities (i.e., 'entrepreneurial-hybrid', 'hybrid-entrepreneurial', 'hybrid-traditional', 'traditional-hybrid', etc.). A similar approach was utilized to study identification of typologies in Finland's VTT Technical Research Centre (Suominen et al., 2021). This approach revealed that 28% of the Estonian responders were 'hybrid-entrepreneurial', 26.2% 'entrepreneurial-hybrid', 16.9% 'hybrid-traditional', 11.6% 'traditional-hybrid', and the rest variations were less than 4%. It was interestingly to find that some of the researchers self-determined themselves as 'pure traditional-entrepreneurial (n=2), 'entrepreneurial-pure traditional' (n=1), 'pure traditional-hybrid' (n=1), 'hybrid-pure traditional' (n=3), 'traditional-entrepreneurial' (n=2), 'entrepreneurial-traditional'(n=4), putting themselves into both poles with contradiction in values.

Table 4. The typology of online survey responders according to the classification proposed by Lam (2011)

Type		First best	First best (%)	Second best	Second best (%)
'Pure traditional'	I believe that academia and industry should succeed strictly in the distinct and I pursue success strictly in the academic arena	13	*6.1%*	5	*2.4%*
'Traditional'	I believe that academia and industry should be distinct, but I pursue industrial links activities mainly to acquire resources to support academic research	30	*14.1%*	50	*24.0%*
'Hybrid'	I believe in the fundamental importance of academic-industry collaboration, and I pursue industrial links activities for scientific advancement/breakthrough	106	*49.8%*	86	*41.3%*
'Entrepreneurial'	I believe in the fundamental importance of academic-industry collaboration, and I pursue industrial links activities for application and commercial exploitation	64	*30.0%*	67	*32.2%*
	Total	213		208	

Source: authors online survey; author's calculations

After that, the defined researchers' categories (Lam, 2011) were analyzed with the data on motivation. The online survey showed that the Estonian researchers were most likely motivated or would be motivated by the following motivations:

1) to put their ideas into practice (mean score 6.01);
2) desire to yield tangible results from the research efforts (mean score 5.72);
3) further development of the research towards application (mean score 5.61).

Somewhat likely, Estonian researchers will be motivated by:

1) the receiving more autonomy ('to work and make decisions on my own', mean score 5.11);
2) by own exploitation knowledge for financial gain (mean score 4.96);
3) by getting more funds on their research (mean score 4.77);
4) by extra income to improve quality of life (mean score 4.52).

The practical value of the research results, financial gain, and autonomy aligns with previous studies on researchers' drivers towards commercialization of research results (Novotny, 2017; Vega-Gomez et al., 2018). These results were also in line with the defined generalized map of Estonian researchers' typology (Lam, 2011), i.e., 'hybrid-entrepreneurial and

‘entrepreneurial/hybrid’, which were mostly driven by the solving ‘puzzle’ for the real applications, ‘gold’ as a financial reward of their research and higher autonomy in conducting their research. The Estonian researcher most likely won't be motivated by the third party to establish the company. The descriptive statistics on Estonian researchers' motivations are presented in Table 5.

Table 5. The mean scores on motivations of responders with standard deviations (n=225)

#	Motivation description	Mean	Std. error	Var.	Mode	Min	Max
1	I could not make ends meet from my university salary.	4.08	1.86	3.43	4	1	7
2	I needed extra income to provide for an acceptable quality of life.	4.52	1.92	3.65	5	1	7
3	I wanted my research efforts to yield tangible results.	5.72	1.30	1.69	6	1	7
4	To complement my research activities.	5.30	1.30	1.69	5	1	7
5	To exploit my knowledge for financial gain.	4.96	1.58	2.50	5	1	7
6	To further develop research results towards application.	5.61	1.27	1.61	6	1	7
7	To put my ideas into practice.	6.01	1.20	1.42	6	1	7
8	To work and make decisions on my own.	5.11	1.63	2.65	5	1	7
9	I could best make use of my skills by working independently.	4.22	1.68	2.81	4	1	7
10	To be my own employer.	4.19	1.80	3.22	4	1	7
11	To identify and exploit new market opportunities.	4.11	1.67	2.79	4	1	7
12	Motivated by the third parties to have my own company.	3.33	1.67	2.76	3	1	7
13	To solve scientific problems independently	3.82	1.67	2.76	4	1	7
14	To have more challenges at work.	4.08	1.72	2.94	4	1	7
15	I want to try myself in competition.	3.70	1.74	3.01	4	1	7
16	To build my own business.	3.93	1.89	3.56	4	1	7
17	To have more funds and better equipment for my research.	4.77	1.75	3.05	5	1	7
18	To have higher prestige and reputation.	3.90	1.85	3.40	4	1	7
19	To advance my career as a researcher.	4.32	1.86	3.43	5	1	7
20	To get rich.	3.86	1.99	3.92	4	1	7

Source: online survey; author’s calculation

3.1.2 Motivations' peculiarities of Estonian researchers

The Estonian researchers' motivation was further analyzed by principal component analysis coupled with cluster analysis to reveal the hidden patterns and peculiarities in motivations. The PCA-cluster analysis revealed that the testing dataset could be divided into two main clusters with three subclusters described below (

Figure 8). The motivations set attributed to each principal component was found and assigned to one or multiple motivations using eigenvectors (Appendix 6) and the percentage of variation captured for each principal component (Appendix 7). The description of each PC is presented in Table 6 and Appendix 8.

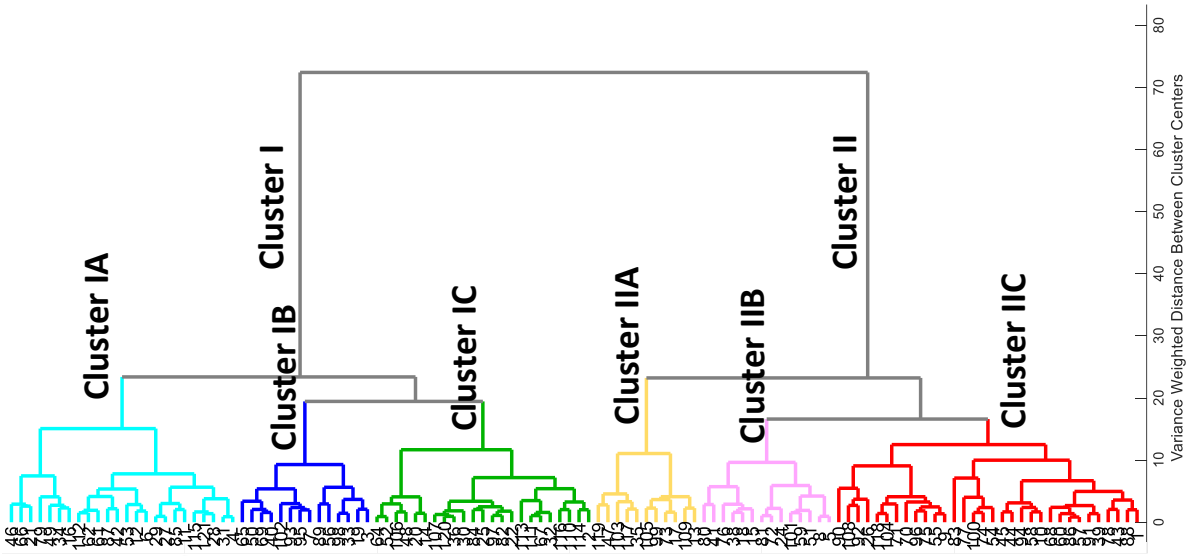

Figure 8. Dendrogram of online survey´s dataset (n=121) cluster analysis (Wards's method, PCA 1-5, preprocessing autoscaling). Cluster I – business orientated; Cluster 2 – practical output and additional resources or own research
Source: online survey; author's calculation

PCA analysis revealed that PC1 (33.59% of the data) described the following motivations: working independently, being own employer, and exploiting market opportunities and new knowledge. PC2 (11.94%) was attributed to the application search, putting ideas into practice ('puzzle'), advancing a career as a researcher, and getting prestige and reputation ('ribbon'). PC3 (9.69%) was attributed to prestige and reputation, advancing the career ('ribbon'), and experiencing more challenges. PC4 (7.08%) described motivation to work independently ('autonomy'), to get new knowledge for financial gain ('gold'). PC5 (5.81%) explained the monetary incentive for better equipment for the research. PC6 (4.59%) described the necessity of getting extra income, dissatisfaction with universities' salaries, and a research career.

Table 6. The principal components' characterization

Principal component number	Description
PC1	Prestige and reputation ('ribbon') Autonomy Exploit market opportunities
PC2	Application search ('puzzle') Advance research ('gold')
PC3	Advanced career and reputation ('ribbon') 'Gold' to advance research Competition – EO Challenge – growth mindset, 'Puzzle'
PC4	Application search ('puzzle') Autonomy
PC5	'Gold' to advanced research Competition – EO Externally motivated by the third party
PC6	Extra income 'gold' to advance the quality of life

Source: online survey; author's calculation

A 3D scatter plot of PCA biplots of PC1-PC2-PC3 best represented the clusters' distribution and grouping of the responders by defined motivations set (Figure 9). The researchers from the first cluster (

Figure 8 Cluster I) were more likely motivated by higher income ('gold'), higher autonomy/independency, advancing their research career, getting a higher reputation and prestige ('ribbon'), exploiting market opportunities, gaining knowledge for financial gain, and establishing the company. These were all attributes of 'hybrid-entrepreneurial' researchers, i.e., 'gold', 'ribbon' and autonomy, high self-efficacy, and internal locus of control. The last three showed that this group of Estonian researchers had the characteristics of an entrepreneurial mindset that could positively impact the spin-off venture establishment, success, and performance (Ferretti et al., 2020).

The main two clusters were divided into minor clusters, i.e., subclusters. Subcluster IA was classified as a strong motivation to become independent ('autonomy'), search for challenges, and desire to compete. These attributes belong to the entrepreneurial mindset. Therefore, this cluster was characterized as 'entrepreneurial'-like. The subcluster IB and IC responders were motivated by searching for practical applications ('puzzle'), advancing their research careers, and getting prestige and reputation ('ribbon'). These attributes belong to 'hybrid' researchers. The researchers

of subcluster IC were more motivated to earn extra income (‘gold’) for a better quality of life and becoming independent (‘autonomy’).

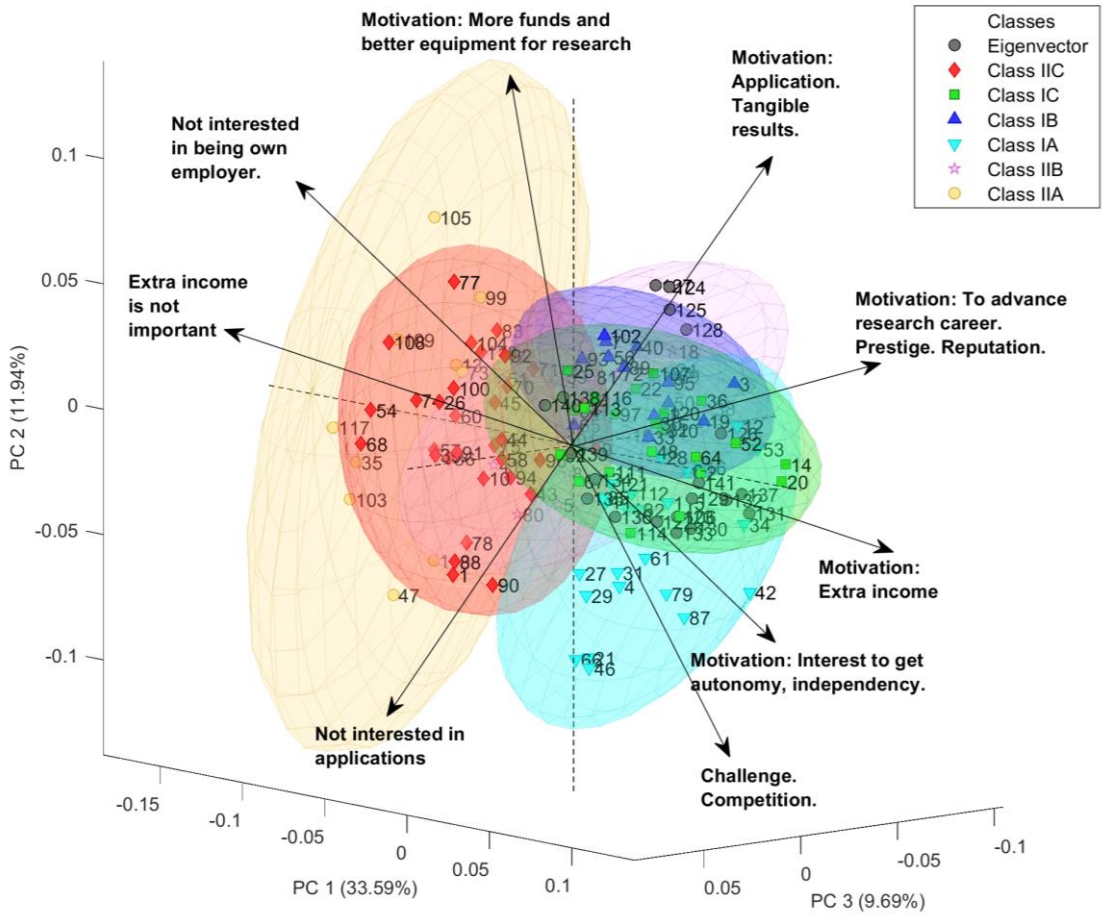

Figure 9. The defined clusters and motivations strength distribution presentation using a 3D scatter plot of PCA biplots (PC1-PC2-PC3) (confidence interval 95%)
Source: online survey; author’s calculation

The Estonian researchers from cluster II were less motivated than researchers of cluster I to establish the spin-off companies. Nevertheless, the unique peculiarities in motivations were defined for each subclusters II A-C. Subcluster IIA and IIC were less motivated (IIC) or even amotivated (IIA) to establish the spin-off unless more funds and advanced equipment for their research could be acquired. These subclusters can be attributed to ‘pure traditional or traditional’-like researchers. Only subcluster IIB possessed more interest in searching for practical applications of their research (‘puzzle’) and advancing their research career and reputation (‘ribbon’). Consequently, cluster II was classified as researchers with signatures of ‘pure traditional’,

'traditional', and 'hybrid-traditional' researchers. The statistics on motivations' clusters are presented in Appendix 9.

The previously determined subtypologies of Estonian researchers were utilized as dependent variables for the PCA model on motivations. The minor typologies' groups were excluded from the analysis. PCA results showed that the Estonian researchers' motivation strength to establish the spin-off venture is distributed between the researcher's typology and their motivations strength to establish the spin-off venture.

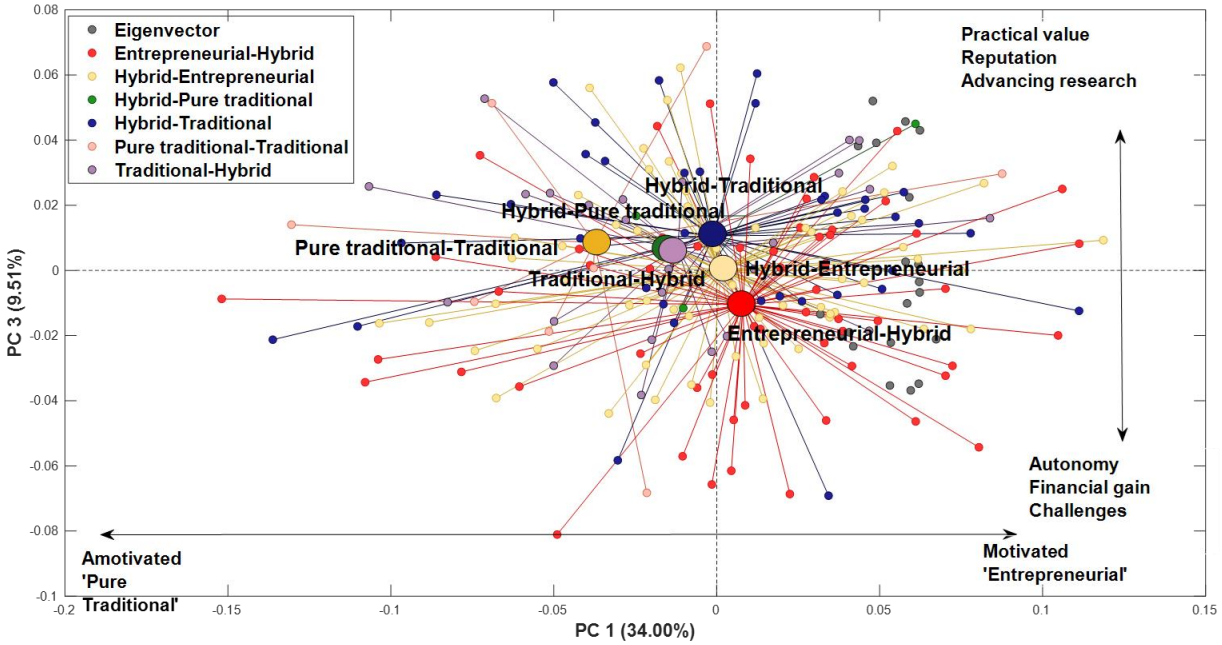

Figure 10. Estonian researchers' typologies (Lam, 2010; Suominen et al., 2021) and their motivations' strength toward research commercialization. A PCA biplot (PC1-PC3) with eigenvectors (confidence interval 95%)
Source: online survey; author's calculation

Figure 10 shows the direction of motivations strength decline from 'entrepreneurial' to 'pure traditional' pole, going through different subtypologies transformation: 'entrepreneurial-hybrid' > 'hybrid-entrepreneurial' > 'hybrid-traditional' > 'traditional-hybrid'/'hybrid-pure traditional' > 'pure traditional-traditional. These findings were in line with the conceptual framework proposed by Lam (2011) (Figure 4). The previously defined clusters and assigned motivations to each cluster were also in line with the researcher's typology and motivation in the spin-off establishment (data not shown).

3.1.3 Estonian researchers motivations

The Estonian researchers' motivations were compared to the responses to the question number 33 regarding their current concern to establish or not establish the spin-off ventures. The biplots of PC1-PC3 and PC1 vs. PC4-PC6 (not so distinct distrubituon as for PC1-PC3) revealed that motivation to establish the spin-off ventures grew by financial gain, autonomy, 'puzzle-solving', advancing research, reputation, and search for the practical value. Those Estonian researchers who had not decided yet (39.4% of responders), were located between two poles by their motivation strength. It was also found that the group of researchers who has already established the company do not show significantly higher motivation's strength than those that would like to do it. The possible reasons behind it (previous experience, failures, success, performance, etc.) are one of the possible future research directions. Figure 11Figure 11 presents the theoretical model of the Estonian researchers' motivation to establish spin-off ventures.

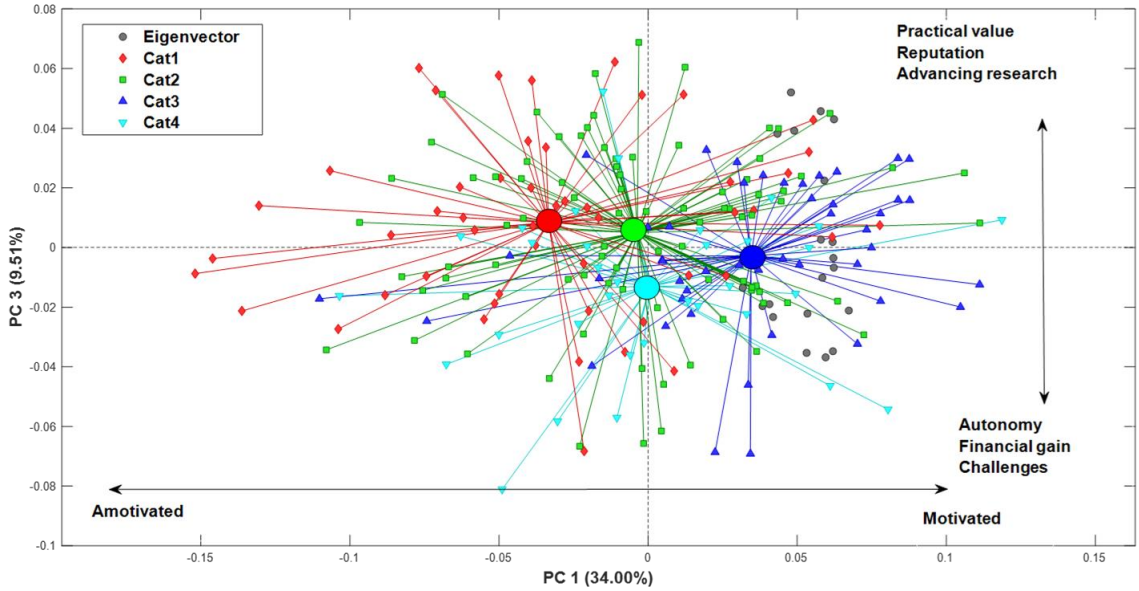

Figure 11. The comparison of the motivations of Estonian researchers to establish the spin-off ventures and researchers' response to establish the company. A PCA biplot (PC1-PC3) with eigenvectors (confidence interval 95%). Cat1 – "I do not want to establish a science-based firm (answer if you were, imagine this case)", Cat2 – "I have not decided yet", Cat3 – "I would like to establish a science-based company", Cat4 – "I have already established a science-based company."
Source: online survey; author's calculation and visualization

The higher the eigenvalue (PC1) corresponds to the higher Estonian researchers' motivation strength to establish the spin-off venture or commercialize their research results in the future. Other PCs' eigenvalues can be used to determine the possible drivers' set (motivations) to trigger the researcher's motivation towards the company establishment. However, it should be highlighted

that the current theoretical model has various limitations due to the relatively small number of responders and predominant response from the Life Science researchers from Tallinn University of Technology. The model should be further tested, advanced, and validated using an additional independent validation set, introducing more researchers from other universities, public research organizations, and other disciplines. Possibly the advanced model could be used for the automatized tool development aiming to screen the Estonian researchers' motivations and determination of possible rewards to facilitate the spin-off venture establishment. This is one of the possible future research directions.

One of the background variables is the position of the researcher. The alignment between academic position and motivation was examined in the current research. The results depicted that 85% of professors (n=13), 71% of associate professors, and 80% of the leading researcher were described mainly by cluster II. Professors were motivated by additional funding rewards to advance their research (38%), less motivated to find applications (23%), or other extra rewards (income, independency, competition).

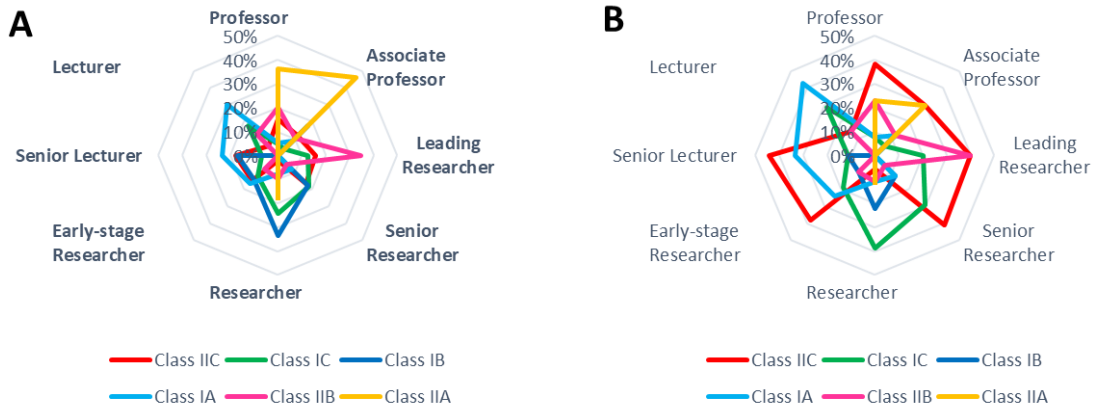

Figure 12. Polar charts of academic responders (based on online survey) and their motivations to establish spin-off (corrected by position sample size) between positions (A) and within one position (B)
Source: online survey; author's calculation

The associate professors' group was less motivated in any of the proposed motivations listed in the survey (29% within the group and 46% between groups). 40% (within-group) of responded leading researchers were interested in the possibility of getting additional funding, equipment for their research, and finding real applications (Figure 12-B). Senior researchers (41% within-group) were motivated by additional funding for their research. Researchers (38% between and 24% within-group) were inspired by additional funding and autonomy for their scientific research.

Early-stage researchers were also motivated by prestige, reputation, building their career as a researcher, and extra income (19% within-group). The motivations of senior lecturers were similar to lecturers, i.e., prestige and building career, independency, and additional funding for their research. Figure 12 presents the direction of motivation for each defined cluster (IA-C, IIA-B) between positions (A) and within position (B). The groups' sample size was corrected by the population of each class attributed to the motivation to minimize the results misrepresentation.

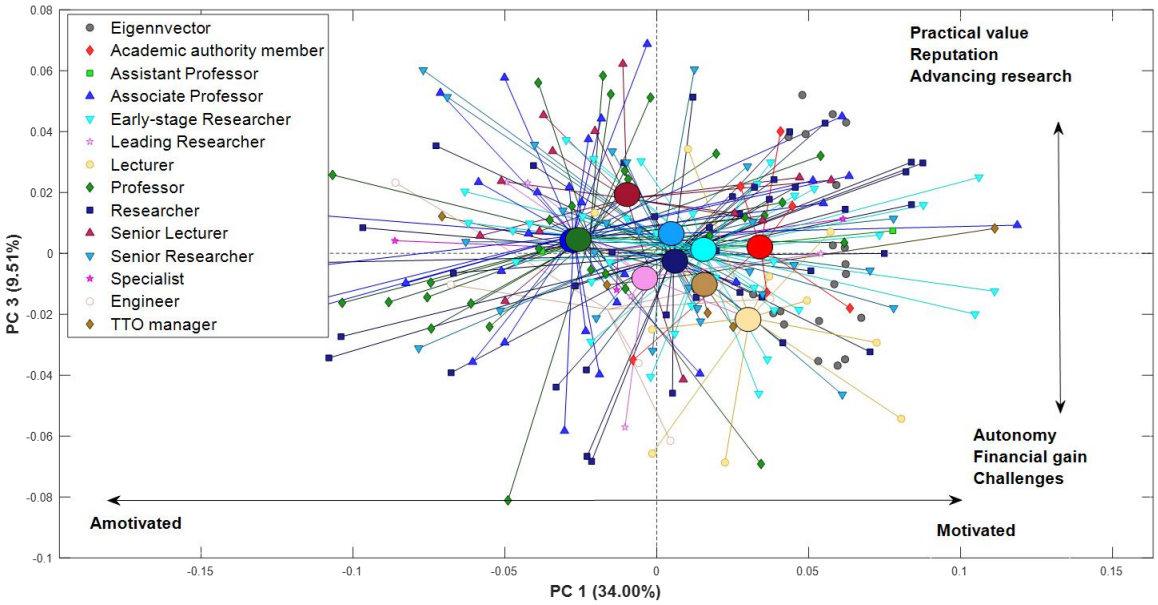

Figure 13. The comparison of the motivations of Estonian researchers to establish the spin-off ventures and researchers' position. A PCA biplot (PC1-PC3) with eigenvectors (confidence interval 95%)
Source: online survey; author's calculation and visualization

There researcher's position and the motivation's strength can be examined using a biplot of PC1 and PC3 (or PC4, PC5, PC6). This biplot presented both test and validation sets. The validation set was consistent with the test set. The groups' distribution is not apparent using only two PCs and used only to present the tendency of the entrepreneurial mindset growth, as well as the motivation growth to establish the spin-off company or commercial their research results within the positions of researchers (Figure 13).

37% of early-stage researchers, 30% of researchers and 18% of lecturers would like to establish spin-off companies (Figure 14). These lecturers will most likely be motivated by financial gains, higher autonomy, and early-stage researchers toward career advancement and reputation.

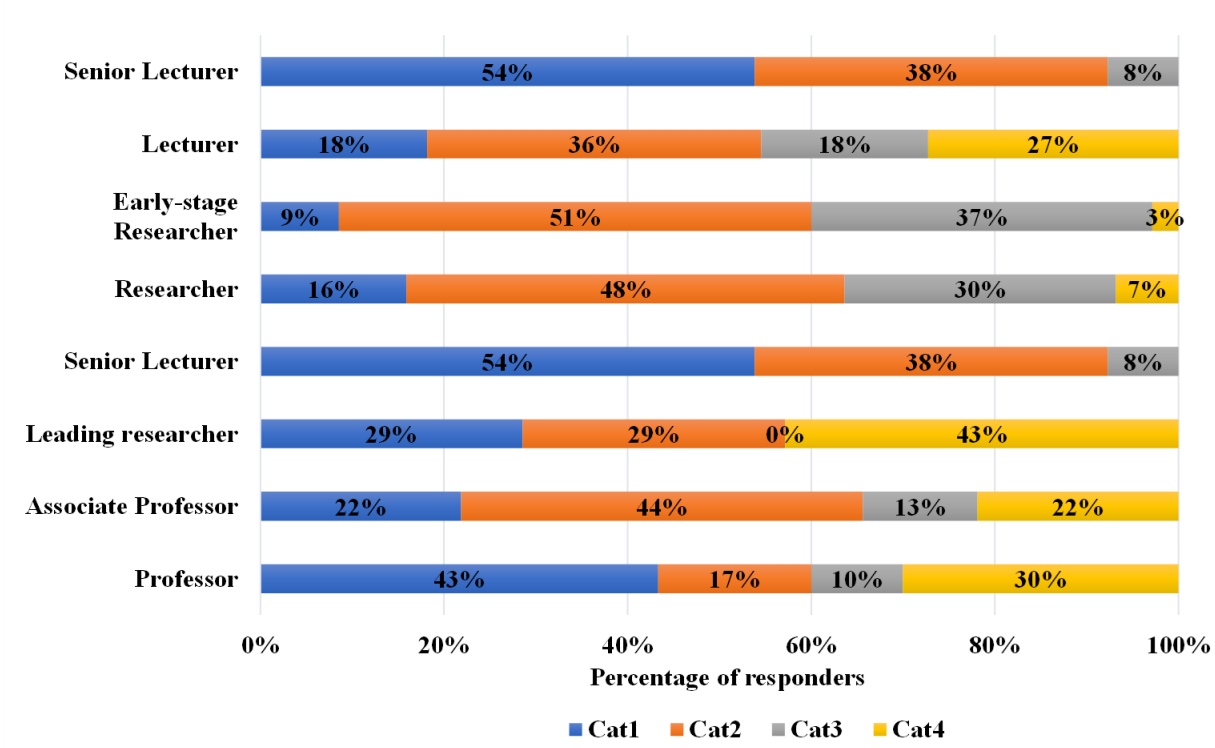

Figure 14. Question 33 results were aligned to the responder positions (only academic positions). The distribution of categories within the position (n=225). Legends, as in Figure 11
Source: online survey; author's calculation

According to the survey's question number 33, 43% (within-group) of professors and 22% (within-group) of associate professors, 29% of leading researchers are not interested in establishing the spin-off companies, showing the lowest scores on the motivations. Interestingly, 30% (within-group) of the professors, 22% (within-group) of associate professors, and 43% of leading researchers have already established the companies. The statistics revealed that the TTO should be attention to the early-stage researchers and researchers' motivations toward research results commercialization.

3.1.4 The profile of the Estonian spin-off founder and Estonian spin-off

This research has examined the researchers who have already established their spin-off venture. In total, 36 responders answered that they had already established a science-based company, but only 27 responders confirmed that they are founders or co-founders. Therefore, the nine responders can misrepresent the founder's average profile. The descriptive analysis of data on founders revealed the profile of the average spin-off founder (Appendix 12).

Research results show that the average spin-off founder is a 30- to 39-year-old (28%) man (67%) who holds a Ph.D. (81%) in life science (56%) and has listed at least one patent (56%). He is still employed as a professor (24%), senior researcher (21%), or associate professor (18%) and is a leader (47%) of a multidisciplinary research team (86%). He has published more than 21 publications (64%). His H-index is at least 11 (47%). He has also been involved in research and development activities for more than 11 years (69%). The average founder has worked in at least one academic organization (44%) and has not held a postdoctoral position (58%). Instead, he has at least six years of nonacademic working experience. He is still employed by a nonacademic organization with at least a 0.5 man load (48%). The founder is responsible for research and development (R&D) (90%) and business administration and management activities (71%) in the nonacademic organization. The average founder has classified themselves as "entrepreneurial-hybrid" researchers (50%). This person is mainly doing research to solve important scientific problems (20%), satisfy his intellectual curiosity (19%), and improve the world, creating social impact (19%). The average founder believes that the university can attract industry by showcasing success stories (67%) and faculty expertise (56%), having an office dedicated to building and managing partnerships (42%), and setting up a multidisciplinary institute on campus in collaboration with industry (42%).

The research revealed that more than 66% of founders were involved in contract research activities, 53% in applying for patents or utility models, and 11% in licensing university technology. More than 75% of respondents were previously involved in joint projects with academia (75%), joint projects with industry (67%), contract research (58%), and projects to provide consultancy and services to external parties (42%). It was impossible to determine where these collaborations were within the spin-off venture or being an employee of the university. According to the founders' beliefs, new collaborations should be initiated through industry needs (89%), through faculty contacts (44%), and through TTO (44%) and should be based on previous success stories or past successful experiences (53%).

To estimate the success rate of spin-off ventures, the data on annual revenues, the number of employees, and the company's age were examined and collected through an online survey. About 50% of Estonian spin-off ventures showed that their annual revenue is less than 25,000 euros, 17% less than 50,000 euros, and 14% less than 100,000 euros. Approximately 19% of spin-off ventures declared that their annual revenue is higher than 100,000 euros. The findings are similar to previously published data on Estonian academic spin-off ventures' performance, which showed

that more than 65% of Estonian spin-offs showed minimal activities (average annual revenue of 26,000 euros), focusing mainly on research in universities than spin-off development (Eljas-Taal et al., 2019). A previously published report (Eljas-Taal et al., 2019) also showed that only 20% of established spin-off ventures have remarkable revenue (more than 600,000 euros per year), and only 11 spin-off ventures had an annual revenue of more than 1.8 million euros in 2018. In general, this research has found that 41% of the spin-off ventures have not shown any growth during their lifetime (annual revenue of fewer than 25,000 euros during the first year of their establishment vs. current annual revenue, companies less than two years old excluded). The average age of the Estonian spin-off venture is five years (medium quantile). Eleven spin-off ventures were established more than 10 years ago (31%).

The survey showed that 41% of founders have participated in accelerator and incubation programs. About 25% of the respondents have not contacted TTO, and 14% do not know what TTO means. Approximately 61% have reached TTO. It should be noted that 71% of the companies that have not contacted TTO are more than 10 years old. The representatives of nine companies, i.e., older than four years, did not know what TTO is. About 48% of the spin-off ventures have raised money from public funds. Eleven responders (31%) declared that one of their spin-off ventures' stakeholders is a university (4 of 36), venture capital (VC) firm (3 of 36), or angel investor (4 of 36). Interestingly, it was also found that the companies where one of the stakeholders is a university, VC firm, or angel investor have an annual revenue of fewer than 25,000 euros and are at least three years old. However, it is unknown when the external organization was involved in the company.

More than 30% of responders self-assessed as unsuccessful academic entrepreneurs (less than 3 of 7 points), 27.8% somewhat unsuccessful (3 of 7 points), 16.7% to some extent successful (5 of 7 points), and 8.4% successful (more than 6 of 7 points). Of the respondents, 16.7% have not decided (4 of 7 points). Consequently, most of the respondents (58.4%) considered themselves unsuccessful academic entrepreneurs whereas 47.2% (less than 4 points) were also not satisfied with the degree to which the scientific results have been transferred to the market by their firm. Only 13.8% of founders were satisfied with the commercialization of their research results (more than 6 of 7 points). Also, 41.7% of respondents (n = 36) raised money for their spin-offs through public funding (EAS, Horizon, EIC, etc.).

3.2 Drivers and barriers analysis

According to the conducted literature review, the researchers continuously face different challenges during the different development stages of spin-off ventures (Table 1, Table 2). The quantitative analysis revealed the main drivers and barriers that Estonian researchers considered a driving force to successful spin-off venture establishment and development.

First of all, the most significant driver was the establishment of good relationships with partners that can be vital for the spin-off or project success (95% calculated for a score higher than six). Secondly, teams' technical competence and expertise were considered strong drivers (93%). Thirdly, the entrepreneurial orientation of the principal investigator (92%) was highlighted as a significant driver. The Estonian researchers suggested that the main barriers were the following: the lack of resources (88%), the lack of applicability of knowledge (85%), differences of knowledge and opinions between investors and academics (85%), stability and lifelong employment at academia (79%) and lack of skills, negotiation techniques and business experience (77%). The Estonian researchers strongly disagreed that gender, seniority, or geographic distance impact spin-off venture implementation and success. Table 7 presents the summary of the main drivers and barriers for Estonian researchers toward spin-off venture establishment. The findings were in line with the literature review (Table 1, Table 2). The survey statistics on drivers and barriers is presented in Appendix 10 and Appendix 11.

Further research was dedicated to the analysis of the universities' ecosystem attributes. The ecosystem plays an important role in academic entrepreneurial activities. Generally, the science-based spin-off requires multiple supporting mechanisms. First the supporting instruments to search the practical applications of the research project's results. The proof-of-principle (POC) grants are one of the financial instruments that can be provided for the scientific teams (OECD, 2019). For instance, the Estonian Research Council provides a scientific proof-of-the-principle (POC) grant for the scientific team that can prove that their research results have achieved the technology readiness level 4 (i.e., technology validated in the lab (ETAG, 2019)) and having a great potential.The online questionnaire revealed that researchers (n=84) are looking for the following supporting instruments from the university: infrastructure, helping researchers to find required competence (business, legal, etc.), and providing financial support (pre-seed) (Figure 15).

Table 7. The most significant drivers and barriers for Estonian researchers towards spin-off venture establishment (thresholds: at least 85% of responders score higher than 6 for drivers and 70% for barriers)

The most significant drivers	The most significant barriers
Establishing good relationships between partners is vital for a project's success (95%)	The lack of resources (88%)
Technical competencies and expertise of a team are vital (93%)	The lack of applicability of knowledge (85%)
Entrepreneurial orientation of principal investigator is important (92%)	The differences in knowledge and opinions between investors and academics (85%)
Trust between research partners and industry/collaborative stakeholders reduces the risk of project failure (92%)	Stability and lifelong employment in academia (79%)
Entrepreneurial orientation of principal investigator is important (92%)	Te lack of skills, negotiation techniques, and business experience (77%)
The multidisciplinary team is important (88%)	Lack of legal knowledge (71%)
The motivation of individual researchers is critical for project success (88%)	Unclear intellectual property strategy (71%)

Source: online survey; author's calculation

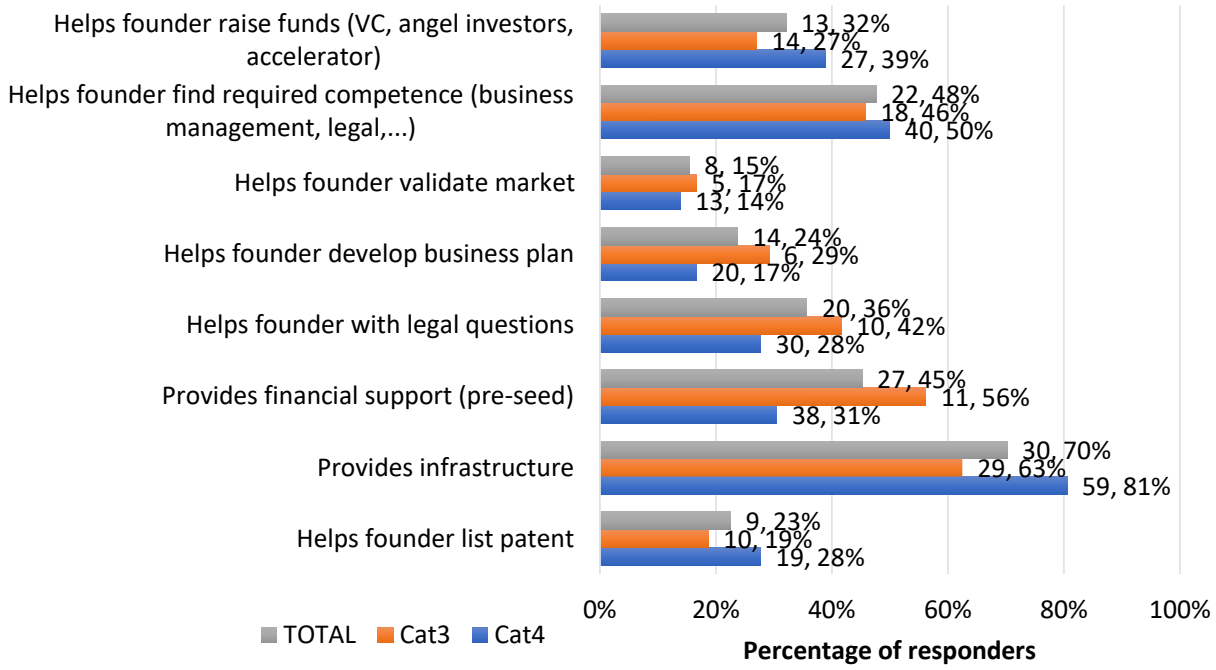

Figure 15. The universities' ecosystem attributes supporting the spin-off venture established by the opinion of online survey responders by Cat3 – "I would like to establish a science-based company" (n=48), Cat4 – "I have already established a science-based company" (n=36), and the total number of responded Estonian researchers (n=84) (data labels: number of responders and the percentage of responders)
Source: online survey; author's calculation and visualization

The founders of the spin-off ventures and potential founders were analyzed separately. It was revealed that the potential founders are looking for infrastructure and financial support to establish the spin-off ventures, while founders are looking mainly for infrastructure support. Furthermore, the potential founders are looking for help finding the required competence (business management, legal, etc.) and support in legal questions. The market validation and support to list patents were less important for both founders and potential founders. It should be noticed that founders are also looking for support to raise the next seed rounds. The assistance in developing a business plan was important only for future founders. The statistics on ecosystem from survey is also at be found in Appendix 12.

The opinion of the Estonian researchers who participated in the current study on the possible supporting ecosystem for spin-off venture facilitating in Estonian universities was in line with recommendations from OECD (2019) and the case studies from the literature review on supporting mechanisms.

3.3 Discussion and qualitative research results

The interviews have confirmed the findings and conclusions on Estonian researchers' motivations, drivers, and barriers that Estonian researchers face in establishing spin-off ventures. Nevertheless, the peculiarities of the motivations of Estonian researchers and some specific barriers to Estonian universities' ecosystems were revealed only from qualitative research. In general, the interviews have confirmed the findings in the literature review but highlighted the motivations' peculiarities.

This thematic analysis revealed that Estonian researchers are driven by the social impact of their research, which was also presented by another study (Vega-Gomez & Miranda-Gonzalez, 2021). Indeed, all interviewees highlighted the importance of the research results and their practical values. Several interviewees (INT1, INT3, INT5, INT7) mentioned the moral desirability to save the world, solving problems that other community members face every day, helping them save lives, and protecting the environment. This moral desirability drives their motivations toward applied science research projects. Therefore, Estonian researchers can be motivated by their strong moral desirability to establish spin-off ventures. This was not so evident from the quantitative research results on motivations, but the question in the questionnaire regarding the research confirmed that 52% of Estonian researchers conduct research to improve the world and create a

social impact. The search for a higher matter of science, finding more practical applications applicable for problem-solving in the real world, drives Estonian scientists to commercialize their research or at least, for some researchers, contribute to commercialization activities. One of the interviewed spin-off founders (INT1) stated, “I was motivated with a strong desire to save the world. Other aspects that pushed me to establish my spin-off company are scientific ambition and recognition.”

The researchers’ motivation strengths toward practical application can be different. One of the founders suggested that they were tied to their scientific activities and looked for something new, more inspiring, and real. INT2: “At certain times, I felt that I had reached some kind of ceiling, and I started to get bored of my scientific research. Therefore, I wanted it to be real, practical.”

Another important theme is the team, its expertise, and its commitment. Interviewees (INT1, INT2, INT4) stressed that an academic team with deep knowledge and commitment is one of the keys to successful research and spin-off establishment. The quantitative analysis also revealed that Estonian researchers consider the individual researcher’s motivation critical for success. Moreover, a deeper analysis of the theme revealed peculiarities of teams’ contributions to spin-off success. Both INT1 and INT2 confirmed that finding a highly committed scientific partner with the same goals and required expertise is a real win. The Estonian researchers also highly regarded the importance of technical competencies and expertise of a team in the online survey (93%). INT1 suggested that one of the most significant barriers to their spin-off was the absence of the required scientific expertise, not business or marketing manager.

Interestingly, both founders (INT1, INT2) suggested that business administration expertise and skills can be easily acquired outside. INT1: “To find the right academic team member with strong scientific background and commitment in your spin-off specific field is extremely complex compared to nonacademic staff with finance, marketing, or business administration skills.” Another founder, INT2, confirmed, “The team is all! For me, business management and marketing skills are not so important. But I can find this competence from outside.” The quantitative study also found that the Estonian researchers do not consider the nonacademic business manager as an important driver for spin-off venture development and success. However, the literature highlighted the positive influence of nonacademic members inside the spin-off ventures, making them more attractive to VC firms and angel investors (Ferretti et al., 2020). Therefore, the lack of entrepreneurial orientation is considered a constraint to successful spin-off development and

sustainability. Moreover, INT10 revealed that the interdisciplinary team is vital for resolving highly capacitive and scientific problems.

The Estonian researchers considered that one significant barrier was the lack of ecosystem support. For instance, support mechanisms can be found in infrastructure and preseed funding for spin-off ventures. INT8 revealed one deeper problem that Estonian researchers and universities face because of the Estonian ecosystem's legislative gaps. While the spin-off is established, the public organization cannot directly support the private enterprise. Therefore, the mechanism should be developed for spin-off venture support. This is crucial at the early development stages of the spin-off venture, as well as for supporting the spin-off ventures at the stages of growth through a "soft" mechanism (networking and support in the next seed rounds). The legislation should define how, to what extent, and at what conditions the parent academic organization can support the development and growth of a spin-off venture.

The contradictions in the currently available financial instruments were also identified by another interviewee, suggesting that special grants should be designed for commercialization purposes. INT9: "The scientific research achievements and breakthroughs achieved through taxpayer funding should be accessible for all… …The scientific research that is performed for commercialization purposes might be funded through special granting mechanisms, for instance, European Horizon grants or proof-of-the-concept grants." INT9 pointed out that scientific knowledge should be shared with the whole society for free.

The fourth theme considered differences in the understanding of academics and entrepreneurs. The interviewed TTO managers revealed a gap in understanding between scientists and entrepreneurs. Therefore, TTO incorporated the "soft" instruments designed for entrepreneurial skills and orientation development, such as the training of Estonian researchers through entrepreneurship programs dedicated to developing and learning the business model, finance, budgeting, marketing, market validation, and product design, and IP, among others. Such training programs can be up to three years long with an extensive course of 1.5 years. The interviewees also pointed out that the Estonian researchers' communications skills should be developed, trained, and improved to reach better cooperation and communication skills between academia and industry.

Despite the entrepreneurial training designed for researchers, not all of them can participate in this training because of time constraints. Professors, lecturers, and researchers are overloaded from

teaching and fulfilling research grants, writing new proposals, and supervising students. Furthermore, the interviews revealed that the current employment contracts do not foresee the time for entrepreneurial activities. INT9 said that as a professor and team leader, they have no time for these activities; their primary job tasks are teaching and research. INT9 proposed that they would appreciate it if somebody would deal with the commercialization of their research results, but it must be a separate person. INT9 proposed that it could be a person from TTO or a new person in their research team. The same interviewee stressed that the university should regulate the time spent on commercialization activities in the contract. INT7 also suggested that it would be beneficial to have a separate person in the institute helping the researchers and administration in commercialization activities. Furthermore, INT7 stressed that this person should have a scientific background and understand the entrepreneurs.

The lack of knowledge is another barrier for Estonian researchers. They pointed out that the proof-of-the-concept grant applications are challenging to fill, as they do not have the required skills and knowledge. Several interviewees said they do not know the terminology and how to evaluate the market, define competitors, and others. INT5: "My skills in the entrepreneurship field are limited. My research group and I have multiple patents. But there are no further activities regarding our patents. I do not have time to deal with it as well as skills. Of course, I could spend some time googling, but I do not have time." The interviews introduced an important topic on ecosystem attributes. The Estonian researchers require support to evaluate their research results' market potential. This support can be institute-based or from TTO. TTO can organize POC grant proposal writing training, but it would be better if a skilled person could evaluate the commercial potential of the scientific achievement in collaboration with the research team.

The interviews with INT5 and INT10 revealed no career model for researchers that would like to deal with commercialization activities. The researchers should publish publications in Q1 journals by the current career model; otherwise, they would not qualify for researcher or professor positions. The interview with INT5 revealed that it is impossible to demand everything from one person, that is, from one researcher. INT10: "Science, commercialization activities, and teaching. The person can only do well two things at a time." INT5 and INT10 confirmed that their universities' career models are not suitable for academic entrepreneurship and facilitating an entrepreneurial mindset.

Another drawback is poor communication and information exchange inside Estonian universities. INT7 argued that the researchers do not receive the information on time or do not receive it at all. The communication system is an essential component of a collaborative, participative, and interdisciplinary work environment that affects academics' individual and collective productivity (Uslu, 2018).

Other critical barriers revealed during the interviews were bureaucracy, complexity, and nontransparency. The bureaucracy covered different aspects. For instance, founders of spin-off ventures revealed (INT2, INT3, INT4) that spin-off venture establishment terms are not distinct. INT2 and INT4 claimed that their spin-off venture establishment was approximately for one year. The major reason was the absence of predefined terms inside the organization. The process of spin-off venture establishment was uncomfortable for founders because of the lack of knowledge and limited support from the organization. One of the founders (INT2) compiled the conditions themselves and consulted a lawyer outside the home organization. One of the potential founders (INT3) is still in the process of negotiation, stating that the conditions are not clear and the process is slow.

Interviewers also revealed crucial topics regarding PhD and postdoc students' initiatives regarding commercialization activities. First, it was pointed out that the PhD students are employed for the supervisors' projects, meaning that the idea and financing behind the project belong to the supervisor. It could be a problem if the student wants to commercialize the idea without the supervisor's approval. The interviews found no regulatory mechanisms (or researchers do not know about the existing mechanisms) for how students can establish a spin-off venture (INT5, INT7, INT9). INT9 argued that they would be happy if their student found valuable opportunities for their research results commercialization. But the topic should be connected with their project, being a win–win for both parties. INT9 pointed out that if the student wants to develop another idea (not their supervisor's), they should do it only in their spare time. INT9 revealed the fact that the students in the university are temporary, and they should see their path afterward. Therefore, spin-off venture establishment is one opportunity for students to succeed in their careers. In general, interviewees stated that their attitude to commercialization activities is positive (INT5, INT6, INT7, INT9).

Table 8. The defined universities' ecosystems gaps in support of academic entrepreneurship

Ecosystem's pitfalls	**INT number**
Poor information exchange	INT7
Entrepreneurial activities are not foreseen in the contact of academic staff	INT6
No career model for entrepreneurial scientists	INT10, INT9
Bureaucracy	INT2, INT3, INT4
No entrepreneurial knowledge	INT5, INT7, INT9
Lack of time, overloaded staff	INT5, INT7, INT9, INT10
Mechanism and terms of Ph.D. students' spin-off establishment	INT5, INT7, INT9
Not accepted by the colleagues	INT2
Conflicts and counteractions from the administration	INT3, INT6
No specific knowledge and competence is required for the project	INT1
No resources	INT1, INT2

Source: author's thematic analysis

Furthermore, tension between groups and academic colleagues was discovered. This could happen if researchers' typologies differ to a large extent ("pure traditional" and "entrepreneurial") (Lam, 2011). Several interviewees revealed difficulties in acceptance by other academic staff and administration. INT2 revealed that other academic colleagues were disappointed by INT2's decision to establish the spin-off. Time helped the founder to be accepted by their colleagues. Moreover, INT3 and INT6 revealed counteractivities and even bullying coming from the administrative structure because of commercialization activities and the search for support in these activities. The major barriers defined by all interviews are summarized in Table 8.

3.4 Recommendations and future research

The quantitative and qualitative research revealed and prioritized the major drivers and barriers that Estonian researchers face while dealing with the commercialization of research achievements and breakthroughs. Despite their different attitudes and beliefs, Estonian researchers are positively orientated to commercialize their research results. The findings of the current research, knowledge, and understanding of Estonian researchers' motivations through typology mapping can help policymakers, university authorities, and TTO develop effective mechanisms to facilitate academic spin-off venture establishment in Estonian universities.

Various data on Estonian researchers were collected during this study. However, not all data was examined and presented in the thesis. Therefore, future research can consider a deeper analysis of the researchers' background influence on motivations. Furthermore, other disciplines can be involved, comparing motivation signatures between scientific disciplines and organizations.

The current research presented Estonian researchers' typologies in Estonian universities using Lam's (2011) theoretical approach. It showed that this approach was suitable to differentiate researchers by belonging to one typology or subtypology (modification of the current study) and examine their motivation strength toward spin-off venture establishment. The developed model can be applied to Estonian researchers' evaluation to predict their entrepreneurial orientation and motivation strength to establish spin-off ventures. Moreover, the theoretical model helps define possible rewards that can strengthen the motivation to develop spin-off ventures. Nevertheless, the author considers that more data should be collected. Appendix 12 summarizes the descriptive statistics on the online questionnaire that can be used for further research studies. The results are classified according to the commitment of the researcher to establish a spin-off venture.

CONCLUSION

This study aimed to examine Estonian researchers' motivations to establish spin-off ventures at Estonian universities. It also focused on the ecosystem attributes that would facilitate spin-off venture establishment. Moreover, possible drivers and barriers were defined from the perspective of researchers, administration, and TTO managers from four Estonian universities and institutes.

Theoretical implications

Estonian researchers classify themselves mainly into "hybrid" and "entrepreneurial" researchers. It must be stated that Estonian researchers are not purely "hybrid" and "entrepreneurial." They belong mostly to two transition subcategories: "hybrid-entrepreneurial" and "entrepreneurial-hybrid." Estonian researchers are mainly driven by the search for applications for their research results and extra funding possibilities for advancing their research. Autonomy is also a driving factor that can be achieved through additional funding opportunities from possible research results commercialization. Most likely, Estonian researchers would not be motivated by third-party inspiration to establish spin-off companies. Consequently, external motivation must consider financial instruments such as financial ('gold'), resource, or reputation rewards (ribbon) and autonomy to motivate Estonian researchers to commercialize their research. The theoretical model presented in the current study can help depict the internal and external motivations of the Estonian researchers based on their typology determinations using Lam's (2011) methodology and the questionnaire on motivation based on publications (Ibrahim Saad Darwish, 2022; Novotny, 2017; Rijnsoever & Hessels, 2021; Suominen et al., 2021).

Practical implications

The following practical implications are summarized based on the research results of this study:

- An Estonian university career model is missing for entrepreneurial researchers. These researchers can be considered as significant representatives of the talent pool that can be effectively applied inside institutions and universities for knowledge transfer, grant writing (where this specific knowledge is required, e.g., Horizon Europe projects), negotiations with industrial partners for industry needs screening and showcasing of institute expertise

and research achievements as well as supporting other researchers in commercialization activities.

- Estonian universities should elaborate on developing the regulatory instrument for spin-off venture support (infrastructure and preseed, legislative support, searching for the next seed round for existing spin-offs, and supporting their development and growth). The number of spin-off ventures should not be prioritized (Fischer et al., 2018).
- Focus should be directed to the quality of spin-off ventures. Therefore, various instruments supporting the spin-off establishment and growth phases should be developed. These instruments can include financial instruments (preseed, seed fundings, infrastructure), regulatory instruments (distribution of revenue, implication for academic salaries), and soft instruments (training, networking events with potential investors).
- There is no clear and concise regulatory instrument for the establishment of spin-off ventures in Estonian universities. This instrument should consider the intellectual property distribution, conditions of using infrastructure inside the university as well as inside the institute, and the distribution of revenues among interested parties. The interested parties can be presented by coinventors, supervisors, project managers (principal investigator), institute, university, and others. The conditions of spin-off venture creation should be distinct from those of academic staff spin-offs and student spin-offs.
- One important implication is the students' research projects and the possibility of commercializing their research results. The latest has a positive effect on the new employment possibility of students and the creation of a new connection with industry and university for knowledge transfer (OECD, 2019). The mechanism of the student's spin-off ventures should be developed. Attention should be paid to due diligence (supervisors' research projects, patents, licensing, further research within the university, supervisors' shareholders, student shareholders). The term should be considered such that the newly established spin-off has the potential to raise the next seed round and be attractive to investors. Financial and/or reputational rewards should be considered for the supervisor if they do not want to be an active stakeholder in the spin-off venture. It can be considered that the university can manage the stakeholders of the supervisor instead of the supervisor themselves.
- Soft instruments can be implemented inside institutions. For instance, a TTO specialist, manager, or consultant who is tightly linked to the institute and researchers' groups visits all the institutes' weekly seminars and negotiations with researchers to monitor the

emerging technology creation to proactively protect the intellectual property. This person helps define market opportunities, market size, and potential competitors, as well as develop strategies for research results exploitation in collaboration with the research group.

- The entrepreneurial education programs of early-stage researchers, researchers, and other academic personnel involved in commercialization activities should be integrated and/or intensified to develop and enhance the entrepreneurial orientation inside the academic community. These will help overcome the gap in understanding between academics and entrepreneurs, facilitating possible future collaborations between academia and industry and commercialization activities.
- One of the significant drivers of Estonian researchers is the social impact of research results. Therefore, it is suggested that universities, institutes, and TTOs turn their attention to industrial challenges and cope with these challenges through intensive networking of researchers and industry.

Policymakers and university administrations can use the findings of the current research to find supporting instruments (regulatory, financial, or "soft") to overcome the existing ecosystem gaps and therefore facilitate spin-off venture establishment in Estonian universities.

Limitations

The current study has several limitations. First of all, the survey is skewed to Tallinn University of Technology as a major contributor to the online survey. Secondly, the main disciplines are Life Science, Engineering, and Digital and Technology. The margin error of the online survey is 6.2% (population of 3,078 researchers (FTE) in four universities, number of responders = 225, confidence level 95%).

Future research avenues

This study does not provide insights on how spin-off ventures can become successful and create a societal impact, which could be interesting in future research. It would also be interesting to expand the research to other countries (Latvia, Lithuania) and disciplines, allowing us to evaluate and compare the facilitating mechanisms and their efficiency.

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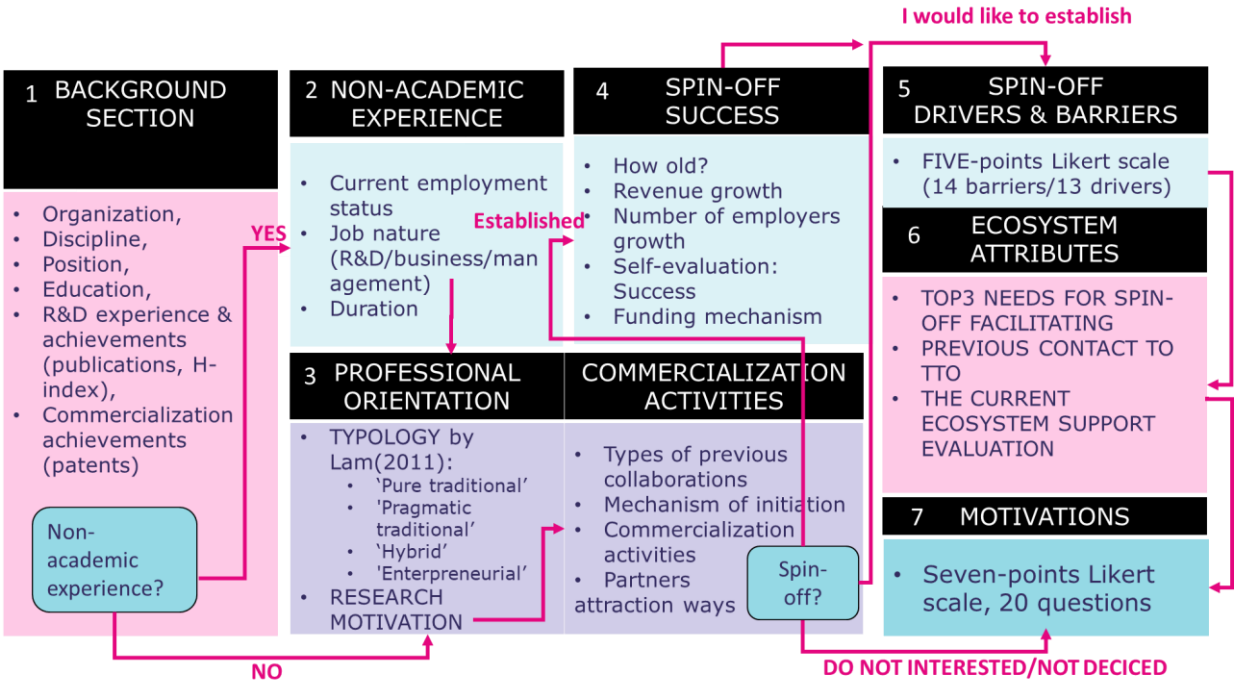
APPENDICES

Appendix 1. Online survey questionnaire structure



Source: (Ibrahim Saad Darwish, 2022; Novotny, 2017; Suominen et al., 2021; van Rijnsoever & Hessels, 2021); author's design

Appendix 2. Online survey on academic entrepreneurship in Estonia

This questionnaire is a part of research on Academic entrepreneurship in Estonian universities held by a master's student in the MBA program at Tallinn University of Technology, School of Business Administration. The current survey aims to examine the extrinsic and intrinsic aspects of Estonian scientists' motivation to commercialize their research ideas and develop approaches and recommendations that can facilitate the spin-off establishment in Estonian universities.
This survey should not take more than 5-20 minutes.

Thank you for participating! I value your feedback, and I will keep all of your answers anonymous.

Privacy policy:
The answers to the questionnaire are anonymous and shall be used as generalized format for writing a master's thesis. Your answers and processed data will be stored securely on a Tallinn University of Technology's server.

Contact info:
Jekaterina Mazina-Šinkar, MBA Master Student e-mail: jekaterina.mazina@taltech.ee
ETIS: https://www.etis.ee/CV/Jekaterina_Mazina/est
LinkedIn: linkedin.com/in/jekaterina-mazina-269b3335

Section Background

1. Please enter the name of your academic institution (primary working place) *
   a. Tallinn University of Technology
   b. Tartu University
   c. Tallinn University
   d. Estonian University of Life Sciences
   e. Other
1. Please specify your school/faculty *
   a. Information and Digital Technologies
   b. Engineering
   c. Life Science
   d. Business and Governance/Social Sciences
   e. Medicine
   f. Arts and Humanities
   g. Administrative or support structure
   h. Other

Appendix 2. continued

2. Please specify your gender *
    a. Male
    b. Female
3. Please specify your age *
    a. 20-29
    b. 30-39
    c. 40-49
    d. 50-59
    e. 60-69
    f. 70-...
4. Please specify your highest degree or level of school completed *
    a. Bachelor's degree
    b. Master’s degree
    c. Doctorate or Ph.D.
    d. Other
5. Please specify the main discipline (Frascati classification) *
    a. Natural Sciences
    b. Engineering and technology
    c. Medical and health sciences
    d. Agricultural and veterinary sciences
    e. Social Sciences
    f. Humanities and the arts
6. Please specify your second highest degree or level of school completed (if you have received the second higher education in another discipline)
    a. Bachelor's degree
    b. Master’s degree
    c. Doctorate or Ph.D.
    d. Other

Appendix 2. continued

7. Please specify the secondary discipline (Frascati classification) (if you have received the second higher education in another discipline)
    a. Natural Sciences
    b. Engineering and technology
    c. Medical and health sciences
    d. Agricultural and veterinary sciences
    e. Social Sciences
    f. Humanities and the arts
8. Please specify your experience in the research and development field (this includes the time you spent working on a Ph.D.) * (Less than 2, 2-5, 6-10, 11-20, More than 20)
9. At how many universities or knowledge institutes have you been employed? * (this includes where you completed your Ph.D. and your current institute)
    a. 1
    a. 2
    b. 3
    c. 4
    d. 5
    e. Other
10. Please describe your current position in the academic organization. *
    a. Professor
    b. Associate Professor
    c. Assistant Professor
    d. Leading Researcher
    e. Senior Researcher
    f. Researcher
    g. Early-stage Researcher
    h. Senior Lecturer
    i. Lecturer
    j. Technician (engineer)
    k. Technology transfer specialist/manager/consultant
    l. Academic authority member (rectorate, deans, directors...)

Appendix 2. continued

11. Over your career, how many patents (including utility models) are you listed on as an inventor/co-inventor? * (1,2,3,4,5,6,7,8,9,10, more than 10)
12. Over your career, how many research papers are you published as an author/co-author in peer-reviewed journals?
    a. None
    b. 1-5
    c. 6-10
    d. 11-20
    e. 21-50
    f. 51-100
    g. More than 100
13. What is your H-index? (preferably Google Scholar) *
    a. Not applicable for me
    b. Less than 2
    c. 3-5
    d. 6-10
    e. 11-15
    f. 16-20
    g. 21-30
    h. Higher than 30
14. Do you have postdoc experience? *
    a. Yes, an international postdoc position
    b. Yes, a national postdoc position
    c. No
    a. Are you a leader of your research group? * Yes or no
15. Is your research group multidisciplinary? * Yes or no
16. Have you ever been employed or are employed by a non-academic organization? Yes or no

Appendix 2. continued

Section Non-academic experience

This section explores how non-academic experience affects the attitudes and beliefs on spin-off creation.

17. Are you still employed by a non-academic organization type?
    a. Yes (manload more than 0.5)
    b. Yes (manload less than 0.5)
    c. No
18. Please select one of the following external organization types you are or have previously been employed at
    a. Large enterprise / corporate
    b. SME (Small and mid-size enterprise)
    c. Microenterprise
    d. Spin-off (academic)
    e. Governmental Organisation
    f. NGOs (Non Governmental Organization)
    g. I never worked outside academia
19. Is (was) your activity in a non-academic organization connected to R&D activities? *
    a. Yes
    b. Yes, partially
    c. No
20. Is (was) your activity in a non-academic organization connected to business administration and management activities?
    a. Yes
    b. Yes, partially
    c. No
21. How many years have you been employed or are employed in a non-academic organization?
    a. Less than 2
    b. 2-5
    c. 6-10
    d. 11-20
    e. More than 20

Appendix 2. continued

Section Professional orientation

This section will help me define your scientific typology based on your tendency to work with industry and then correlate with your attitudes and beliefs on science commercialization.

22. Please indicate which of the following statements best describe your professional orientation (indicate your first best and the second-best choice if appropriate) *

	First best	Second best
I believe that academia and industry should succeed strictly in the distinct and I pursue success strictly in the academic arena		
I believe that academia and industry should be distinct, but I pursue industrial links activities mainly to acquire resources to support academic research		
I believe in the fundamental importance of academic-industry collaboration, and I pursue industrial links activities for scientific advancement/breakthrough		
I believe in the fundamental importance of academic-industry collaboration, and I pursue industrial links activities for application and commercial exploitation		

23. Please finish the sentence: "I mainly do research to..." (select 3 answers, prioritizing them)

	First priority	Second priority	Third priority
Gain recognition within academia			
Build my career within acdemia			
Build my career outside academia			
Improve the world and create social impact			
Satisfy my intellectual curiosity			
Solve an important scientific problem			
Become famous			
Build networks			
Educate people			
Increase my personal wealth			
To help me start my own business			

Appendix 2. continued

24. Select from the list of the collaboration types that you have been frequently involved in the past? (Please select the checkboxes accordingly)
    a. Contract Research (new knowledge is produced as a service)
    b. Joint projects with academia (both parties is participated in the knowledge production)
    c. Joint projects with industry
    d. Project and consultancy services provided by the university to external parties for a fee
    e. I have not been involved in any collaboration before
    f. Other
25. How do you think collaborations should be initiated? (select only 3 answers) *
    a. Through faculty contacts and connections
    b. Through industry need
    c. Through government calls
    d. Through grant calls
    e. Through technology transfer office
    f. Based on previous success stories or past successful experiences
    g. Other
26. Have you been involved in any of the following commercial university activities listed below? (Please select the checkboxes accordingly) *
    a. Applying for patents, utility models
    b. Licensing of university technologies/IP
    c. New Venture/ Startup Creation
    d. Project and consultancy services provided by the university to external parties for a fee
    e. Contract Research (new knowledge is produced as a service)
    f. None of the above
27. Have you ever been in contact with individuals working at a Technology Transfer Office? (regarding your spin-off establishment, licensing, patenting, etc.)
    a. Yes
    b. No
    c. I do not know what is a Technology Transfer Office

Appendix 2. continued

28. How can universities/research centers attract industry partners? (select three most important)
    a. By showcasing faculty expertise
    b. By showcasing facilities and available services
    c. By showcasing success stories
    d. By having an office dedicated to building and managing partnerships
    e. University administration need to make industry-university partnerships a strategic priority
    f. Setting up a multidisciplinary institute on campus in partnership with industry to break down
    g. traditional academic silos and drive a new multidisciplinary culture and curricula
29. Please specify
    a. I have already established a science-based company Skip to question 34
    b. I would like to establish a science-based company Skip to question 47
    c. I do not want to establish a science-based firm (answer if you were, imagine this case)
    d. Skip to question 51
    e. I have not decided yet

Section Entrepreneurial success

a. Are founder or co-founder of the spin-off? * Yes or no

30. How old is your spin-off? * (1,2,3,4,5,6,7,8,9, more than 10)
31. What is your company's average annual revenue at the moment?
    a. less than 25,000 euro
    b. 25,000 - 50,000 euro
    c. 50,000 - 100,000 euro
    d. 100,000 - 250,000 euro
    e. 250,000 - 500,000 euro
    f. 500,000 - 1,000,000 euro
    g. 1,000,000 - 5,000,000 euro
    h. 5,000,000 - 10,000,000 euro
    i. more than 10,000,000 euro

Appendix 2. continued

32. What was your company average annual revenue during the first year? (answer, if your spin-off is at least one year old)
    a. less than 25,000 euro
    b. 25,000 - 50,000 euro
    c. 50,000 - 100,000 euro
    d. 100,000 - 250,000 euro
    e. 250,000 - 500,000 euro
    f. 500,000 - 1,000,000 euro
    g. 1,000,000 - 5,000,000 euro
    h. 5,000,000 - 10,000,000 euro
    i. more than 10,000,000 euro
33. How many employees are employed in your spin-off? (1, 2, 3, 4, 5, 6-10, 11-25, 26-50, 51-100, 101-250, 250-500, More than 500)
34. How many employees were employed during the spin-off establishment? *(1, 2, 3, 4, 5, 6-10, 11-25, 26-50, 51-100, 101-250, 250-500, More than 500)
35. Do you consider yourself a successful academic entrepreneur based on your own definition of success? From 1 (Not at all) to 7 (Absolutely successful)
36. How satisfied are you with the degree to which your expertise/invention/research result has been transferred to the market by your firm? From 1 (Not at all) to 7 (Absolutely successful)
37. Does the university hold ownership of your company? * Yes or no
38. Does a venture capital organization hold ownership of your company? Yes or no
39. Does an angel investor hold ownership of your company? * Yes or no
40. Have you raised public funding? (EAS, Horizon, KIK, etc.) *Yes or no
41. Have you ever participated in a Startup accelerator/ incubation program? * Yes or no

Appendix 2. continued

Section Spin-off creation phase

42. What do you think? How do the team's structure, competence, and relationships affect the spin-off's success? From 1 (Strongly disagree) to 5 (Strongly agree)

	1	2	3	4	5
Multidisciplinary team is important					
Entrepreneurial orientation of principal investigator is important					
Non-academic business manager is important					
Trust between research partners and industry/collaborative stakeholders reduces the risk of project failure					
Establishing good relationships between partners is vital for a project success					
Motivation of individual researchers is critical for project success					
Geographic distance has a negative impact on project implementation					
Transparent and frequent reporting/communication with the collaborative partner is crucial or project success					
Level of seniority of principal investigator affects a project's success					
Gender of principal investigator is an influential factor for project initiation and success]					
Previous experience of the principal investigator in similar collaborations is an influential factor for project success					
Strong project management is necessary for project success					
Technical competences and expertise of a team is vital					
Multidisciplinary team is important					
Entrepreneurial orientation of principal investigator is important					
Non-academic business manager is important					
Trust between research partners and industry/collaborative stakeholders reduces the risk of project failure					

43. How do the following aspects affect the spin-off creation?* From 1 (Strongly disagree) to 5 (Strongly agree)

	1	2	3	4	5
Lack of resources					
Lack of applicability of knowledge					
Lack of training in entrepreneurship					
Lack of legal knowledge					
Unclear intellectual property strategy					
The lack of organizational support					
Lack of support and negative pressure from colleagues					
Differences of knowledge and opinions between investors and academics					
Lack of marketing skills, negotiation techniques and business experience					
Lack of pre-seed capital					
Stability and lifelong employment at universities					
Fear of taking risks					
Bureaucratic procedures					

Appendix 2. continued

44. How should the university contribute to the spin-off creation and development? Please specify TOP3:
    a. Provides infrastructure
    b. Provides financial support (pre-seed)
    c. Helps founder list patent
    d. Helps founder with legal questions
    e. Helps founder develop business plan
    f. Helps founder validate market
    g. Helps founder raise funds (VC, angel investors, accelerator)
    h. Helps founder find required competence (business management, legal,...)
    i. None of the above

45. What do you think about university's support in spin-off venture establishment? * From 1 (The university is a huge obstacle to academic entrepreneurship) to 7 (The university helps a lot in entrepreneurial activities

Appendix 2. continued

Section Motivations

This section is designed to estimate scientists' motivations to start a science-based firm (spin-off). If you are not establishing the company and not planning to establish it, imagine yourself developing a successful spin-off venture. What would be your motivations? From 1 (Strongly disagree) to 7 (Strongly agree)

	1	2	3	4	5	6	7
I could not make ends meet from my university salary.							
I needed extra income to provide for an acceptable quality of life.							
I wanted my research efforts to yield tangible results.							
To complement my research activities.							
To exploit my knowledge for financial gain.							
To further develop research results towards application.							
To put my ideas into practice.							
To work and make decisions on my own.							
I could best make use of my skills by working independently.							
To be my own employer.							
To identify and exploit new market opportunities.							
Motivated by the third parties to have my own company.							
To solve scientific problems independently							
To have more challenge at work.							
I want to try myself in competition.							
To build my own business.							
To have more funds and better equipment for my research.							
To have higher prestige and reputation.							
To advance my career as a researcher.							
To get rich.							

Appendix 3. The number of personalized emails sent across universities

University	Institute/Department	Number of personalized emails
Tallinn University of Technology	Department of Chemistry and Biotechnology	96
	Department of Marine Systems	13
	Department of Materials and Environmental Technology	51
	Department of Cybernetics	29
	Department of Geology	17
	Department of Electrical Power Engineering and Mechatronics	53
	Thomas Johann Seebeck Department of Electronics	10
	Department of Software Science	10
	TOTAL (Tallinn University of Technology)	**279**
Tallinn University	School of Natural Sciences and Health	97
	School of Digital Technologies	66
	TOTAL (Tallinn University)	**163**
Estonian University of Life Science	Institute of Forestry and Engineering	81
	Institute of Agricultural and Environmental Sciences	12
	TOTAL (Estonian University of Life Science)	**93**
Tartu Univeristy	Institute of Biomedicin and Transition Medicine	80
	Institute of Genomics	35
	Institute of Chemistry	77
	Institute of Technology	77
	Institute of Genomics	45
	TOTAL (Tartu Univeristy)	**314**
	TOTAL (4 universities)	**849**
	Number of survey responses	225
	Responce rate%	26%
	Population of researchers (FTE)	3,079
	Margin of error (confidence level 95%)	6.3%

Source: author's survey, Estonian universities websites; author's calculations

Appendix 4. Semi-structured interview's possible questions

The questions are compiled with modifications from the following publications (Ibrahim Saad Darwish, 2022; Novotny, 2017; Rijnsoever & Hessels, 2021; Suominen et al., 2021).

1. Please describe your field of research, your position, and your degree, education, and work experience.
2. Let's discuss the commercialization of scientific research results. How does commercialization affect science, society, and the economy?
3. To what extent is it spread in Estonia?
4. Do you know what the spin-off means?
5. Do you have any experience with spin-off venture establishments?

RQ1: Motivations (Levels: individual, team, process/project and institutional)

1. **Why** do you think academics **do not want to commercialize** the research results?
1. Are they overloaded with teaching and administrative tasks? Do they prefer to conduct abstract or basic research?
2. **What motivates you** (scientist or image you are a scientist) to **join the collaborations** with the industry partner and governmental organizations?
3. (Solving problems, satisfying intellectual curiosity, applying research in a real-world practical context, training and exposing your students)
4. What is your experience with spin-off venture establishment?
5. What **motivates/motivated** you to establish the spin-off venture?
6. What **motivates other team members to join your spin-off**?
7. What are the **main benefits** of these collaborations to the **university**?
8. What are the **main benefits** of these collaborations to the **industry**?

Appendix 4. continued

RQ2: Drivers and barriers to the success of spin-offs

1. What were the **drivers** for establishing spin-off? (team, skills, ecosystem, support from TTO, personal motivation, motivation by another person, funding availability, etc.)
2. What was the **most significant barrier** to establishing the spin-off venture? (time, overloaded with teaching and research, team, team composition, experiences, experience, infrastructure, no pre-seed, poorly designed rewards mechanism, career, etc.)
3. How important is the entrepreneurial orientation of academic team members? How is it possible to change the mindset?

4. Does the **organizational support** is important? How univeristy can facilitate the spin-off venture establishment?

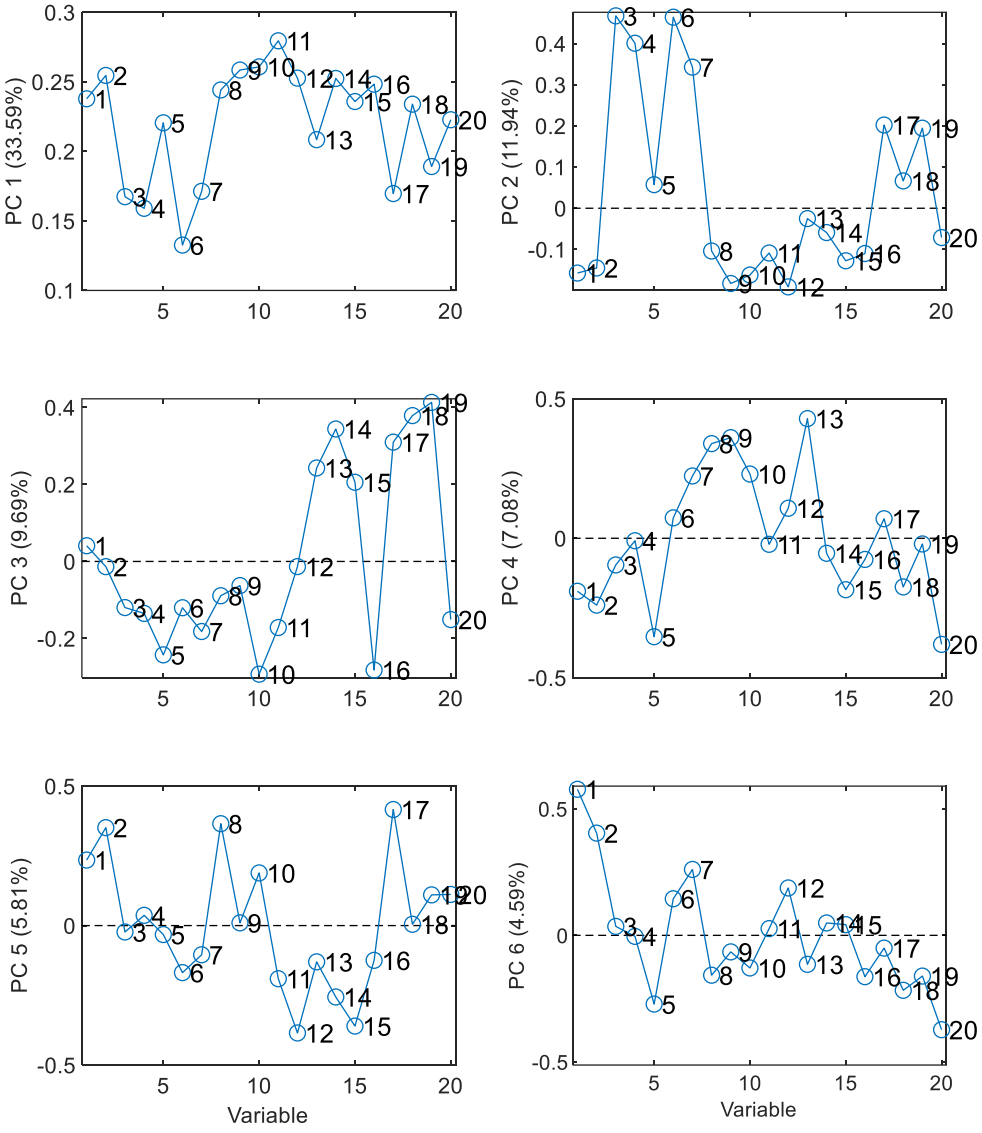
RQ3: Ecosystem's attributes facilitating commercialization success

1. What makes collaborations between industry and academia successful or unsuccessful?
2. **University? How were these collaborations initiated (by industry/by faculty/ by researcher / by grant call)? To what extent must the Technology Transfer Offices play a role in making these collaborations more successful**?
3. Do you think **university size and prestige are important** in attracting more industry partners?
4. How do you **feel these collaborations should be initiated** & **operated to be successful**? Industry comes to the university with a problem. Or the university goes to the industry?
5. **What** type of **support** would **you need as a researcher to be able to join more collaborations**? **Establish spin-off**?
6. **What is missing in your organization**? *Are certain guidelines or supportive mechanisms at the university essential for successful collaboration?*
7. Does having upper management support make a difference?
8. **Do you have anything else you want to add?**

Appendix 5. Descriptive statistics on Estonian researchers' motivation to establish spin-off venture

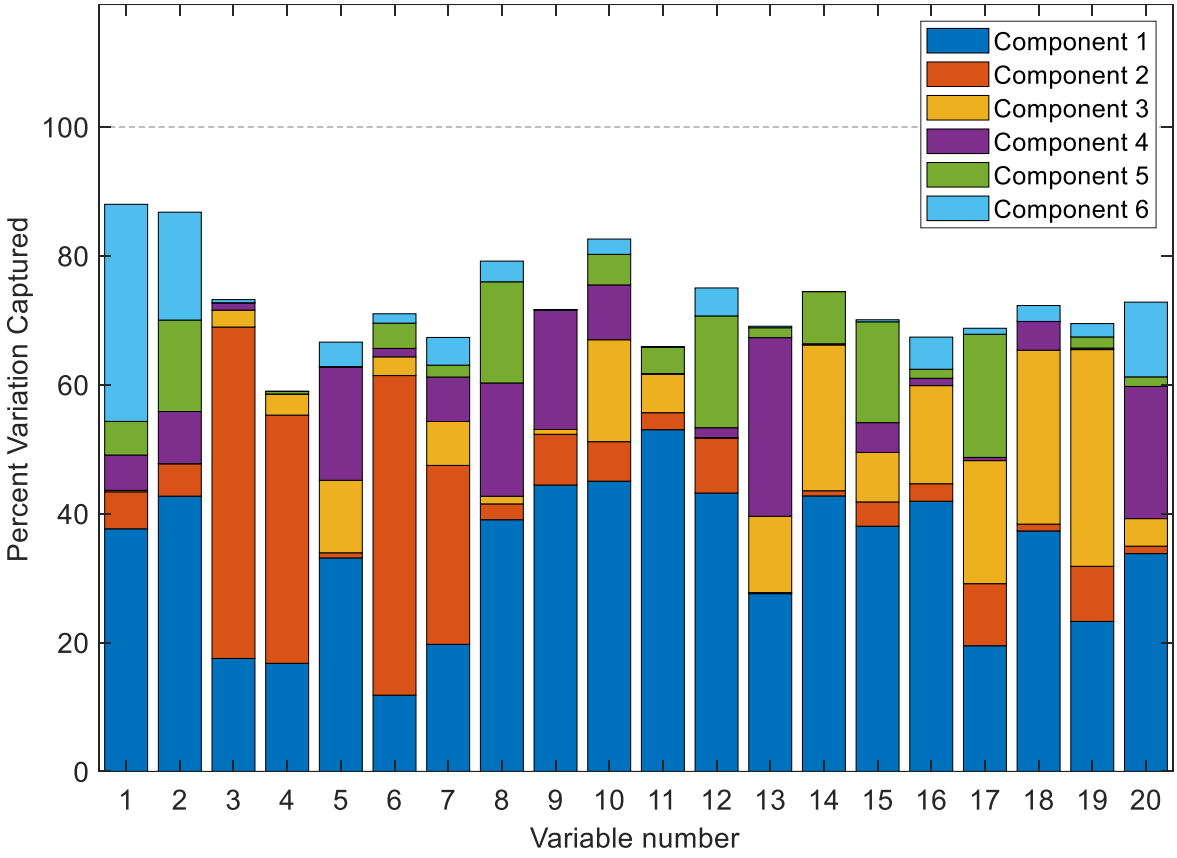
Source: author's online survey; author's calculation

Appendix 6. Principal components' eigenvectors



Source: author's online survey; author's calculation

Appendix 7. The variance captured for model with six PCs



Source: author's online survey; author's calculation

Appendix 8. Principal components eigenvectors description and connection to principal components (blue - minimal variable value, red – maximum variable value)

No	Description of variable	Attributed to PC					
1	I could not make ends meet from my university salary.		PC2				PC6
2	I needed extra income to provide for an acceptable quality of life.		PC2			PC5	PC6
3	I wanted my research efforts to yield tangible results.	PC1	PC2				
4	To complement my research activities.	PC1	PC2				
5	To exploit my knowledge for financial gain.			PC3	PC4		PC6
6	To further develop research results towards application.	PC1	PC2				
7	To put my ideas into practice.	PC1	PC2				
8	To work and make decisions on my own.					PC5	
9	I could best make use of my skills by working independently.	PC1	PC2		PC4		
10	To be my own employer.	PC1	PC2	PC3	PC4		
11	To identify and exploit new market opportunities.	PC1	PC2				
12	Motivated by the third parties to have my own company.	PC1	PC2		PC4	PC5	
13	To solve scientific problems independently			PC3	PC4		
14	To have more challenges at work.			PC3		PC5	
15	I want to try myself in competition.		PC2	PC3		PC5	
16	To build my own business.		PC2	PC3			
17	To have more funds and better equipment for my research.			PC3		PC5	
18	To have higher prestige and reputation.			PC3			PC6
19	To advance my career as a researcher.			PC3	PC4		PC6
20	To get rich.			PC3			PC6

Source: author’s online survey; author's calculation

Appendix 9. Motivations' clusters distribution between-positions and within-position

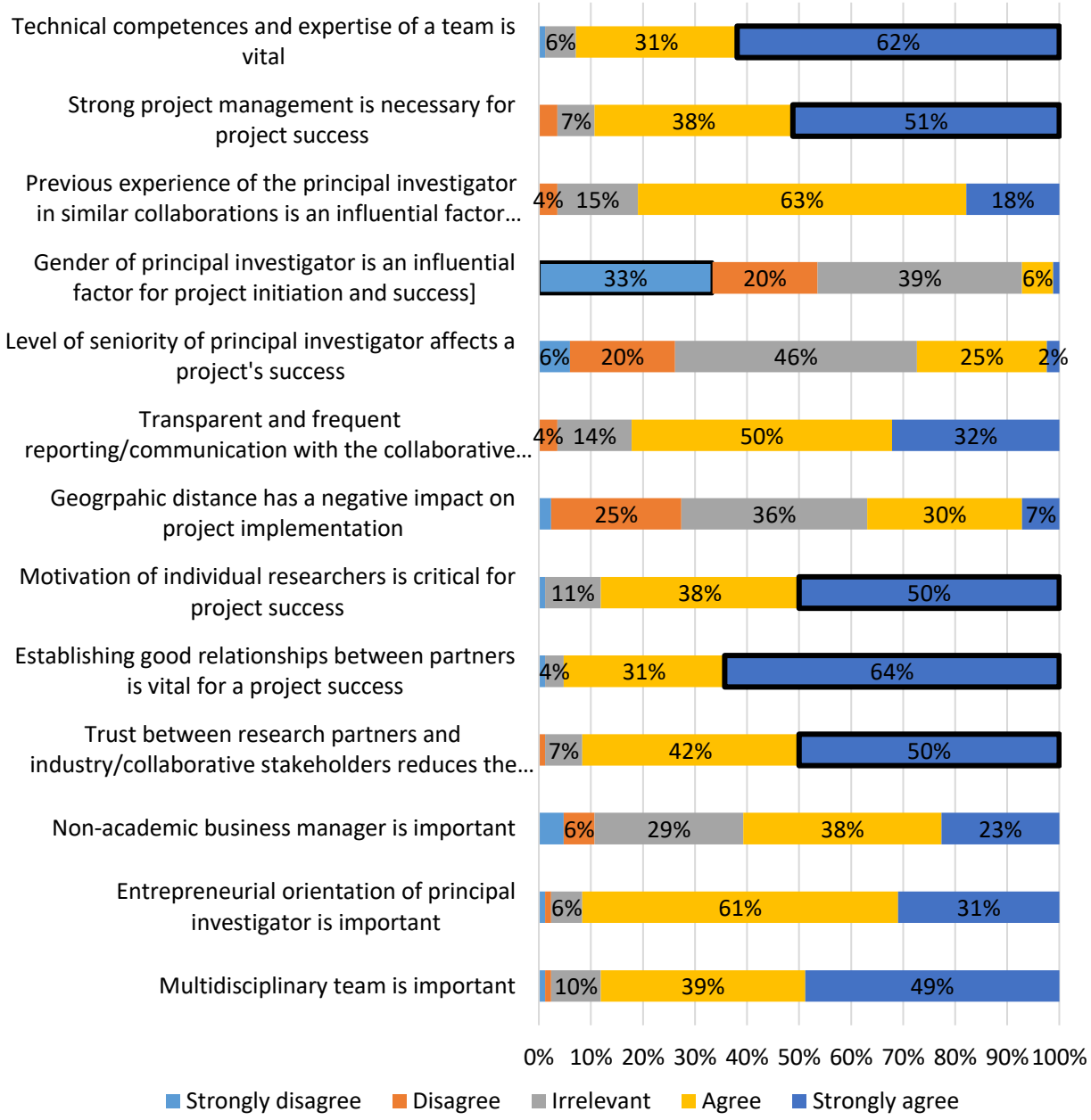
	Cluster IIC		Cluster IC		Cluster IB		Cluster IA		Cluster IIB		Cluster IIA		
Position	**% (a)***	**% (b)***	**% (a)***	**% (b)***	**% (a)***	**% (b)***	**% (a)***	**% (b)***	**% (a)***	**% (b)***	**% (a)***	**% (b)***	**Responders N**
Professor	4%	7%	11%	9%	0%	0%	30%	16%	33%	14%	22%	17%	27
Associate Professor	7%	13%	0%	0%	3%	5%	41%	22%	34%	14%	14%	11%	29
Leading researcher	0%	0%	20%	16%	0%	0%	20%	11%	20%	8%	40%	31%	5
Senior Lecturer	8%	16%	17%	13%	8%	13%	25%	14%	33%	14%	8%	7%	12
Researcher	13%	24%	21%	16%	0%	0%	18%	10%	36%	15%	13%	10%	39
Early-stage Researcher	13%	24%	13%	10%	25%	38%	16%	8%	22%	9%	13%	10%	32
Lecturer	0%	0%	30%	24%	20%	31%	10%	5%	30%	12%	10%	8%	10
Senior Lecturer	8%	16%	17%	13%	8%	13%	25%	14%	33%	14%	8%	7%	12
Total %	53%		127%		65%		185%		242%	Total	128%	Total	800%
Cluster contribution (c)*	7%		16%		8%		23%		30%		16%		100%

Source: author's online survey; authors calculation

Notes:

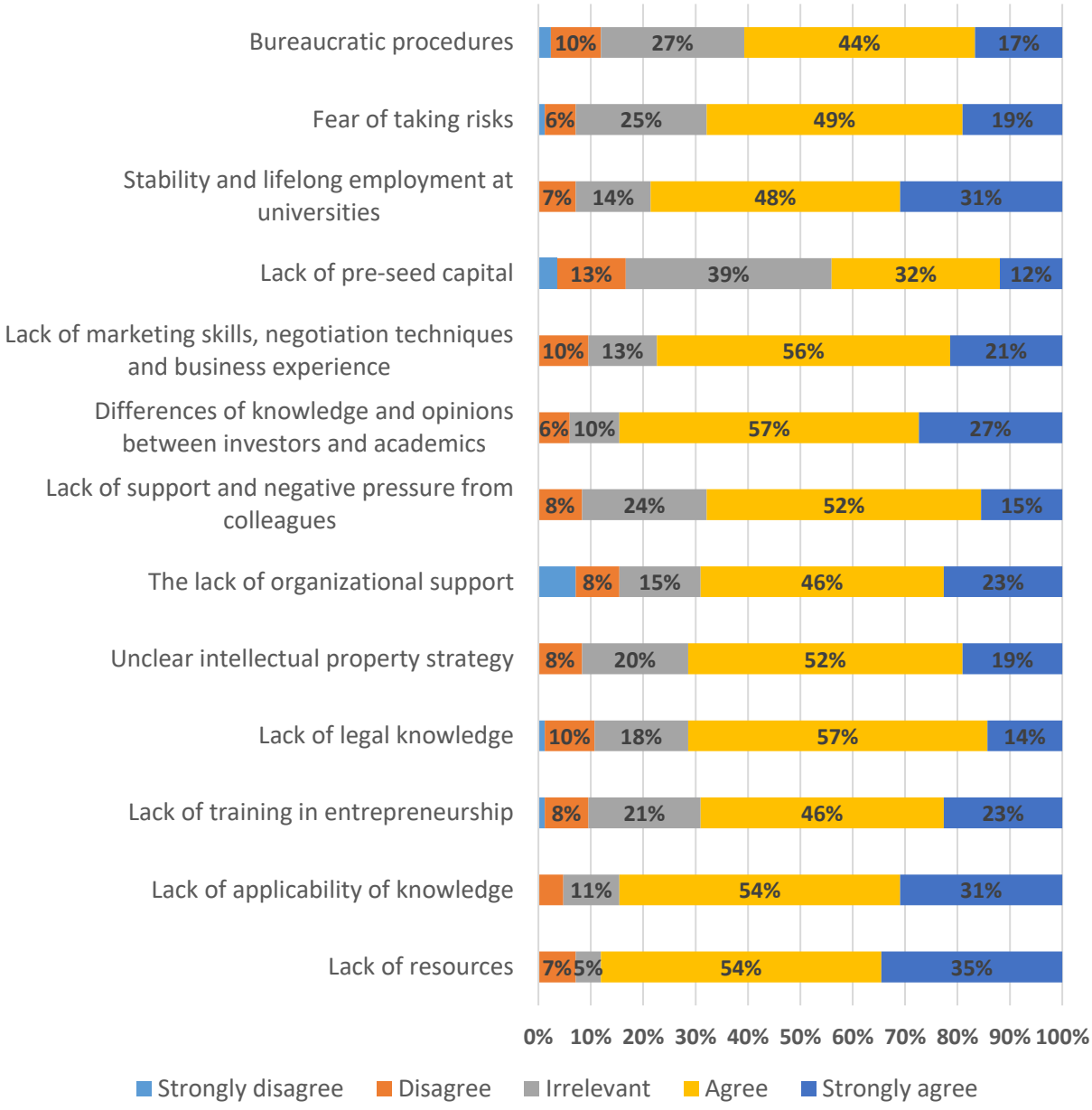
1. % (a)* - the percentage within group, i.e. position.
2. % (b)* - the percentage between groups, i.e. positions.
3. % (c)* - overall class contribution for all academic positions (scaled to 0-100%).

Appendix 10. The main drivers for successful Estonian research commercialization



Source: author's online survey; author's calculations

Appendix 11. The main barriers to Estonian successful research commercialization



Source: author's online survey; author's calculations

Appendix 12. The descriptive statistics on an online questionnaire

Variable	Cat1	Cat2	Cat3	Cat4	TOTAL	% (by variable)
Academic institution (n=225)						
Estonian University of Life Sciences	3	2	5	2	12	5%
National Institute of Chemical Physics and Biophysics			1	1	2	1%
Tallinn University	4	10	3	6	23	10%
Tallinn University of Technology	32	52	26	19	129	57%
Tartu University	14	24	13	8	59	26%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
Discipline (based on faculty) (n=225)						
Business and Governance/Social Sciences	1	3	1	1	6	3%
Engineering	12	16	10	6	44	20%
Information and Digital Technologies	5	7	11	8	31	14%
Life Science	31	49	24	20	124	55%
Medicine	3	6	1		10	4%
Other	1	7	1	1	10	4%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
Gender (n=225)				**36**		
Female	24	47	17	12	100	44%
Male	29	41	31	24	125	56%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
Age (n=225)						
20-29	3	13	5		21	9%
30-39	9	28	23	10	70	31%
40-49	18	27	16	8	69	31%
50-59	12	11	4	8	35	16%
60-69	6	6		6	18	8%
70-...	5	3		4	12	5%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
The highest degree or level of school completed (n=225)						
Bachelor's degree		2			2	1%
Doctorate or Ph.D.	46	59	31	29	165	73%
Master's degree	7	27	17	7	58	26%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
The current position in the academic organization (n=225)						
Assistant Professor	2		1		3	1%
Associate Professor	7	14	4	7	32	14%
Early-stage Researcher	3	18	13	1	35	16%
Leading Researcher	2	2		3	7	3%
Lecturer	2	4	2	3	11	5%
Professor	13	5	3	9	30	13%
Researcher	7	21	13	3	44	20%
Senior Lecturer	7	5	1		13	6%
Senior Researcher	6	7	9	8	30	13%
Specialist	1	1	1		3	1%
Technician (engineer)		5		1	6	3%
Others (administration, support, TTO)	3	3	3	3	12	5%
TOTAL (by groups)	53	85	50	38	225	
% (by groups)	24%	38%	22%	17%	100%	

Appendix 12. continued

Variable	Cat1	Cat2	Cat3	Cat4	TOTAL	% (by variable)
Team leader (n=225)						
No	35	67	36	19	157	70%
Yes	18	21	12	17	68	30%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
Team multidisciplinarity (n=225)						
No	22	34	12	5	73	32%
Yes	31	54	36	31	152	68%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
Publications number (n=225)						
1-5	6	18	6	3	33	15%
6-10	3	8	11	2	24	11%
11-20	6	21	11	4	42	19%
21-50	19	18	9	7	53	24%
51-100	9	6	3	8	26	12%
More than 100	8	5	4	8	25	11%
None	2	12	4	4	22	10%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
H-index (n=225)						
11-15	10	14	7	2	33	15%
16-20	7	6	2	5	20	9%
21-30	8	7	2	7	24	11%
3-5	4	8	8	4	24	11%
6-10	8	18	15	9	50	22%
Higher than 30	5	2	2	3	12	5%
Less than 2	3	12	5	2	22	10%
Not applicable for me	8	21	7	4	40	18%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
R&D experience (years) (n=225)						
Less than 2	2	13	3	1	19	8%
2-5	2	15	12	5	34	15%
6-10	7	18	10	5	40	18%
11-20	14	26	15	9	64	28%
More than 20	28	16	8	16	68	30%
TOTAL (by groups)	53	88	48	36	225	100%
% (by groups)	24%	39%	21%	16%	100%	
Patents number (n=225)						
1	9	15	2	6	32	14%
2	5	1	1	6	13	6%
3	3	3	2	4	12	5%
4		1	3	1	5	2%
5	1				1	0%
6		1			1	0%
More than 10		1	1	3	5	2%
None	35	66	39	16	156	69%
TOTAL (by groups)	53	88	48	36	225	75%
% (by groups)	24%	39%	21%	16%	100%	

Appendix 12. continued

Variable	Cat1	Cat2	Cat3	Cat4	TOTAL	% (by variable)
Number of academic organizations employed (n=225)						
1	24	37	22	16	99	44%
2	13	27	11	6	57	25%
3	11	16	9	7	43	19%
4	3	7	4	4	18	8%
5	2		2	3	7	3%
5+	1				1	0%
TOTAL (by groups)	54	87	48	36	225	56%
% (by groups)	24%	39%	21%	16%	100%	
Postdoctoral experience (n=225)						
No	32	61	27	21	141	63%
Yes, a national postdoc position	2	6	3	2	13	6%
Yes, an international postdoc position	19	21	18	13	71	32%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
Non-academic experience (by years) (n=225)						
11-20	5	8	8	6	27	12%
2-5	8	18	10	9	45	20%
6-10	7	15	7	7	36	16%
Less than 2	5	16	12	3	36	16%
More than 20	1	5	1	5	12	5%
No experience	27	26	10	6	69	31%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
Current employment in non-academic organization (n=225)						
No	17	41	25	10	93	41%
Yes (manload less than 0.5)	4	10	11	15	40	18%
Yes (manload more than 0.5)	5	10	2	6	23	10%
TOTAL (by groups)	26	61	38	31	156	
% (by groups)	17%	39%	24%	20%	100%	
R&D job nature in non-academic organization (n=225)						
No	10	28	16	3	57	25%
Yes	7	19	9	15	50	22%
Yes, partially	9	14	13	13	49	22%
TOTAL (by groups)	26	61	38	31	156	
% (by groups)	17%	39%	24%	20%	100%	
Business job nature in non-academic organization (n=225)						
No	15	31	21	9	76	34%
Yes	6	13	4	9	32	14%
Yes, partially	5	17	13	13	48	21%
TOTAL (by groups)	26	61	38	31	156	
% (by groups)	17%	39%	24%	20%	100%	

Appendix 12. continued

Variable	Cat1	Cat2	Cat3	Cat4	TOTAL	% (by variable)
Typology of Estonian researchers (Lam, 2011) with modifications (Suominen, 2021) (n=225)						
Entrepreneurial-Hybrid	10	19	12	18	59	26%
Entrepreneurial-Pure Traditional		1			1	0%
Entrepreneurial-Traditional	2	2			4	2%
Hybrid		1	1		2	1%
Hybrid-Entrepreneurial	10	29	15	9	63	28%
Hybrid-Pure Traditional		2		1	3	1%
Hybrid-Traditional	10	11	13	4	38	17%
Pure traditional			1	1	2	1%
Pure Traditional-Entrepreneurial	1	1			2	1%
Pure Traditional-Hybrid		1			1	0%
Pure traditional-Traditional	5	2	1		8	4%
Traditional	1				1	0%
Traditional-Entrepreneurial	1		1		2	1%
Traditional-Hybrid	9	13	2	2	26	12%
Traditional-Pure Traditional		1			1	0%
Multiple self-classification	4	5	2	1	12	5%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
I mainly do research to… (TOP3 answers, n=225)						
To help me start my own business	1	8	7	8	24	11%
Build my career within acdemia	14	30	15	6	65	29%
Gain recognition within academia	13	9	7	4	33	15%
Build my career outside academia	5	10	8	3	26	12%
Increase my personal wealth	6	10	5	5	26	12%
Improve the world and create social impact	20	47	29	20	116	52%
Satisfy my intellectual curiosity	37	51	31	20	139	62%
Solve an important scientific problem	31	37	21	21	110	49%
Become famous	1	1	1		3	1%
Build networks	3	11	6	3	23	10%
Educate people	20	39	13	17	89	40%
TOTAL (by groups)	151	253	143	107	654	
% (by groups)	23%	39%	22%	16%	100%	
Do you consider yourself a successful academic entrepreneur based on your own definition of success? (n=36)						
1 (not at all)	-	-	-	6	6	17%
2	-	-	-	5	5	14%
3	-	-	-	10	10	28%
4	-	-	-	6	6	17%
5	-	-	-	6	6	17%
6	-	-	-	2	2	6%
7 (successful)	-	-	-	1	1	
TOTAL (by groups)	-	-	-	36	36	
% (by groups)	-	-	-	100%	100%	
How satisfied are you with the degree to which your research result has been transferred to the market by your firm? (n=36)						
1 (not at all)	-	-	-	6	6	17%
2	-	-	-	5	5	14%
3	-	-	-	10	10	28%
4	-	-	-	6	6	17%
5	-	-	-	6	6	17%
6	-	-	-	2	2	6%
7 (absolutely satisfied)	-	-	-	1	1	
TOTAL (by groups)	-	-	-	36	36	
% (by groups)	-	-	-	100%	100%	

Appendix 12. continued

Variable	Cat1	Cat2	Cat3	Cat4	TOTAL	% (by variable)
Select from the list of the collaboration types that you have been frequently involved in the past?(n=225 responde						
Joint projects with academia (both parties is participated in the knowledge production)	36	49	26	27	138	61%
Contract Research (new knowledge is produced as a service)	23	31	23	21	98	44%
Joint projects with industry	20	28	18	24	90	40%
Project and consultancy services provided by the university to external parties for a fee	24	23	20	15	82	36%
I have not been involved in any collaboration before	5	16	4	0	25	11%
TOTAL (by groups)	108	147	91	87	433	
% (by groups)	25%	34%	21%	20%	100%	
How do you think collaborations should be initiated? (select only 3 answers) (n=225 responders)						
Through faculty contacts and connections	28	48	27	16	119	53%
Through industry need	40	77	45	32	194	86%
Through government calls	27	34	19	7	87	39%
Through grant calls	30	51	20	14	115	51%
Based on previous success stories or past successful experiences	23	32	17	19	91	40%
Through technology transfer office	8	21	13	16	58	26%
TOTAL (by groups)	156	263	141	104	664	
% (by groups)	23%	40%	21%	16%	100%	
Have you been involved in any of the following commercial university activities listed below? (n=225 responders)						
Applying for patents, utility models	12	16	8	19	55	24%
Licensing of university technologies/IP	3	3	5	10	21	9%
New Venture/ Startup Creation	5	5	10	26	46	20%
Project and consultancy services provided by the university to external parties for a fee	25	25	21	14	85	38%
Contract Research (new knowledge is produced as a service)	24	35	21	24	104	46%
None of the above	12	30	13	1	56	25%
TOTAL (by groups)	81	114	78	94	367	
% (by groups)	22%	31%	21%	26%	100%	
Have you ever been in contact with individuals working at a Technology Transfer Office? (n=225 reponders)						
I do not know what is a Technology Transfer Office	10	20	7	5	42	19%
No	29	49	23	9	110	49%
Yes	14	19	18	22	73	32%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	

Appendix 12. continued

Variable	Cat1	Cat2	Cat3	Cat4	TOTAL	% (by variable)
How can universities/research centers attract industry partners? (n=225)						
By showcasing faculty expertise	39	48	22	20	129	57%
By showcasing facilities and available services	38	57	22	14	131	58%
By showcasing success stories	31	48	25	24	128	57%
By having an office dedicated to building and managing partnership	13	33	17	15	78	35%
University administration need to make industry-university partnerships a strategic priority	22	41	30	13	106	47%
Setting up a multidisciplinary institute on campus in partnership with industry to break down traditional academic silos and drive a new multidisciplinary culture and curricula	11	36	27	15	89	40%
TOTAL (by groups)	154	263	143	101	661	
% (by groups)	23%	40%	22%	15%	100%	
Please specify your attitude to establish science-based company (n=225)						
I do not want to establish a science-based firr	53				53	24%
I have already established a science-based company				36	36	16%
I have not decided yet		88			88	39%
I would like to establish a science-based company			48		48	21%
TOTAL (by groups)	53	88	48	36	225	
% (by groups)	24%	39%	21%	16%	100%	
To facilitate spin-off creation and development university (N=84):						
Provides infrastructure	-	-	30	29	59	70%
Provides financial support (pre-seed)	-	-	27	11	38	45%
Helps founder list patent	-	-	9	10	19	23%
Helps founder with legal questions	-	-	20	10	30	36%
Helps founder develop business plan	-	-	14	6	20	24%
Helps founder raise funds (VC, angel investors	-	-	13	14	27	32%
Helps founder find required competence (bus	-	-	22	18	40	48%
Helps founder validate market	-	-	8	5	13	15%
TOTAL (by groups)	-	-	143	103	246	
% (by groups)	-	-	58%	42%	100%	
What do you think about university's support in spin-off venture establishment? (n=84)						
1 (The university is a huge obstacle to academic entrepreneurship)	-	-	1	2	3	4%
2	-	-	2	5	7	8%
3	-	-	6	6	12	14%
4	-	-	15	13	28	33%
5	-	-	18	5	23	27%
6	-	-	4	4	8	10%
7 (The university helps a lot in entrepreneurial activities)	-	-	2	1	3	4%
No response	-	-			141	
TOTAL (by groups)	-	-	48	36	225	
% (by groups)	-	-	21%	16%	37%	

Source: author's online survey; author's calculations

Notes:

- Cat1 – "I do not want to establish a science-based firm (answer if you were, imagine this case)", Cat2 – "I have not decided yet", Cat3 – "I would like to establish a science-based company", Cat4 – "I have already established a science-based company."

Appendix 13. The raw anonymous data directory

The one drive folder contains :

- the original unprocessed data of the online survey (attention, all personal emails of the responders left for the purpose of participating in the face-to-face interviews are removed from data) (link)

- the folder contains the transcribed and coded interviews used for the qualitative research and the blank questionnaire (link)

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