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Human Resources in Start-Ups: Expert Interviews with Managers on the Transition of Start-Ups from Academic to Private

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Abstract: This study investigates the changes in team composition in four academic high-tech start-ups and spin-offs. These companies were initiated on academic grounds and had to undergo transition in order to act as private companies. For human resources of all kinds this goes along with a change in the requirements of their skills and their work. This pilot study focused on four high-tech start-ups from Germany and Slovakia that are active and still in transition in the year 2021. Data was obtained with qualitative research methods from managers that were in charge during the transition of the company. During expert interviews, the researchers used semi-structured questionnaires in order to gather data from the managers on particular aspects of spin-off team member skills and requirements. The qualitative results obtained from the managers were compared, showing that with fundamental changes in the business objectives of the company the required management skills and team composition changes from an academic skills portfolio towards a private-sector portfolio. Likewise, a change in the human resource hiring strategy of the spin-offs was found in that stage. However, research also showed that spin-offs seem to undergo two transition phases during their way from an academic research group towards a company based on free market principles.

Keywords: human resource; start-up; transition; academic start-up; spin-off; high tech



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1. Introduction

Start-ups and spin-offs have been coming into public focus in recent years with the rising popularity of technical start-ups and unicorns, such as Tesla and Dropbox. These companies are characterised by a valuation of at least USD 1 billion prior to initialising private market activities [1]. While these start-ups overcame the first years of operation, evidence shows that in general about 90% of start-ups fail [2]. Ref. [3] states this number already reaches 92% in the first three years of operation. Failure reasons are manifold, being in line with the lack of resources identified in small and medium-sized enterprises (SME), such as lack of experience, lack of finances and lack of skilled human resources (HR) [4]. Studies found that the initial challenges of SMEs and spin-offs are similar [5]. Amongst others, the initial employee team was found to be one of the crucial factors for the long-term success of these companies [6]. This was found to have even more frapping impacts when considering the gender of the start-up initiator or the gender of the start-up manager [7]. Furthermore, these factors were found to be the precondition for early internationalisation of the start-up [8]. Even though nonacademic start-ups and academic spin-offs differ in their founding procedure, in the transition period from academic to private, academic spin-offs face the same challenges that nonacademic start-ups experience.

Thorough research on start-ups as well as on unicorns was also conducted in recent years. Research carried out with 100 technology start-ups suggested a lack of skills on the management levels, leading to a need for advice in order to facilitate the success of start-ups in initial phases [9]. On the contrary, start-ups seemed to provide the opportunity for skill transfer even into rural areas, particular for managerial skills and for technical skills of the concerned HR. This leads to a gradual acquisition of those skills in rural

start-ups [10]. Especially, early moves of diversification and risk reduction play a crucial role on the survival probabilities of a start-up [11]. The entrepreneurial mindset formed during university education was found to be a mediator for entrepreneurs and employees to conquer the early challenges of start-ups [12].

A Japanese study came to the finding that university spin-offs are tightly bound to universities and to taught entrepreneurial education programmes [13]. With almost 7% of PhD students actively contributing to start-ups as part of their study curriculum, these students play an active role in the academic and technological knowledge transfer [14]. Such academic spin-offs were found to be strong in technology, while lacking skills in management, sales and marketing, as well as entrepreneurial skills [15]. These skills are even more important, as such academic spin-offs are in need of strong and loose relationships gathered through business networks [16].

Academic spin-offs and start-ups are known to lack resources in crucial areas of business, disposing usually only over academic experts in the initial phase [17]. This matters even more in the high-tech area where many academic start-ups evolve [18]. While studies on production transitions from start-up to scaled production are available [19], the transition from a spin-off towards a self-organised and market-conforming SME was merely targeted by recent research [20]. Still, in 2021, this represents a research gap where the research on academic spin-off team members is not yet touched. Differences in mixed teams over time were not yet the main focus of spin-off research [21]. While critical success factors were already identified in previous research, this research paper wants to have a closer look at the transition with regard to HR. It focuses on four academic spin-offs having faced or just facing transition and their perceived changes on HR and the skill matrix during the transition. The research contributes to the body of knowledge in the area of determining the differences of start-up spin-offs and SMEs before and after transition. This allows to formulate the research question for the paper:

Research question: How do academic spin-off teams change during their transition from an academic research group towards a private company in their first years of existence with regard to their team composition?

2. Literature Review

2.1. Academic Start-Ups and Spin-Offs

The area of operation of academic start-ups and spin-offs is assumed to be in close relation with universities' research specialisation [22]. This may also be due to the specialised university-established incubators that provide services in order to promote innovate ideas during start-up with financial advice and expertise [13]. Pakistani research suggests that government and university play a higher role for these companies than their relationship with the industry [23]. As these universal ecosystems are understood to facilitate start-ups and spin-offs, universities provide even more ground for start-up ecosystems. These benefit from the close relations with universities as well as from the experience of already-established start-ups and spin-offs [24]. However, it seems that the opportunities arising from these academic start-up ecosystems are not fully exploited [25].

The academic start-up ecosystem provides a systematic background for the spin-off and start-up process. Research studies mainly focus on one component in their research [26], such as university–industry cooperation [27], transfer of technology from universities to spin-offs and start-ups [28] and entrepreneurial education with the strategic goal to enhance regional development [29]. Acting as the transfer channel for ideas from academic grounds towards commercialisation [30,31], these academic start-up ecosystems also provide opportunities for newly-established companies to go into niche markets [32]. One strategy of technological academic spin-offs and start-ups is to enter niche markets that are assumed to provide the future potential of market growth [17].

While still in 2018, ref. [33] found few and contradictory research articles on the management of academic spin-offs that allow the assumption that universities provide finances and profound business plans as support for spin-offs. Knowledge-intensive start-

ups seem to have a high degree of agility and a certain tolerance for risk in their actions by neglecting customer focus [34]. However, for spin-offs, it is assumed that understanding the managers' and the owners' structure provides important insight into the given spin-off [35]. Furthermore, ref. [35] believed the heterogeneity of the whole team, including managers and all further team members, to be negatively related to economic outcome, while previous research came to the conclusion that this relation should be of a positive nature [36]. As publications are available primarily in a few successful cases allowing for longitudinal research, this point is not yet consistently developed in the literature [37]. Even though the key performance indicators (KPIs) of spin-offs are linked to tangible resources, these companies usually start with an excess of intangible resources transferred from the university [38]. In the area of HR, ref. [39] suggested to make use of a variety of indicators considered to go far beyond employee number and growth rate.

From the above stated, the following research subquestions are formulated:

- Research subquestion RSQ1: How does the team composition in academic high-tech spin-offs influence financial performance during the transition from an academic research group towards a private company?

2.2. Spin-Off Transition

Taking the model of [40,41] into account, spin-offs have to undergo the following stages of transition: (a) research, (b) opportunity sketch, (c) preorganization, (d) reorientation and (e) sustainable returns [42]. The academic foundation of the start-up seems to be vital in the initial steps in order to establish and to start operations. In later stages, a profound entrepreneurial foundation is suggested to represent the crucial success factor [43]. While stakeholders provide the spin-off with the initial resources [44], tensions may arise about the way of governance of the spin-off with respect to the heterogeneity of the team with academic and nonacademic background [45]. According to a Portuguese study, the incubating university and shareholder should provide rules for the governance of these spin-offs being able to mediate potential conflicts between academics and nonacademics [46]. High-tech and sophisticated work environments are still human centred and human based [47].

In order to prevent risks from occurring, the integrated methodology for evaluating academic spin-offs focuses on five areas of risk: (a) market, (b) technological, (c) implementation, (d) governance and (e) financial [48]. Academic researchers founding or initiating the spin-off seem to substitute their academic work with the work of the academic enterprise, while patenting activities are mainly performed within the researchers' company [49]. The proposed governance from the university [46,50] should provide the ability to level between market orientation and entrepreneurial orientation [51]. While academic governance provides the framework for early company development [52], in the long-run, this governance is understood to be ambivalent as far as it refers to financial performance [53].

During the initial set-up of the spin-off, the founding teams struggle to set a suitable extent of openness, where a higher degree of openness towards nonacademic partners is assumed to lead to lower returns [54]. While business logic and academic logic provide the field for conflict, founding researchers being solidly embedded in the academic field are less likely to act as managers in spin-offs [55,56]. Even though spin-offs are able to trigger newly emerging business models [57], the initiators usually profit by raising its income and remaining in the company for a longer time than their nonacademic pendants [58]. The management team may undergo two transition phases: one from an academic research group to the early academic spin-off and yet another from the early academic spin-off towards a market-oriented company. The conflict potential in both these transition phases goes along with a new type of management within the company [59].

From the above stated, the following research subquestions are raised:

- Research subquestion RSQ2: How do team characteristics change in each stage during the transition of academic high-tech spin-offs during their movement from an academic to private market sphere?

2.3. Human Resources in Spin-Offs, Start-Ups and Small and Medium-Sized Enterprises

Entrepreneurial-oriented universities seem to trigger the creation of spin-offs through their academic personnel [60]. Entrepreneurship education takes a key role in transferring an idea into an academic spin-off [61]. This provides the opportunity for on-the-job training and learning-by-doing approaches as well as financial remuneration [5]. While research is on hand, human resource management (HRM) and development may be performed within the whole framework [37]. In any form of start-up, intrapreneurship managers have to take the soft aspects (emotions) of a heterogeneous team into account, rather than relying on hard logic [62]. As research in nonacademic spin-offs suggests, the initially unclear leadership and the nontransparent role of the leader provide challenges, especially for teams of mixed character [63]. According to [64], the initial team and its founders may be categorised by four different types of intrapreneurship. According to the academic position of the main initiator and founder, the following spin-off project types may be distinguished: (a) science-preneur-driven projects for a heterogeneous group of scientists as the main initiators of the spin-off company, (b) professor-preneur-driven projects for projects with professors as main initiators, (c) postdoctoral-preneur-driven projects for projects with one or more postdocs as main initiators and (d) context-preneur-driven projects for projects initiated by one or more graduates.

Still, in 2021, ref. [21] found a gap in research dealing with the mix and the differences of academic and nonacademic personnel of academic spin-off teams. However, the study suggests that tensions might arise when it comes to stronger positions held by nonacademic than by academic personnel. Academic personnel is usually dominant in the case of science-preneur-driven and professor-driven projects [64], while those lack private-market skills usually foreign to the academic founders of spin-offs, even though the technological level is high [65]. An Italian study suggested even more that teamwork in the initial phases might even hinder the development of a spin-off, while close structural relations hinder the financial success of a newly established company [66]. With growing company size, SMEs are known to outsource coordination activities [67]. The issues of transition with respect to human resources and the team formation and changes were merely targeted in available research [20].

The difference in lead by academic or by nonacademic entrepreneurs in spin-offs leads to differences in the composition of the team. Mixed and nonacademic teams show the highest long-term performances [68]. Concerning short-term performance, technological and knowledge-intensive spin-offs with patenting backgrounds were able to achieve high growth rates in the first six years [69]. Previous research suggested that as a success factor in recent years, the importance of working experience ranked higher than academic education and experience [70]. A Romanian study assumed that all companies go through a reorganisation phase with high human resource fluctuation and limited profits [71]. While it is assumed that the shortage of market-oriented knowledge of academics would be levelled by nonacademic personnel, spin-offs struggle in the challenge to scale up [72] with the initial team. Spin-offs usually facilitate the research activities of the initial academic founders [73] allowing interests to differ by seeing the spin-off primarily either as a research project or as a value-generating business. This being said, reorganisation may also provide the required shift in human resources to allow for market-conform spin-off teams and interests.

According to the acquired information, the following research subquestions are stated:

- Research subquestion RSQ3: How do the team composition characteristics differ between the different types of intrapreneurship of spin-offs?
- Research subquestion RSQ4: What are the stage characteristics during the transition and reorganisation phase in academic high-tech spin-offs?

2.4. Theoretical Framework

The purpose of this paper is to analyse the different HR frameworks in four university high-tech spin-off companies. These academic spin-offs usually work with a mixed team of academic and nonacademic employees. As such, it is assumed that the previously

research-based academic background shall lose influence with the commercialisation of activities. Coming from a nonacademic background, private stakeholders and further non-research-based professionals shall provide the necessary workforce to allow for synergy. Tensions in such mixed teams concerning direction and tensions concerning the question of decision making were observed in several research studies previously, e.g., [62–64,74]. It is therefore assumed that, based on human resources, the transition from an academic research group to a private company has to go hand in hand with transformation in its management. A basic model of organisations and their growth was presented by Greiner, with a first version in the 1970s [75] assuming a leadership crisis in the transition from phase 1 (growth through creativity) to phase 2 (growth through direction). This leadership crisis should go along with a change in the team composition of the academic spin-off.

The research framework assumes that there are different targets in an heterogeneous group. The main difference to be found in such spin-offs is assumed to be the difference between the group of pure academic researchers and the group of pure work-trained professionals. The purpose of the company is to then further develop the product from primary research into a competitive product on the free market. This implies that the research skills should still be required in the company during the beginning. With the rising duration of the spin-off operations, these skills should lose their importance. This leads to the assumption of an early academic lead in the beginning and a nonacademic lead after a few years. In the case of a researcher acting as entrepreneur in the early stages, this would assume a transition either into a nonacademic position, or it might lead to the moment that the initial academic founder drops out.

Taking the previous research into account, which is mostly based on empirical case studies, this suggests a five-stage model for the development of a spin-off towards financially independent company. The stage model assumes the stages of (a) research, (b) opportunity sketch, (c) preorganisation, (d) reorientation and (e) sustainable returns [40–42]. These five stages were not yet analysed with regard to team compositions and changes in high-tech spin-offs. While publications on spin-offs are still rare and focus mainly on qualitative case study research, there is an apparent gap in the understanding of the team dynamics in these companies. The reorganisation stage is known for a high number of fluctuations in the team that transfers from an academic focus towards private market [71]. It should be explored whether the workforce goes through one long transition, or whether the spin-off teams rather go through two vital transition phases that are distinguished from each other. From the understanding of [71], the transition phase should go in line with the reorientation phase of the spin-off in the mentioned five-stage model.

The research in this paper focuses on interviewing the current managers of the companies' on the team composition and cooperation since they have entered the company. Managers and scientists that left were not taken into account. As such, the study looks at the perception of current managers on academic spin-off HRM. It is an ex-post descriptive research approach that seeks to confirm the presented theoretical framework in Figure 1. The theoretical framework assumes that the reorganisation phase of the spin-off also acts as the transition phase in HRM in the company. While the nature and the frequency of these transitions has not been subject to research studies yet, it present a gap of knowledge in the research of academic spin-offs. As three of the four studied companies (referred to as company A, company B, company C, company D) are still in the reorganisation phase, the research aims to understand up to which degree the academic base has sustained in the team and up to which degree the nonacademic part of the team has taken over and when.

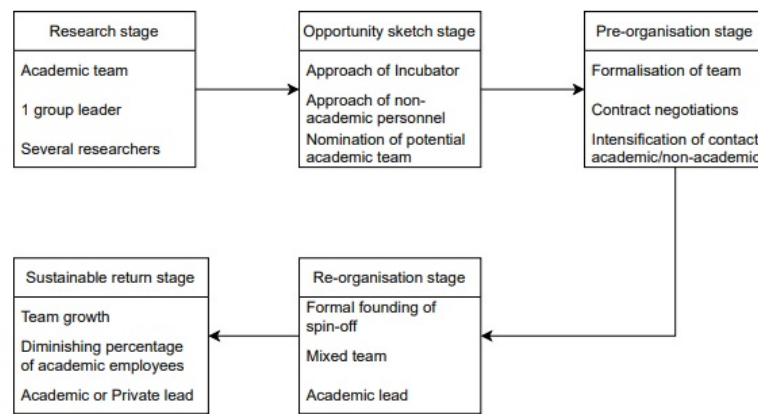


Figure 1. Stage model based on [40–42].

3. Materials and Methods

3.1. Methodology

While previous research studies make use of the multiple case study method, this research acquires its data through semi-structured interviews. The research methodology may be found in Figure 2. The research is carried out in three steps according to the research methodology (a) by developing the theoretical framework for research (see Section 2.4), (b) by gathering data on the companies and additionally conducting structured expert interviews in the companies and (c) by applying the gathered results to adapt the proposed theoretical framework.

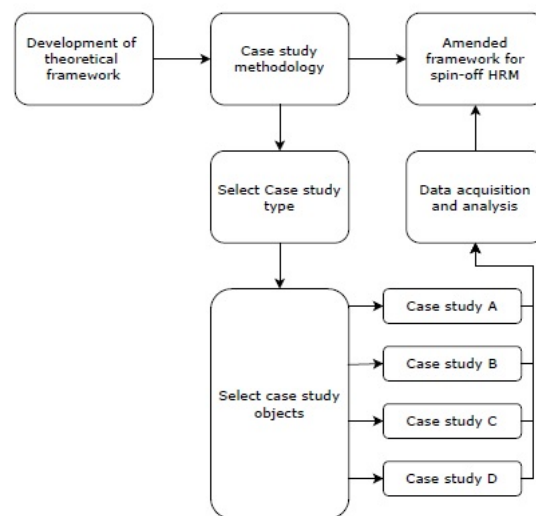


Figure 2. Research methodology.

Semi-structured interviews are understood as a case study method [76]. As such, they belong to the qualitative methods [77] together with questionnaires for qualitative surveys [78] and further data recording methods, such as observations [79]. These qualitative methods are also able to provide opportunities to support further quantitative research methods [80]. As qualitative methods are understood as lacking control of the context—contrary to a strictly regulated laboratory experiment [81]—this requires careful design of research in semi-structured interviews and focus groups [82].

Semi-structured interviews are understood to provide qualitative data [83] used in various research areas, such as clinical medical science [84] and geography [85]. Ref. [86] suggests that qualitative research methods require a more accurate definition of the study and case design due to the freedom arising from the qualitative methods. In educational

research connectivity, humanness and empathy (CHE) provide the principles for a robust case study framework based on semi-structured interviews [87]. During the interaction of researcher and respondent (interviewee), a relation between the two is formed [88], leading to potential bias by sympathy.

The research was conducted in four academic high-tech spin-offs in the high-tech equipment manufacturer area coming from two different universities. While this research study describes the whole population of academic high-tech equipment manufacturer spin-offs in these universities, this small number of companies lacks generalisability. However, this research framework allows the study act as a pilot study for a wider application field [89]. According to [90], academic start-ups mainly operate in progressive technology fields, in equipment manufacturing and in knowledge-intensive services [91]. Manufacturing high-tech spin-offs are known for developing a mixed team from former purely academic research [64]. Team tensions up to the highest management ranks, such as chief executive officer (CEO), have been reported for these kinds of companies [92]. Previous research suggests that the tensions in the team also have a direct impact on the business activities and on the team composition of high-tech spin-off companies [93], as this corresponds to a great extent to information on academic spin-offs in general [62–64,74]. Due to their strong reliance on prior academic research, these high-tech equipment manufacturing companies were chosen for this research in order to study mixed team compositions through the first years of operation in an ex-post view.

3.1.1. Validation of the Proposed Framework

Case studies are an acknowledged form of acquiring qualitative data from study objects. Additionally, they provide not only hard number-based outcomes, but they also allow for even more textual outcomes related to qualitative data [94]. The minimum number of required case studies, units and objects is not agreed upon among scientists. While multiple-case studies are able to set the acquired information into relation, single case studies go into the depth and reality of things to explore the researched phenomenon in detail [95]. With reference to quantitative research methods, some scientists assume that case studies should also meet the requirements in order to allow for generalisability and conclusion making. Other scientists propose that even one case study is correct and valid [96]. For the research in academic spin-offs, multiple-case studies are widely used, while they are believed to take account of the nature of the spin-off as SME, and while they are able to explore details in a heterogeneous group [97].

Case studies are constructed to confirm the correctness of a previously built theory. The theoretical framework is available prior to the analysis [98]. The case study used in this paper focuses on in-depth expert interviews with managers of all levels in knowledge-intensive spin-offs. All companies are university spin-offs, while two companies observed are spin-offs of a German university, the other two spin-offs were founded at a Slovak university. It is assumed that these companies undergo a certain cycle in their human and management resource availability according to a stage model [40–42]. In order to confirm the constructed theoretical framework, the application of a multiple-case study that allows for making use of comparative advantages arising from the heterogeneous nature of the cases must be applied [99].

Multiple-case studies confirm the theoretical framework by analysing multiple sources [100]. Data may be viewed from various viewpoints [101], as several multiple-case study researches have carried it out in similar fields of research (e.g., [46,69,73]). While the incubation of spin-offs through the university ecosystems has come into focus, research and publication activities also increased in recent years. As research showed, spin-offs may act as a trigger for regional development, however, universities as an organisation do not seem to benefit from the cooperation. Individuals behind the spin-offs seem to personally profit from the provided platforms and cooperation potentials in order to realise their ideas through heterogeneous and multidisciplinary teams. This multiple-case study research

should structure information on the HR management of spin-offs during their way from an academic background to a privately owned spin-off.

In order to evaluate the theoretical framework, this research makes use of the multiple-case study design [102]. Case studies may be applied individually on a given case with the possibility to adapt in certain ranges in order to gather specific information on the study object. As such, it is possible to combine qualitative and quantitative methods in design, realisation and validation [103]. The validation in this case was based on expert interviews that were conducted in the given state of development of the spin-off company during the year 2021. Expert interviews are conducted with all present managers of the four monitored companies on all levels. While the companies all belong to the category of small companies according to the taxonomy of the European Commission [104], they only have a small management structure with a maximum of four managers and advisers. The results of the case studies are based on the qualitative inputs of the managers that may allow for a qualitative characterisation of the phenomenon, rather than allowing for a generalisation of results from a global perspective.

3.1.2. Acquired Data

Data was acquired in the case-study companies by expert interviews with the managers. Semi-structured interviews are a frequently used method to gather qualitative data, either from an individual or from a group that is understood as expert in the given field [105]. It allows the interviewer to go deeper into the matter in case of need, as the interviews might be extended by improvised or upcoming questions [106]. While being understood as a method to easily gather data [107], these interviews require basic knowledge of the interviewer in order to set the correct questions and in order to use spontaneous follow-up questions whenever required [108]. The interviewer has to be able to understand the opportunity for researching related content [109]. As a nature of these subjective interviews, the answers underlay a certain self-bias [110]. Thus, interviews are also subject to a variety of critique points such as the sampling choice and the interpretation of results [111].

As the herein presented research is conducted ex-post for descriptive reasons, the expert interviews are chosen as the proper means of researching the given phenomenon. The young companies may have undergone a stage of transformation and some hints and evidences might already be lost. However, interviewing the whole of the management allows for the most complete picture available, as semi-structured interviews also allow to go into details of memories of only one individual. Hard logic and quantitative approaches are, due to the lack of information collected during the time of transition, not available.

3.1.3. Case Study Description

All companies analysed in the case study belong to the knowledge-intensive academic spin-offs. All of these companies come from a background in chemistry and petrol according to class 20 of the NACE rev. 2 classification [112]. Due to their youth, all companies have been registered in the last 7 years, when the transition process from academic to private ownership began. Registration of the company as a private entity is the formalisation of the organisation and the legal beginning of the company, while relations and silent cooperation might have been used already prior to that. As no company has made a prompt market breakthrough, these companies are all small companies with a maximum of 25 employees. One company is even smaller with only 6 employees, belonging to the microenterprises that have fewer than 10 employees in total [104].

While legal frameworks in the European Union (EU) might be similar for the four enterprises, even small details in the rules might have impacts on the companies' performance. Even more, all four companies began with a start-up grant that was given through public institutions. These companies were founded with a unique technical solution, the initial companies' marketing and sales force was either recruited from the university or it was provided by the private investor as a contribution to the partnership. Differences may also be found in the companies' management teams, as well as in the technical and

administration areas. While some of the companies took off with a pure academic team, the other companies used people chosen by the private partner or other external sources, such as from a consulting company.

Depending on the stages of the transition process, the companies already went through changes in their employees and management team, which might have occurred with different frequency. It should be assumed that companies with a longer time since their formal registration might have a longer history, and therefore should also be advanced in processing through the organisation stages. In the HR area, it might be assumed that with a longer lasting public engagement, academics would retreat from the corporate team, or at least the percentage of employees coming from an academic research background would be continuously diminishing. Thus, as the work of the spin-off should go far beyond the academic research topics, an additional engagement should not be assumed.

The research study was conducted in the year 2021. All analysed companies were already registered as a private company. Tables 1 and 2 show the basic company information as well as chosen employee and management team information that was part of the case study processes.

Table 1. Overview of studied companies in Slovakia.

Country Case	Slovakia	
	A	B
General Company Information		
Founding year	2014	2018
Founding mechanism	professor-preneur-driven projects	professor-preneur-driven projects
Type of company	limited (Slovak: s.r.o.)	public limited company (Slovak: a.s.)
Shares of initial founder (2021)	0%	25.1%
Sold units (average per year)	1.6	3.5
Yearly turnover (in thousand USD)	360	540
Number of employees	20	11
Number of managers	4	3

Table 2. Overview of studied companies in Germany.

Country Case	Germany	
	C	D
General Company Information		
Founding year	2015	2018
Founding mechanism	postdoctoral-preneur-driven projects	professor-preneur-driven projects
Type of company	public limited company (German: AG)	public limited company (German: AG)
Shares of initial founder (2021)	25.1% (12.3% & 12.8%)	20%
Sold units (average per year)	10.7	2.9
Yearly turnover (in thousand USD)	1430	280
Number of employees	14	6
Number of managers	3	3

3.1.4. Conducted Case Study Interviews

The interviews were conducted in the first half of the year 2021 with all managers of the companies. In total, this meant interviews with 13 managers. The interviews were constructed as semi-structured interviews. Two rounds of interviews were conducted within 8 weeks, both with all 13 interviewees. All interviews had a descriptive character from an ex-post view to map the last years of operation. The two rounds were carried out, as in the first round several unplanned topics popped up. In order to obtain information

from all managers, the additional topics were taken up with the other interviewees in the second round. This allowed for a consistent information base from the different companies. However, there were specific topics that were individual to only one company.

Table 3 shows a summary of all manager answers on the HR policy and the team compositions in the years since the establishing of the spin-off company. The summary shows the information gathered after two rounds of interviews. The table gives an aggregated overview of the information of each company. Detailed information on each interviewee may be found in the supplementary materials.

Table 3. Interview answers—summary.

Characteristics	Professor-Preneur-Driven	Postdoctoral-Preneur-Driven
University eco-system support	Support and training for grants Support to find investor	Training on sales and marketing
Incubator services related to HRM	Investor search Sales and marketing search	None
Helpful bondages with university	Academic: Yes nonacademic: Bureaucratic and non-business-like practices	Yes, tightened
Salary increase from academic to private	Yes	Yes
Economic benefit decrease for mixed teams	No	No
Mixed teams increase tension	Yes	No
Period of tension	1 to 2 years	N/A
Period of tension	1 to 2 years	N/A
Human-resource-related KPIs given in business plan	Employee growth rate	Employee growth rate
Initial research team	Employee number	Employee number
First team change period	1 professor, postdocs, students MD (leader) changed to nonacademic Additional nonacademics	2 Postdocs, PhD students, students Students ended study and were replaced
Second team change period	Deterioration of academic focus Leaving of academic team (1 case)	N/A
Duration of resource fluctuation	1 to 2 years	1 to 1.5 years
Period of fluctuation with regards to company life duration	From 3rd year onward	

After the second round of interviews, it could be stated that all managers gave their input to all questions. No question remained unanswered.

3.1.5. Case Study Analysis

The case study shows several patterns in the understanding of the four companies. While the sample is small with only four companies, all current managers in the companies were asked to give their input to the upcoming questions in two interview rounds. The first round of interviews was conducted between March 2021 and April 2021. The second round of interviews took place in May 2021 and June 2021. Due to the organisation structures of the companies with only 3 or 4 managers, each company had one managing director (MD) with 2 or 3 department managers acting as first-line managers. All further employees in the company act as employees who are direct subordinates of the mentioned managers.

Even though these organisations are small, two companies already showed changes in their management teams. While in one company there was a smaller change by exchanging one manager for a new one, the other company had a complete change in the management team due to differences in understanding of the company targets. This was in line with the retreat of the whole academic research team and the change in ownership into fully private hands. A substitute research team was gathered. However, this shows how unstable such spin-off ecosystems might be if the management is not able to moderate between the academic and the nonacademic team members. If there would be a direct change with a founder of the spin-off leaving, this might bring several disadvantages, such as the retreat of further academic personnel under the lead of the initial academic founder.

Furthermore, data seem to suggest that there are two major transition periods for the HR management and the employee fluctuations. The first wave may be found in the moment that the initial academic research group is transferred to the privately owned spin-off company. Usually, the research group leader is also the academic initiator of the spin-off. However, administrative work that was handled by the academic group or by the academic secretary before was transferred to a private administration worker. Furthermore, prior to the initiation of the spin-off in three of the four cases, the research group was led by one academic person. This person may be understood to act as the manager of the research group.

A second transformation process was found in the two companies that already completed more than five years of operations. These companies had their second transformation of the employee and management team between their third and fifth year of existence. According to the managers' information, this transformation was due to the target to go for a scale-up technology according to private market rules. In this case, the influence of the academic personnel was diminished as their percentage in the team composition decreased. In one case, this also led to the complete retreat of the academic personnel, while in the other company the academic first-line managers left the company. Instead of academic successors taking over, the free seats were given to employees from the private sector.

Furthermore, it was found that intense differences in the understanding of the academic and the private side may exist. The case of the total breakup of the academic and nonacademic team brought the spin-off to the situation that it was still relying on external funds contracted and bound to the research work of the academics. Furthermore, the nonacademic team was to a vast majority not experienced with the acquisition of external research grants. The company's private owners decided to bear the risk and to proceed with operating the company while depositing additional financial funds as working capital into the spin-off. However, to date, the company is still trying to recover from this event, while it is still focused on finishing the projects it began and looking for new projects. The breakthrough in the private market with a scale-up technology has not yet been reached.

While it is assumed that universities and incubators are able to provide start-up and spin-off consulting, the marketing and sales is understood as only targeting the scale-up target. The target is to build up a company in the incubator within a short amount of time and to bring it to the scale-up level. This scale-up level is important for two reasons according to the interviewees: (a) the company fulfils the target to conquer the market fast and to be worth the money invested as it can stand on its own feet and (b) the owners target to sell the company to other companies or financial investors as soon as possible in order to avoid the risk of operating a business that they might not be able to cope with. This understanding of business making is fundamentally foreign to the individual managers who are nonowners of the company. However, they step back as they are not the shareholders.

Additional findings concerning the university and the incubator of the ecosystems were made. According to the nonacademic managers' opinions, the university is taking a high stake of interest in areas and in KPIs that are not even required. While the university is not taking too much influence in the process of working as well as controlling their academic workers that are in a double function, there are basic bureaucratic processes that have to be met even by the spin-off company. In the case of the Slovakian spin-offs, the university was not even an owner of the spin-off. In the German spin-offs, the university acted directly as a co-owner. However, the set rules of the university might also apply to purchase, sales and further processes of the spin-off. In addition, human resources and open positions might have to be openly tendered according to the universities' rules, in which the spin-off has no autonomy.

Besides the hypothesised topics, it has also been found that early spin-offs make extensive use of students as low-cost workforce. Students of all levels might work on research projects in university, while the differentiation and distinction between university research and company research interest is not clearly defined. This suggestion is also

supported by the case of the company where the academic staff retreated and the company had to acknowledge that they were not able to substitute the mostly unpaid students with a financially adequate alternative. While the official human resources might be only a core team, the university spin-off seems to bring in students on a low-cost basis. Hence, the real team working on a solution might be bigger than the officially named team.

3.2. Improvement of the Applied Framework

The findings suggest that the proposed theoretical framework coming from the stage model for spin-offs [40–42] may be adapted according to the characteristics in human resource management (HRM) and team composition in each stage. The model shows two transition periods (a) from research group to a mixed team and (b) from grant-orientation focus towards market-orientation focus. Furthermore, this must be distinguished for the professor-preneur-driven projects and the postdoctoral-preneur-driven projects. The postdoctoral-preneur-driven project, even though only one company was analysed in this study, seemed to show a different understanding in the composition and in the target of the spin-off. While the professor-preneur-driven project looked for fast scale-up and initial nonacademic support, the postdoctoral-preneur-driven project worked with a younger team of assumed flexible individuals. The extended stage model with reference to the HRM may be found in Figure 3.

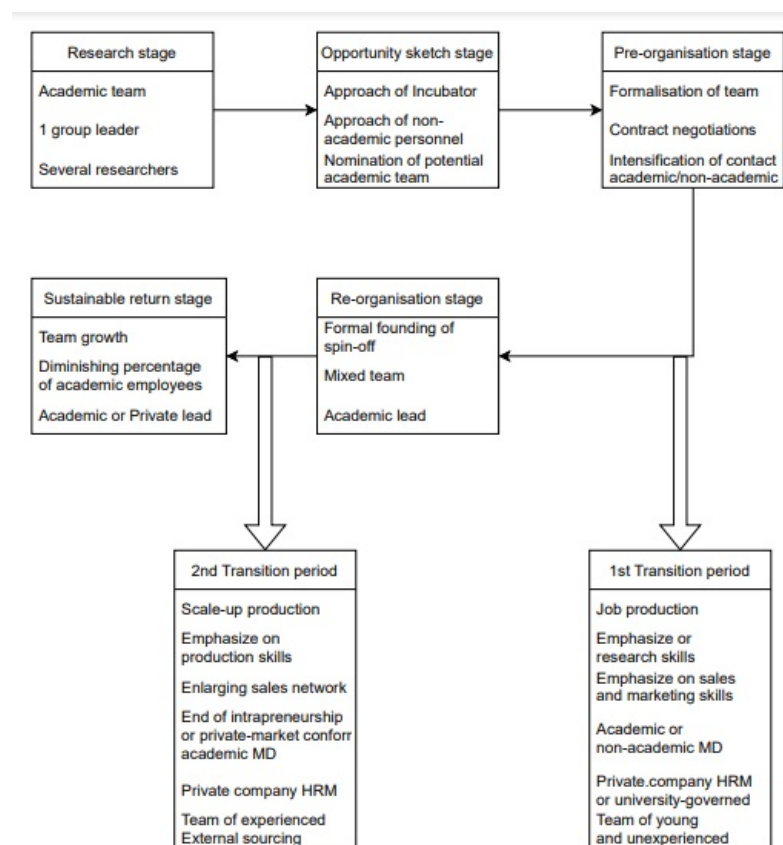


Figure 3. Extended stage model of spin-off creation with reference to team composition and human resources.

It is also suggested that postdoctoral-preneur-driven projects provide a team with higher stability in the long term. While there is only one case study available in this category, it seems to show certain differences to the professor-preneur-driven projects. While the professor-preneur-driven projects are still stuck in the reorganisation stage struggling with changing teams and tensions between the academic and the nonacademic team, the postdoctoral-preneur-driven project has conquered the reorganisation stage while

keeping the initial academic founder in place. This might point towards a potentially higher flexibility of postdoctoral-preneurs and their team. From this understanding, the professor-preneur-driven projects give the hint that there are two stages of transition that are closely bound with the reorganisation phase, standing at its beginning and at its end.

4. Results and Discussion

The case study seems to fit into the categories of the stage model for spin-offs developed by [42] based on [40,41]. Team composition seems to be not only a highly individual aspect of spin-offs, but it is also highly volatile and unstable. Previous Norwegian research assumes, rather, that additional heterogeneity may create benefits for high-tech spin-offs [113]. However, young teams seem to have a longer duration in their work in spin-offs than older ones among the four presented cases. A younger team is also built in postdoctoral-preneur-driven projects. These team seems to be to a certain extent less volatile, although also they show a certain dynamic indicating the transitions in HRM during the first years of the spin-off. Likewise, previous Irish research found that the academic founder and initiator usually stay at the head of the company, hindering the company from developing [114].

As previous research found, academic researchers contribute to the spin-off, also being initiators [49], but do not influence their academic work and publication activity. This is in line with the findings in this research [55,56]. The reason given by the managers is the use of students for laboratory work in academic as well as in spin-off areas. Thus, the way of working did not seem to change from the research group to the spin-off in the first transition. Ref. [66] suggests that team work in this way could even create obstacles rather than benefits. This way of working may be expected to change in the second transition. As a case study showed, the neglected calculation of laboratory workers due to student work made it necessary to recalculate the costs and delayed the development of knowledge in the company for further projects [14]. Such a constellation provides learning-by-doing opportunities and allows for creating income for everybody in the hierarchy [5]. However, the research in this paper suggests that cheap student personnel does the work.

While the whole start-up is supported by the incubator to stand financially on its own feet in a short amount of time, three of the four companies are hugely dependent upon research grants and other public funds related to projects. In addition, ref. [64] assumes that due to the proximity of scientists to the academic ground, they are able to acquire further funds for the company through research grants rather than through sales. Only one company from Germany was able to stand on its own feet and to bring the requested scale-up. This company was postdoctoral-preneur-driven and worked with a young team from the beginning. However, with the scale-up, this spin-off also showed that the percentage of mere academic personnel was constantly decreasing. Previous research from the Netherlands found that even external stakeholders are able to mediate the management of technical start-ups [115].

However, the KPIs for the spin-offs showed a planned increase in the headcount, but fluctuation was not seen as indicator worthy in this regard. The spin-offs' employment strategy and structure is subject to the spin-off, while it is not subject to the conditions for financial grants. Thus, the dynamics in incoming and outgoing new employees is neglected from the incubator side. Previous research suggests that even academic entrepreneurs have basic knowledge of human resources and their management [116], even though findings in this research allow the assumption that they are not coping with mixed teams. While setting up scale-up indicators is understood as business support, setting up a loyal and durable employee foundation is not taken into account. While [117] believe the operational stages of a company are solely defined by growth, according to Greiner's model [75], the research in this paper claims that stability in the initial team may enhance the transition phase.

Previous research also suggests that the university should be involved in the governance of its spin-offs in some areas. The research conducted in this paper suggests that for HRM this may be true for the first transition of the research group towards a formal

company. With the incoming nonacademic personnel and rules, the academic process of bureaucratic legislation might hinder the development of the spin-offs in the area of HRM. In many cases, the academic initiator hands the management agenda to a nonacademic person [58], which was found to be the same in the case-study companies. Previous research in Indian IT found that a significant percentage of start-ups faced a leadership crisis [118]. Thus, between the first and second transition, it might be suggested that the university is backing off from setting HRM regulations. However, the interest in governance should exist for the university in case a university researcher is also part of the spin-off, even more so if the same person is the initial founder or the initiator. An Italian research suggests that even academic governance is not able to provide full guidance for the start-up [53]. This evolves in gaps, for e.g., in the team management, as found in this research paper. The rules for this constellation seem to not be set clearly.

With the aforementioned, the research subquestions are answered according to Table 4:

Table 4. Overview of research subquestions of the paper.

Research Subquestion	Description	Result
RSQ1	How does the team composition in academic high-tech spin-offs influence financial performance during the transition from an academic research group towards a private company?	Positive performance benefits in professor-preneur-driven spin-off may vanish due to team break up. Heterogeneity in general boosts financial performance.
RSQ2	How do team characteristics change in each stage during the transition of academic high-tech spin-offs during their movement from academic to private market sphere?	The different stage characteristics found may be found in Figure 3.
RSQ3	How do the team composition characteristics differ between the the different types of intrapreneurship of spin-offs?	The professor-preneur-driven start-ups change their MD to nonacademic, and additional nonacademics were taken in. The doctor-preneur-driven spin-off sourced internally, hiring former students that also worked for the spin-off part time.
RSQ4	What are the stage characteristics during the transition and reorganisation phase in academic high-tech spin-offs?	The postdoctoral-preneur-driven spin-off shows stability throughout its operation. Professor-preneur-driven spin-offs show increased tensions in the team in the two transition phases around the reorganisation phase. The reorganisation stage characteristics may be found in Figure 3, having an academic lead but a mixed team. The reorganisation phase is framed by two transition periods that imply employee fluctuation.

5. Conclusions

This research study focuses on the team dynamics of academic high-tech spin-offs during their first years of work. While a previous study already mentioned the tensions arising from mixed teams of academic and nonacademic workers [74], this pilot research suggests that there are at least two transition phases that the spin-off teams have to undergo. This brings further tensions into the team and led to a total break up of the heterogeneous team in one of the cases. The two transitions fit into the already existing stage model [42] and further existing research. Furthermore, it fits into Greiner's stage growth model of organisations where a leadership crisis evolves between stage 1 and stage 2 [75]. However, it must be clearly distinguished that Greiner's model works on a higher level, while the current research in this paper proposes a stage model for the team composition in academic high-tech spin-offs. As such, the research contributes to the existing body of knowledge by proposing an enlarged stage model with particular focus on the team composition of spin-offs and their stage characteristics during transition.

This research shows that there is a reorganisation phase with high fluctuations in the companies that is framed by two different transition periods with fundamental changes in team composition. While the first transition phase formalises the team composition with working contracts, the second transition leaves the academic background towards operations and production scale-up. Professor-preneur-driven companies showed this pattern, while the postdoctoral-preneur-driven company remained stable over time and showed the highest degree of development. Hence, another suggestion may be that professor-preneurs have a larger focus on the initiation of projects to foster research, while the postdoctoral-preneur-driven company goes for full commercialisation. This is also documented in [64], assuming postdoctoral-preneur-driven companies strive for patents and their commercial exploitation.

The enlarged stage model also suggests academic initiators (professors) drop out of the spin-off during the second transition period. The presented research proposed the difference in these companies to be found in the age structure of the official team, rather than in the spin-off model. Younger teams seem to be stable, academic driven and homogeneous. These teams work with minimum support in areas they are not able to deal with. Professors seem to drop out in the moment of production scale-up with a decreasing role of research. While it is only confirmed by little information in this research due to the small sample size, this point shall receive further attention in future works. As previous start-up and spin-off research suggests, the initial composition of all factors is vital [119]. Even more so is the stability of the framework, even though [120] believes that different frameworks should be suitable in different phases, similar to [75]. Thus, an intrinsic stability of the founder's team paired with a common goal might be able to skip the reorganisation and transition phases. The postdoctoral-preneur-driven companies and their intrinsic stability might be another subject for future research.

Additional open questions targeting academic spin-offs seem to arise from the presented model itself, as well as from the small amount of companies that the case study took into account. Thus, it is conducted as a pilot study requiring further confirmation from future research in order to achieve generalisability. While the case study for these young companies with a maximum of seven years of operation shows two transition phases related to HR, future research shall also have to look at older start-ups in this area and the way of their transition. It remains unknown whether there is an additional transition pattern that is not yet presented in theory. However, this research focused on the knowledge gap in the human-resource transition of academic spin-offs, a topic that has not received high recognition in academic publications. With the developed transition model, this research contributes to fill the research gap in this area.

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Abbreviations

The following abbreviations are used in this manuscript:

CEO	Chief executive officer
EU	European Union
HR	Human resources
HRM	Human resource management
KPI	Key performance indicator
MD	Managing director
RQ	Research question
RSQ	Research subquestion
SME	Small and medium-sized enterprises

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