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ABSTRACT

A Procedural Perspective on Academic Spin-off Creation: The Changing Relevance of Academic and Commercial Logics*

We analyze the influence of two contradicting settings on the success in the academic spin-off creation process. Scientists, who are embedded in the academic setting, have to reach out and adapt to the logics of the commercial setting to successfully found their firm. However, along this process, many scientists fail because they cannot overcome the contradictions between these logics. We provide the first empirical evidence on the relevance of these two contradicting logics along the spin-off creation process. Based on a phase-based conceptualization of the spin-off process, we hypothesize a decreasing relevance of the academic setting and an increasing relevance of the commercial setting for successful transitions between the process phases. We test these relationships with a representative sample of German scientists using dominance analysis to determine the relative importance of the two settings. Our findings show a decreasing relative importance of the academic setting along the spin-off creation process, in line with our hypotheses. The relevance of the commercial setting initially increases before it decreases in the latest stage of the process, contrary to our hypothesis. Additionally, we find that the commercial setting is generally more important than the academic setting, especially in the beginning of the process. Our results provide a deepened understanding of the academic spin-off creation process and extend existing theories. Furthermore, they provides intervention points for policy along the spin-off creation process.

JEL Classification: academic entrepreneurship, transition process, phase model, dominance analysis

Keywords: L26, O31, O33

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1 Introduction

Academic spin-offs (ASOs) are considered an important mechanism for transferring scientific and technological knowledge to commercial application (Meoli & Vismara, 2016; Rasmussen et al., 2006; Shane, 2004). Thus, they have a deep economic and societal impact (Fini et al., 2018; Rasmussen et al., 2020; Vincett, 2010). For example, start-ups with a university background, such as BioNTech, Booking.com, Genentech, Google and JustEat-takeaway.com have led to the formation of new industries, created thousands of jobs, and pioneered business models and business practice. While the number of ASOs consistently increased over the last decades (Mathisen & Rasmussen, 2019), the rate of spin-off projects that have been abandoned at some point in the venture creation process remains very high, leaving a large stock of research knowledge with commercial potential unexploited (e.g. Braunerhjelm, 2007; Fini et al., 2017). Consequently, understanding the determinants of ASO formation and development is crucial for scholars, practitioners and policymakers (Fini et al., 2018; Sandström et al., 2018).

It is widely recognized in the academic entrepreneurship literature that ASOs are created in a dynamic, multiphase process, where each phase is characterized by a specific set of activities that the venture must accomplish before progressing to the next phase of development (Kleinhempel et al., 2020; Ndonzuau et al., 2002; Rasmussen, 2011; Vohora et al., 2004; Wood, 2009). However, to pass through these phases and become an established firm with sustainable returns, ASOs must overcome key obstacles referred to as "critical junctures" (Vohora et al., 2004). They are defined as complex problems that "occur at a point along a new high-tech venture's expansion path preventing it from achieving the transition from one development phase to the next" (Vohora et al., 2004, p. 159). Critical junctures arise because the venture project requires new configurations of resources, capabilities, network ties and support in different process phases. Despite numerous studies acknowledging the procedural structure of spin-off creation (e.g. Fernández-Alles et al., 2015; Rasmussen, 2011; Roberts & Malonet, 1996; Vanaelst et al., 2006), there is little empirical evidence on how scientists move through the process and what determines the success of the ASO creation process.

A central determinant for successfully going through the venture creation process is the scientists' embeddedness in the academic and the commercial setting (Dasgupta & David, 1994; Rasmussen, 2011; Stephan & Levin, 1996). Scientists are embedded in an academic setting in which Mertonian norms prevail and knowledge is considered a public good. From such a setting, scientists have to reach out to the commercial setting in which substantially different norms and logics apply–rent seeking and secrecy. For a successful venture creation, scientists have to overcome the contradictions between the logics throughout the ASO creation process. We link the procedural perspective of the ASO creation process with the two contradicting settings and want to understand how the relevance of the two settings changes along the process for a successful venture creation. For this purpose, we first conceptualize the ASO creation process and separate it into four subsequent phases, where scientists have to make a transition across critical junctures. Second, we hypothesize that the relevance of the academic settings decreases along the process, while the commercial setting increases in relevance. We, third, test these hypotheses empirically with novel survey data.

Our study contributes to the academic entrepreneurship literature in two important ways. First, we apply a micro-level perspective to the ASO creation process. In particular, we explore how the commercial and academic settings influence the individual scientists in mastering transitions along all process phases and turning a business idea based on scientific research into a spin-off venture. This allows us to overcome the limitations of previous research that either applied qualitative research methods to analyze small firm samples (e.g. Clarysse & Moray, 2004; Hayter, 2016a, 2016b; Vohora et al., 2004), focused on single process phases (e.g. Krabel & Mueller, 2009) or limited their analyses to successfully created spin-offs (e.g. Landry et al., 2006). Second, to understand how the relative importance of scientists' embeddedness into the two settings changes along the ASO creation process, we conduct dominance analysis (Azen & Budescu, 2003; Azen & Traxel, 2009; Budescu, 1993). This method computes the relative importance of predictor variables by decomposing the overall goodness-of-fit measure of a regression model into the predictors' individual contributions. Thus, as far as we are aware, our study provides the first quantitative analysis of the mechanisms that enable scientists' transition along all phases of the spin-off creation process as well as the selection processes that are involved in this transition.

Using data from a representative sample of scientists employed at universities or public research institutes in the German federal state of Thuringia, we can show that along the ASO creation process, the relative importance of the academic setting decreases. In contrast, the commercial setting seems to become more important as the scientist progresses through the process. Interestingly, for the transition into the final process phase, the commercial setting turns out to be less important than for making the transitions into the previous process phases. These results are robust to several robustness checks including alternative estimation approaches, control variable settings and operationalizations of the spin-off creation process. Overall, our findings suggest that the academic and commercial settings do not work in isolation (see also Murray, 2010) and that scientists, embedded in their academic setting, also need to adapt to the logics prevailing in the commercial setting if they aim to be successful in the spin-off creation process.

The paper is organized as follows. In Section 2, we discuss the peculiarities and differences of the academic and the commercial settings, propose a conceptualization of the ASO creation process and link both settings to the individual process phases. This is followed, in Section 3, by the description of our data and empirical approach. Our analysis is presented in Section 4. Finally, Section 5 provides a discussion of the results and concludes.

2 Theoretical background

2.1 Scientists between two contradicting settings

Academic scientists' main task is to generate and diffuse knowledge. Based on their findings, some of them recognize an opportunity to commercialize. Such an economic opportunity can be exploited via different transfer channels, such as patenting, licensing or the creation of a new venture (Bekkers & Bodas Freitas, 2008; D'Este et al., 2019; Ding & Choi, 2011; Wood, 2009). In particular, academic spin-offs, firms founded by scientists based on research outcomes, directly transfer these outcomes into economic application (Karnani, 2012; Steffensen et al., 2000). Thereby, the scientists either leave academia completely to work solely on their spin-off or they stay in both the academic and the commercial settings, sometimes referred to as an entrepreneurial hybrid (Lam, 2010; Nicolaou & Birley, 2003). The latter case is especially of interest because these scientists need to simultaneously engage with two settings where contradicting logics prevail (Murray, 2010; Rasmussen, 2011; Samsom & Gurdon, 1993; Shinn & Lamy, 2006). The differences between the two settings and the way to cope with them might create tensions or even failures in the academic spin-off creation process (Gurdon & Samsom, 2010).

The major challenges in founding an academic spin-off are reaching out from the known academic environment to a commercial one and adapting and acting within this commercial setting (Dasgupta & David, 1994; Rasmussen, 2011; Stephan & Levin, 1996). In this process, difficulties arise because the two settings have contradicting logics (see Table 1) (Ambos et al., 2008). These logics comprise different norms constituting scientists' roles and functions, different understandings and usages of knowledge. Also, the logics contain different reward systems incentivizing a behavior compliant with the respective norms, and different motivational factors to perform their roles and functions (Hayter, 2011; Jain et al., 2009; Lam, 2010). Furthermore, in both settings, competition exists but for different outcomes – academic and commercial success. To fulfill their roles and functions as well as to withstand the competition within each setting, specific competencies are relevant. Overcoming these differences between the two logics is a prerequisite for successfully establishing the academic spin-off. Along this process, scientists need to learn, change and adapt to successfully establish a firm. In the following, we discuss the two settings in more detail as well as the process to deal not only with the academic setting but the commercial setting, too.

According to Merton (1973), in the academic setting the ethos of science can be characterized by four norms: *communism*, *disinterestedness*, *universalism* and *organized skepticism*. To these four norms, Ziman (1984) added a fifth norm referring to *originality*.[1] These norms guarantee the freedom of research, create an open science mentality and treat knowledge as a public good to ensure the progress of science (Baldini et al., 2007; Nelson, 1959; Rosenberg, 1974). Embedded in these norms, scientists are both intrinsically and extrinsically motivated to conduct research. They are intrinsically motivated by the quest for fundamental understanding, the freedom of research as well as the enjoyment of puzzle solving (Lam, 2011; Merton, 1968). Extrinsically, they are motivated by community recognition via publications and citations (Lam, 2011). Another extrinsic motivation is financial rewards, which, however, is the least relevant (Lam, 2011). The academic reward system grants peer recognition and reputation to scientists based on their scientific contributions (Dasgupta & David, 1994). It has its basis in the evaluation of the research performance by publications and citations, leading to a predominant publication-orientation and a "publish-or-perish" culture (Ndonzuau et al., 2002). The reward system introduces competition between scientists in terms of quantity and quality of research outputs, as well as competition for scarce inputs they need for their research (van Rijnsoever et al., 2008). To successfully compete in this setting, certain competencies, such as analytical thinking, methodological and technical skills as well as the ability to communicate research results, are needed (Bartunek & Rynes, 2014; de Grande et al., 2014). Overall, the academic setting is characterized by the underlying impetus of the production and the advancement of knowledge in aiming for the progress of science (Nelson, 1959; Rosenberg, 1974). An economic rationale plays hardly any role.

The commercial setting stands opposite to the academic setting with fundamentally different logics (see Table 1). The norms of this setting revolve around market competition and rent seeking, both of which encourage behavior that leads to knowledge generation and application under cost-benefit considerations. This behavior is embedded in bureaucratic control, secrecy and restrictions on disclosure (Hayter, 2011; Sauermann & Stephan, 2013). Knowledge is understood as a private good,

[1] *Communism* of science refers to unbiased research, knowledge generation and sharing since it is considered a public good. *Disinterestedness* of science describes the independent work of academic scientists only for the contribution to the knowledge stock as an end in itself. Thus, they behave with integrity without any profit-driven motives. *Universalism* of science characterizes the verifiability of research and its results' independence of the investigator. *Organized skepticism* describes the scientists' approach of critical reflection when theorizing and conceptualizing. *Originality* entails the ambition to always search for the unknown to discover novel research results.

the aim of which is exploitation and the attainment of a competitive advantage (Dasgupta & David, 1994; Levin et al., 1987; Stephan & Levin, 1996). The focus is on application-oriented knowledge to solve problems for practical purposes (Bartunek & Rynes, 2014; Stokes, 1997). This knowledge is especially exploited by entrepreneurs who see a business opportunity (Schumpeter, 1911). They are intrinsically motivated by the passionate identification with their business, often describing it as their "baby" (Cardon et al., 2005; Huyghe et al., 2016). Extrinsically, entrepreneurs are motivated by financial gains as well as by growth intentions and self-realization (Cassar, 2007). The reward system recognizes the entrepreneurial success via profits, market shares and their maximization. Entrance or creation of new markets, cost-reduction and quality increase are core drivers of those rewards. Competition takes place for markets and market shares. Firms draw on complementary resources, especially knowledge, as a central input for an innovative activity to gain sustainable competitive advantages (Barney, 1991; Dosi & Nelson, 2010; Powers & McDougall, 2005). In this setting, particular skills and competencies, such as the ability to evaluate the commercial potential, to acquire and manage resources, to lead a team and to show vision, are required to found and run a company (Baldini et al., 2007; Shane, 2004). This describes the need for entrepreneurship specific human capital to understand business regulations and norms (Criaco et al., 2014; Stuetzer et al., 2012; Ucbasaran et al., 2008). Overall, the commercial setting is characterized by market competition in which knowledge exploitation serves as a selection criterion among the firms to generate profits and survive within the market.

Scientists are socialized in the academic setting, and commercializing research results contradicts their norms. Usually, they acquire a "taste for science" (Roach & Sauermann, 2010) which lowers their appeal to work within the commercial setting (Fritsch, 2012). The willingness to spin-off is especially reduced by the open-science mentality, which considers knowledge as a public good (Krabel & Mueller, 2009). However, for a successful application of research results in the commercial setting, scientists need to adapt to the logics of the commercial setting while fulfilling their academic role (Rasmussen, 2011). The transition from the academic to the commercial setting can be understood as a process. It is challenging, risky and the actors are confronted with tensions (Ambos et al., 2008; Neves & Franco, 2018; Samsom & Gurdon, 1993). Along this process, the scientists also make a transition in their role identity and become an academic entrepreneur (Jain et al., 2009). This spin-off creation process can be conceptualized in different phases, which scientists have to pass through to establish a spin-off. However, failure rates along this process are high because scientists might be locked-in to the academic logics and cannot adjust to the commercial logics.

Table 1: Comparison of the logics in the academic and commercial setting.

	Academic setting	**Commercial setting**
Norms	Ethos of science defined by the norms communism, disinterestedness, universalism, organized skepticism and originality (Merton, 1973; Ziman, 1984)	Market competition and rent-seeking under bureaucratic control, secrecy and restrictions on disclosure (Sauermann & Stephan, 2013)
Relation to knowledge	Knowledge production and scientific progress (Nelson, 1959; Rosenberg, 1974)	Appropriation of knowledge for commercial exploitation (Levin et al., 1987)
Motivation	Intrinsic: Quest for fundamental understanding, puzzle solving (Lam, 2011; Stokes, 1997) Extrinsic: reputation, peer-recognition and financial returns (Lam, 2011)	Intrinsic: passion for business ideas (Cardon et al., 2005) Extrinsic: financial gain and growth intentions (Cassar, 2007; Lam, 2011)
Reward system	Career progress and peer-recognition via publications, citations and rankings (Dasgupta & David, 1994)	Maximization of profit and market share
Competition	For journal publications, funding and research inputs (van Rijnsoever et al., 2008)	For markets and market share and for knowledge (Dosi & Nelson, 2010)
Competencies	Analytical thinking, methodological skills, technical skill, etc. (de Grande et al., 2014)	Ability to evaluate commercial potential, acquire resources, to lead a team and show a vision (Baldini et al., 2007; Shane, 2004)

Source: Own elaboration.

2.2 Changing relevance of the different settings during the academic spin-off creation process

2.2.1 The two settings in the academic spin-off creation process model

Scientists who want to create a new firm based on their research results have to balance the logics of the academic and the commercial setting. They usually start becoming embedded in the academic setting, where knowledge that has the potential to be commercialized is created, and academic resources, e.g. laboratories and networks, are used to further develop a business idea. Eventually, they have to cross the boundaries between academia and business to develop and exploit the business idea. This transition process leads to a change in the relevance of the two settings to successfully found a firm. For instance, Clarysse and Moray (2004) suggest in their case study that the academic setting has a stronger influence on the scientists at the beginning of the spin-off creation process. Fisher et al. (2016) conceptualized a change in relevance of goals, norms and values in the progress of adapting to the commercial setting. Based on a broader conceptualization, Rasmussen (2011) conducted case studies in which he emphasizes the change in the environment during the spin-off creation process and the difficulties in the role transformation from a scientist to an entrepreneur.

This shift in the relevance of the two settings can be linked to the notion that the spin-off process can be separated into distinct phases. In each phase, different activities must be carried out and obstacles overcome in order to establish a firm (Clarysse & Moray, 2004; Hayter, 2016a; Hossinger et al., 2020; Ndonzuau et al., 2002; Neves & Franco, 2018; Roberts & Malonet, 1996; Vohora et al., 2004). In this process, the starting point is the scientists' research activities, and the successful firm foundation constitutes the endpoint. In between these points, the process is prone to trial and error where critical steps and barriers in each phase need to be overcome regardless of the order and attempts to do so. This creates loops within each phase, which makes the transition process a quasi-linear process (Vohora et al., 2004). An important consideration is that not all scientists who engage in the academic spin-off creation process are able to complete all the steps necessary for successfully establishing a spin-off (Aldrich & Martinez, 2007; Ndonzuau et al., 2002).[2]

We conceptualize the academic spin-off creation process with four subsequent phases by combining the schemes of Clarysse and Moray (2004), Ndonzuau et al. (2002) and Vohora et al. (2004) to cover the whole development from one setting to another.[3] The four phases are: 1) Research, 2)

[2] See DeTienne (2010) and Wennberg and DeTienne (2014) for reasons for entrepreneurial exit and failure.

[3] Scholars have separated this process into two to five phases, depending on the research question they wanted to answer, e.g. Fernández-Alles et al. (2015), Ndonzuau et al. (2002), Rasmussen (2011), Roberts and Malonet (1996), Vanaelst et al. (2006), and Vohora et al. (2004).

Opportunity framing, 3) Pre-spin-off and 4) Spin-off. Along these phases, scientists have to engage with the economic setting and translate research results into economic ventures. In the following, we bring together the relevance of the two settings along the different phases of the academic spin-off creation process and hypothesize on the change of the setting's relevance for a successful transition from one phase to another.

2.2.2 Research phase

The research phase is the starting point of the venture creation process, where scientists generate new knowledge for potential commercial application. Scientists conduct research with a predominant goal-orientation towards knowledge generation and its publication for reputational gain (Lam, 2011; Merton, 1973; Vohora et al., 2004). They act according to the norms and rules of the academic setting, and the closer they follow them, the better they are embedded and the larger is their research output. Scientists differ in terms of research field and in terms of research orientation, shaping their focus either on basic research (advancement of fundamental understanding) or on applied research (consideration of use) (Stokes, 1997). While the commercial application of basic research is uncertain (Lacetera, 2009), applied research is easier to commercialize because it addresses market demands (Aghion et al., 2008). Regardless of these differences, academic research poses a necessary precondition for recognizing a business opportunity that scientists might pursue.

Several factors influence scientists' recognition of a commercial opportunity in their research (Ardichvili et al., 2003; Mary George et al., 2016). Those who generate more research results and possess more knowledge to recombine have a higher propensity to recognize business opportunities (Louis et al., 1989). Scientists, for example, realize that the identified opportunity satisfies an unfulfilled market need, which could be framed as a business idea (Bhave, 1994). Alternatively, scientists might be driven by a willingness to diffuse their knowledge and technologies, motivated to gain financial rewards as well as by other individual motivating factors (Hayter, 2011). However, engagement in academic entrepreneurship might be detrimental to an academic career, especially for the scientists at the bottom of the academic career ladder (Muscio & Pozzali, 2013), due to promotion and tenure criteria (Sá et al., 2011). Overall, not every scientist recognizes an opportunity, nor does he enter the venture creation process due to the lack of necessary preconditions (Landry et al., 2006), capacities and capabilities to understand the commercial potential (Clarysse et al., 2011) or the absence of entrepreneurial intentions (Goethner et al., 2012).

2.2.3 Opportunity framing

After scientists successfully recognize an opportunity, they enter a phase where they need to frame this opportunity as a specific business idea. Framing a business opportunity requires market related competencies and an understanding of the market value of their research results and how to exploit them (Rasmussen et al., 2011). Scientists need to clarify how to finance their business and need to either identify customer needs or create demands to enter suitable markets (Ndonzuau et al., 2002; Vohora et al., 2004). Furthermore, the technical feasibility as well as the due diligence of the business idea are vital activities to progress commercial development. Scientists can build on their academic infrastructure and their scientific relational capital to acquire the necessary know-how for feasibility tests and due-diligence (Ramos-Rodríguez et al., 2010; Rasmussen, 2011). Additionally, they can use institutional infrastructure, such as technology transfer offices, to receive support for translating their scientific knowledge into a commercial language. In particular, technology transfer offices can act as boundary-spanners between the academic and the commercial setting (Comacchio et al., 2012).

In this phase, scientists need to take into account commercial logics and consider the norms and different utilization of knowledge with a focus on practical application, problem-solving and the evaluation of financial returns. To understand the commercial logics and how to satisfy customer needs, past experience in the commercial setting can be beneficial (Shane, 2004). Past experience is especially relevant to realistically assess the commercial value of their knowledge and technologies (Siegel et al., 2004). As opposed to the public good character of knowledge in the academic setting, protecting the research results and the secrecy of the business idea against unintended knowledge spillover become relevant (Ndonzuau et al., 2002). The opportunity framing phase ends with a commitment to the spin-off project and the initiation of preparatory steps, such as writing a detailed business plan (Vohora et al., 2004). However, not every scientist at this point in the spin-off creation process has this commitment to become an academic entrepreneur and decides to move forward and invest substantially into the spin-off project (Ndonzuau et al., 2002). Reasons for that are especially limited entrepreneurial self-efficacy (Huyghe & Knockaert, 2015), lack of competencies (González-López et al., 2021), a perception that such a spin-off project is too time-consuming and too risky, as well as no willingness to discard the open science mentality (Erikson et al., 2015; Krabel & Mueller, 2009; Nelson, 2016).

2.2.4 Pre-spin-off phase

The commitment to found a firm needs to be implemented in the pre-spin-off phase with the goal to develop the idea to the stage where the firm is ready to enter the aspired market. To achieve this market readiness, a business plan is an essential step, which defines the mid- and long-term goals (Vohora et al., 2004). Writing a business plan requires an adaptation to commercial logics – for instance, having the right competencies, such as managerial skills, and understanding market competition (van Geenhuizen & Soetanto, 2009; Vohora et al., 2004). The business plan is designed to attract potential stakeholders and involves the commercial assessment of the business project and sets its strategic direction (Ndonzuau et al., 2002). Thereby, scientists turn away from the academic usage of their research findings towards commercial exploitation (Fisher et al., 2016). Besides the business plan, resources, such as financial as well as material or qualified personnel, need to be acquired (Fernández-Alles et al., 2015; Hayter, 2016a, 2016b). For some of these resources, the research organization can still be seen as a resource provider or as an intermediary, such as technology transfer offices, which help to acquire them (Huyghe et al., 2014; Rasmussen, 2011). However, most of the financial and human resources must be acquired outside the academic setting (Fernández-Alles et al., 2015; Hayter, 2016a, 2016b).

A thorough understanding of the commercial logics is essential in the pre-spin-off phase, which is fostered by a high embeddedness in the commercial setting. Especially established contacts with actors in this setting, e.g. via previous work experience or collaborative activities with industry, create this embeddedness (Audretsch et al., 2011; Fernández-Alles et al., 2015; Hayter, 2016a; Huynh et al., 2017). Embeddedness eases writing the business plan and acquiring resources. If this is successful, the actual firm can be founded. However, not every scientist does this step. One reason for failed spin-off projects within this phase is the lack of resources, especially venture capital (Wright et al., 2006). Furthermore, some scientists are not able to fully adapt to the commercial logics. Hence, they face tensions between the two settings which prevent them from conducting the necessary steps (Gümüsay & Bohné, 2018; Gurdon & Samsom, 2010). Major reasons for that are allocating enough time to create the business plan and to conduct other necessary activities such as prototyping, since these activities compete with time and preference for research (Barham et al., 2014; Moog et al., 2015). For instance, academic career development and additional duties within academia (e.g. teaching or administration) might come too short (Gilsing et al., 2011; Jacobson et al., 2004; Sá et al., 2011). Overall, uncertainty about the commercial viability of the founding project and insecurity of their personal future prevents them from establishing a firm (Mathisen & Rasmussen, 2019; Raposo et al., 2008).

2.2.5 Spin-off phase

With the founded firm, the spin-off creation process ends. The idea of the scientist has left the academic setting and is successfully transferred into a commercial venture. Hence, business activities in this phase are clearly dominated by the commercial setting. The firm development can take different directions. For instance, the business model can change over time as the academic entrepreneur improves her commercial knowledge (Druilhe & Garnsey, 2004; Heirman & Clarysse, 2004; Rasmussen et al., 2011). While some scientists remain in their founded firm and, thus, in the commercial setting, others exit. This can be either due to a firm's closure or due to its sale (DeTienne, 2010; Wennberg & DeTienne, 2014).

2.2.6 Hypotheses

The four phases previously described constitute the key building blocks of a successful academic spin-off creation process. Facing those four phases, the scientists have to make three transitions to move from the initial research phase to the final spin-off phase (see Figure 1). Thereby, with each transition, the population of scientists decreases because they do not succeed in the necessary steps to move to the next phase, or they leave for other reasons. We argue that the embeddedness in the different settings is decisive for a successful transition from one phase to the next. Thereby, the relevance of each setting changes along the whole academic spin-off creation process. Based on the relevance of the two settings for each phase and in line with Rasmussen (2011) and others (e.g. Fini & Toschi, 2016; Fisher et al., 2016), we hypothesize that the relevance of the academic setting decreases along the process whereas the relevance of the commercial settings increases.

With respect to the academic setting, we expect a decline in its relevance along the process. Conducting research is the predominant activity in the first phase of the spin-off creation process. The scientists' embeddedness in the academic setting is particularly important because it influences the generation of knowledge from which a business opportunity can be recognized and a first transition made. However, the relevance of the academic setting decreases in the subsequent phase. Even though scientists still benefit in the opportunity framing phase from their embeddedness within the academic setting, e.g. by using their academic human and relational capital as well as the infrastructures, the relevance is less pronounced for the second transition. In the pre-spin-off phase, scientists need to largely leave the academic logic behind to successfully commercialize their idea and focus on the commercial exploitation of their knowledge. This renders the academic setting even less relevant and

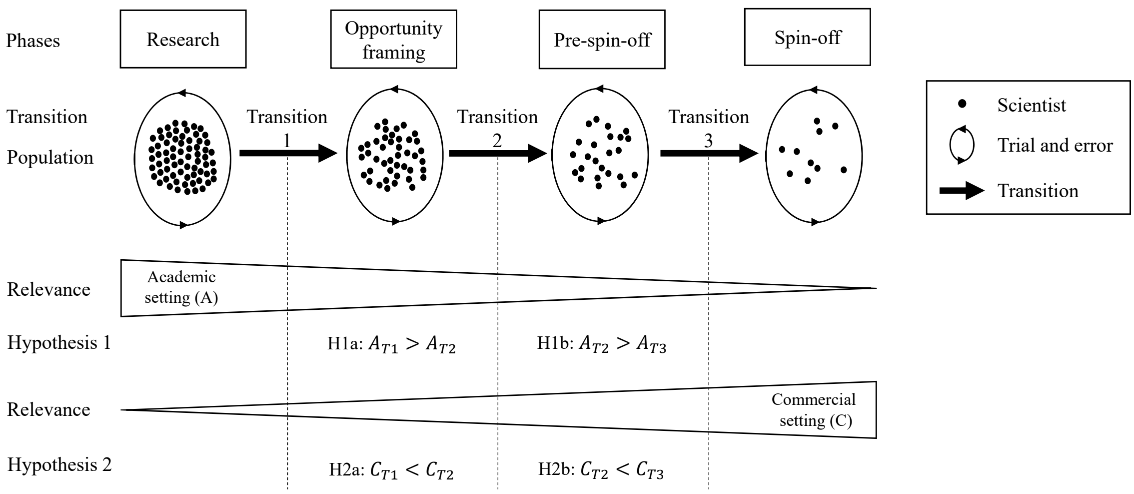

Figure 1: Conceptualization of the transition process and the changing relevance of settings.

can even become a barrier for the third transition to establish a firm. Based on these considerations, we hypothesize:

H1a: The academic setting is more relevant for Transition 1 than for Transition 2.

H1b: The academic setting is more relevant for Transition 2 than for Transition 3.

In contrast to the academic setting, we propose the opposite development for the commercial setting. Even though the initial research phase is dominated by the scientists' embeddeddness in the academic setting, a basic understanding of the commercial logic is required to identify the commercial potential of new research knowledge and to make the first transition. To further develop this idea and frame the entrepreneurial opportunity, experience in or at least with the commercial setting can help to adopt the commercial logic that gains importance in this phase and, thus, to make a successful second transition. In the pre-spin-off phase, scientists have to focus on the commercial exploitation of knowledge. Also, they need to understand the norms and apply the rules of the commercial setting, where previous experiences and contacts with the commercial setting are of high importance. The embeddedness in the commercial setting is highly relevant for the last transition to venture creation. This line of argument for the increasing relevance of the commercial setting allows us to propose the following hypotheses:

H2a: The commercial setting is less relevant for Transition 1 than for Transition 2.

H2b: The commercial setting is less relevant for Transition 2 than for Transition 3.

3 Data and method

3.1 Data

We conducted a novel online survey of academic scientists in the German Federal State of Thuringia to understand the academic spin-off creation process. Thuringia resembles the heterogeneity in the German research landscape well. There are four universities in Thuringia, including one technical university and one university with a university hospital. Furthermore, seven universities of applied sciences, including one music college and 25 research institutes, are present. The research institutes cover the whole range from basic science-oriented institutes of the Max Planck Society, the Helmholtz Association and the Leibnitz Association to the applied science institutes, including the Fraunhofer Society, as well as other public and private research organizations (see Table S3 in the supplementary material). This variety of organizations assures coverage of different disciplines and different modes of research.

We collected publicly available contact information and characteristics of the scientists from their institutional web pages. We identified 7,785 scientists who we invited to participate in our web-based survey in December 2019 and January 2020. We received 1,409 responses (18.1% response rate) of which we had to exclude 260 observations due to incomplete answers and conduct our analysis with 1,149 observations. The difference between the sample of respondents and the initial population is marginal and non-response bias unlikely.[4] A comparison with the overall population of scientists at universities in Germany (Statistisches Bundesamt, n.d.) shows that our sample is representative in terms of academic rank and gender (Table S2).

Our survey consists of a set of novel questions on the academic spin-off creation process. To ensure reliability of our survey, we discussed the items with other scientists and practitioners from technology transfer offices and conducted a pre-test with a random sample of researchers from a comparable German state, as suggested by Sue and Ritter (2007). In our survey, we elicited scientists' general socio-demographic characteristics as well as their engagement in knowledge and technology transfer. We included a list of questions, especially on their spin-off creation activities in the last five years. Respondents were asked separately for their activities in the four different phases of the spin-off creation process (see Figure 1). This retrospective survey of their activities allows us to overcome the cross-sectional nature of the survey and to reconstruct the spin-off creation process into successive

[4] We compared the key characteristics position, gender, organizational focus and academic discipline (Armstrong & Overton, 1977) in Table S1. There are some statistical significant differences with respect to the disciplines. There is especially an under-representation of researchers from medicine in our respondents. We believe that our initial data collection included many medical doctors with an affiliation to the university hospital but who are not involved in research anymore.

phases. Furthermore, asking about the different phases individually allows us to not only consider successful spin-off creations, as is usually the case in studies tracking scientists along the academic spin-off creation process (e.g. Fernández-Alles et al., 2015; Fini et al., 2009; Hayter, 2016a), but also spin-off attempts, which stopped at different phases along the process. Our study considers only the scientists who, in addition to their spin-off project, continued in academia, neglecting spin-offs where the entrepreneur left academia. This specific subgroup of scientists is of our interest because they need to act in both the academic and the commercial settings.

In addition to the survey data, we collected data on the respondents' publication record from Web of Science (WoS) and Scopus.[5] Furthermore, we collected the publications' source normalized impact factor (SNIP) as provided in the journal record of Scopus.

3.2 Variables

3.2.1 Dependent variables

To measure a scientist's successful transition along the four phases of the academic spin-off creation process (Research phase, Opportunity framing, Pre-spin-off phase and Spin-off phase), we construct three dummy variables for each successful phase transition. A transition from one phase to the next is regarded as successful in our data if scientists undertook activities relevant to the subsequent phase. First, we treat all our respondents as part of the Research phase, since they are all scientists conducting research. If respondents reported any business idea recognition or development, e.g. via a discussion with others or an application of creative techniques, they made the first transition (T1) into the Opportunity framing phase. Second, those who reported any activities to prepare the firm foundation, e.g. development of a prototype, preparation of a business plan or acquisition of resources, managed the second transition (T2) and, thus, reached the Pre-spin off phase. Third, respondents completed the third transition (T3) into the Spin-off phase if they reported the foundation of an academic spin-off. From this information, we construct three dummy variables which take the value 1 if respondents successfully transitioned into the next process phase and 0 otherwise.[6]

[5] Our primary source for publication data is WoS. If there is no publication record in WoS for a surveyed scientist, we queried Scopus which has a larger coverage for some disciplines esp. for social sciences and humanities (Martín-Martín et al., 2021). If, again, there are no publications in Scopus listed, we treated such cases as zero, which is plausible especially for PhD students. In doing so, we probably underestimate the influence of publications.

[6] We impose a constraint that scientists had to be active in all previous phases to be considered for a successful transition. In 40 cases, scientists entered the spin-off creation process after the Opportunity framing phase, or they skipped one phase in between and re-entered the process later. We excluded these cases from the later transitions to have a consistent process.

3.2.2 Independent variables

We use two sets of variables to operationalize the scientists' embeddedness in the academic and commercial settings. These sets of variables capture the specific characteristics of each setting, as described in Section 2. For a comprehensive overview of the variables see Table A1 in the Appendix.

Academic setting: We use six variables to proxy scientists' embeddedness in and exposure to the academic setting. First, we create a dummy variable indicating if the scientist is a *professor* or not.[7] The academic rank of a professor in Germany, especially, is a clear indicator for the embeddedness in the academic setting. Previous research shows that the deep embeddedness of professors in the academic setting has a negative relationship with spin-off creation (e.g. Aldridge et al., 2014; Fritsch & Krabel, 2012). Second, we use *time devoted to research* as an indicator of the extent to which scientists value research activity and how they respond to the incentives provided by the academic reward systems. Survey participants were asked to state the share of weekly working hours spent on research activities. Third, the *number of publications* reflects the scientists' reputation as well as their embeddedness in the scientific community. Furthermore, scientific publications serve as a knowledge pool from which commercializable ideas can be identified. Prior research suggests a positive relationship between publication output, research reputation and the propensity to be involved in spin-off activities (e.g. Ding & Choi, 2011; Zucker et al., 1998). We log-transform the scientists' number of publications to account for its skewed distribution. Fourth, we use the *average impact factor* to measure the quality of scientists' research output. Similar to the quantity, a higher quality increases the embeddedness in the academic setting due to reputation and potentially increases access to resources. We construct the variable by averaging the SNIP for each researcher's journal publication to account for differences across disciplines. Then, we include two variables to measure scientists' research orientation within the last five years. Following Amara et al. (2019), respondents were asked to indicate the extent to which they conduct *basic research*, characterized by contributions to fundamental understanding and the extent to which *applied research* is conducted, characterized by the consideration of use of her/his research results. Both variables were assessed on a 4-point Likert scale, ranging from "not at all" to "a lot". Higher scores indicate a stronger embeddedness in the academic system, since they aim to generate research output which concentrates on less understood research problems and new academic practices (Amara et al., 2019).

[7] We treat junior professors as well as directors or heads of department in research institutes equal to full professors.

Commercial setting: We use four variables to operationalize the scientists' embeddedness in the commercial setting. First, the *share of publications with industry* measures scientists' endowment with both commercialization-specific human capital and network ties with actors from the commercial setting (D'Este et al., 2012; Fritsch & Krabel, 2012; Krabel & Mueller, 2009). We calculate the variable as the number of publications with at least one co-author with industry affiliation over the total number of publications. Second, scientists can benefit in the same way from previous *work experience outside academia*. Non-academic work experience can increase awareness of differences between the academic and the commercial setting, and scientists who previously worked in the industry are more likely to engage in commercial activities and to adapt to the commercial setting (Gulbrandsen & Thune, 2017). Third, the *time devoted to knowledge and technology transfer (KTT)* indicates how much time scientists spend per week to engage with the commercial setting. The more time scientists spend on transfer activities, the more likely they are to be familiar with the commercial setting and to better understand the rules and norms of the commercial setting. Lastly, we asked the survey participants about their *disclosed intellectual property (IP)*, the number of ideas or inventions disclosed to the employer that may have commercial potential or be legally protected since 2015. The generation of IP that could potentially be patented indicates scientists' interest in research commercialization and their understanding of the relevance of IP in the commercial environment. Patenting has been found to relate positively to spin-off intentions (Goethner et al., 2012; Prodan & Drnovsek, 2010) and successful firm foundations by academics (Ding & Choi, 2011; Krabel & Mueller, 2009; Landry et al., 2006).

3.2.3 Control variables

In our empirical analysis, we control for several factors that influence the successful creation of academic spin-offs. First, we control for whether the scientist is *female* or not, since a strong gender gap has been identified in the literature (Guzman & Kacperczyk, 2019). Second, we ask the survey participants about their *risk willingness* on an 11-point Likert scale. Scientists' attitude towards risk is highly influential for the persistence in continuing with the spin-off creation process (Fini & Toschi, 2016; Fritsch & Krabel, 2012; Stephan & El-Ganainy, 2007). Third, we control for organizational heterogeneity in the mode of knowledge generation, which influences the general embeddedness of scientists in a setting (e.g. Bercovitz & Feldman, 2008). We create a categorical variable to account for the *organizational focus* which distinguishes the research focus of the scientists' organization in three groups: *basic*, *between basic and applied* and *applied*. We rely on a broad categorization of the

German ministry for Science and Education (Bundesministerium für Bildung und Forschung, 2014).[8] Lastly, we control for differences in spin-off activities across disciplines (see, e.g. Abreu & Grinevich, 2013). Therefore, we distinguish seven broader disciplines: *engineering*, *humanities*, *life sciences*, *medicine*, *physics*, *chemistry*, *social sciences* and *computer science and mathematics*.

3.3 Empirical approach

We apply dominance analysis to test our hypotheses on the relevance of the two settings along the academic spin-off creation process. Dominance analysis computes the relative importance of predictors among each other and decomposes the overall goodness-of-fit measure of a regression into the predictors' individual contribution (Azen & Budescu, 2003; Azen & Traxel, 2009; Budescu, 1993). The dominance analysis allows us to assess which predictor or set of predictors—the academic setting and the commercial setting, in our case—contributes relatively more to the transition into the next phase of the spin-off creation process. Compared to other approaches such as standardized regression coefficients, dominance analysis has the advantage of accounting for correlation among the predictors (Azen & Traxel, 2009).

To conduct the dominance analysis, we first estimate each transition regression. Since the transition is a binary outcome variable Y, we use logistic estimations for each of the transitions $T = \{1,2,3\}$ and the respective individual scientists i in the following stylized form:

$$log(\frac{Y_{iT}}{1-Y_{iT}}) = \alpha + \beta \mathbf{A}_i + \gamma \mathbf{C}_i + \delta \mathbf{Z}_i + \varepsilon_i \tag{1}$$

where $\mathbf{A_i}$ is the set of variables for the academic setting and $\mathbf{C_i}$ is the set of variables for the commercial setting. $\mathbf{Z_i}$ is the set of control variables and ε_i is an error term. We estimate the regression for each of the transitions T individually.

We use the McFadden (1974) R^2 as our goodness-of-fit measure for the dominance analysis. The McFadden (1974) R^2 is frequently used in logistic regressions and fulfills the criteria to be used in a dominance analysis (Azen & Traxel, 2009).[9] The calculation of the relative dominance is an iterative process. Starting with one predictor, the gain in importance is measured with adding another predictor and so forth. This results in a set of regressions where each predictor is compared against

[8] Research institutes of the Leibnitz Association, the Max Planck Society and similar are allocated to basic research, universities are located between basic and applied research and universities of applied sciences as well as institutes such as the ones from the Fraunhofer Society and similar are allocated to applied research (see Table S3).

[9] Azen and Traxel (2009) propose four criteria that a goodness-of-fit measure should fulfill to be suitable for dominance analysis. Besides the McFadden R^2, the Nagelkerke R^2 and the Estrella R^2 can be used, but Azen and Traxel (2009) show analytically that they result in the same direction of dominance, just with a different level of magnitude. Our results are robust with the different goodness-of-fit measures.

every other predictor, and all combinations of predictors are compared against all other combinations. The general dominance is the average of all the gains the predictor has across the different iterations (see Azen & Traxel, 2009, for a detailed example). In our case, we do not conduct the dominance analysis on each predictor but on sets of predictors, the academic and the commercial settings as well as the control variables. For each of these three sets, we calculate the general dominance, where the sum of the general dominance is equal to the overall goodness-of-fit measure of the estimation. As suggested in Azen and Traxel (2009), we furthermore apply bootstrapping to generate a distribution of relative dominance values.[10] To empirically test our hypotheses, we conduct two-sided *t*-tests to compare the mean of the bootstrapped distributions for each setting across the different transitions.

We conduct three robustness tests with respect to our econometric approach, our control variables and our operationalization of the spin-off creation process. First, we use a linear probability estimation and apply the dominance analysis for the OLS regressions (Azen & Budescu, 2003; Budescu, 1993). Second, we conduct another set of linear probability regression, including organizational fixed effects to control for differences between organizations and replacing the organizational focus. Third, we use a different operationalization of the transition process, in which the population of scientists does not change between the phases.

4 Results

4.1 Descriptive results

The descriptive statistics in Table 2 and the correlations for each of the three transitions in Tables S4, S5 and S6 provide a first indication of the transition process and the changes with respect to the two settings. We report descriptive statistics for the three transitions T1, T2 and T3 separately, since they show a distinctive pattern. With respect to the successful transitions along the process, we see a substantial attrition of scientists. Only 22% (249 out of 1,149) recognized a business opportunity necessary for the first transition (T1). The next step, developing the opportunity further to reach the pre-spin off phase (T2), was successful for 58% (145 out of 249). Making it to venture creation (T3), e.g. after acquiring the necessary resources, was achieved only by 44% (64 out of 145), which is 5.6% of the initial sample.[11] Such low success rates are frequently reported in the literature (e.g. Abreu & Grinevich, 2013; D'Este et al., 2019; Haeussler & Colyvas, 2011).

For the independent variables constituting the academic setting, the attrition of scientists along

[10] However, Azen and Traxel (2009) note that the bootstrapping generates larger standard errors than a sampling from the full population but is still considered reliable.

[11] Descriptive statistics for the 64 successful academic entrepreneurs are provided in Table A2.

the transition process reveals a selection of specific characteristics in the sample population. For nearly all six variables, we see a clear trend in the means. The share of *professors* in the sample increases, but the mean *time devoted to research* decreases along the transitions. Only for the *number of publications* is there first an increase but then a decrease in the mean along the process. For publications' *average impact factor*, we also see a decreasing trend. The two variables describing the extent of the scientists' *basic research* and *applied research* show an increase, reflecting an ideal-type of academic scientist in search of both new insights and applications (Amara et al., 2019; Stokes, 1997). When comparing these developments with the scientists who found a firm, these trends are confirmed (see Table A2).

A similar development can be observed for the variables of the commercial setting. The means of the *share of publications with industry*, *work experience outside academia*, *time devoted to KTT* and the *disclosed IP* all increase from transition to transition in the remaining samples. When we compare the trends with the scientists who found a firm, the development is consistent for only two of them (see Table A2).

In addition, the control variables show a similar pattern. We find a decreasing trend in *female* scientists and an increase in *risk willingness*. There is also a selection towards organizations which have a focus on applied research along the process. Trends among the disciplines are also observable, e.g. the number of scientists from life science or medicine decline in the population along the process. Overall, the development of the sample characteristics indicates that selection on these criteria takes place, indicating their relevance for the different settings.

4.2 Regression results and dominance analysis

In the following, we discuss the results of our empirical analysis. To test our hypotheses on the changing relevance along the academic spin-off creation process, we first report logistic regression results for each transition and the respective dominance analysis of the two settings in Table 3. We estimate one model for each of the three transitions (Model 1-3). For each model, we conduct dominance analysis to decompose the overall McFadden R^2 goodness-of-fit measure into a R^2_A for the academic setting and a R^2_C for the commercial setting (and R^2_Z for the control variables). We report the absolute values as well as the relative share of each setting in the overall McFadden R^2, which is our measure of interest. In a second step, we bootstrap the dominance analysis and present the distribution of the relative R^2_A and R^2_C values in Figure 2.[12] Lastly, we conduct two-sided *t*-tests on the difference in

[12] Azen and Traxel (2009) and Tonidandel and LeBreton (2011) suggest that in the case of relative importance analyses, samples of a dominance analysis should be replicated in sufficient numbers to extend the results by confidence intervals. Therefore, we calculate 5,000 bootstrap samples for each model and provide sample statistics.

Table 2: Descriptive statistics for the three transitions.

	Mean			Standard Deviation			Minimum			Maximum		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Dependent variables												
Transition 1 (=1)	0.22			0.41			0			1		
Transition 2 (=1)		0.58			0.49			0			1	
Transition 3 (=1)			0.44			0.50			0			1
Academic setting												
Professor (=1)	0.18	0.24	0.30	0.39	0.43	0.46	0	0	0	1	1	1
Time devoted to research	52.37	49.73	46.13	27.11	23.89	24.63	0	0	0	100	100	100
Number of publications	21.86	28.95	25.68	50.89	69.88	70.53	0	0	0	532	532	532
Average impact factor	0.91	0.84	0.74	0.79	0.74	0.66	0	0	0	4.80	4.80	2.40
Basic research	2.54	2.75	2.78	0.71	0.73	0.73	1	1	1	4	4	4
Applied research	2.75	3.11	3.26	0.86	0.74	0.68	1	1	2	4	4	4
Commercial setting												
Share of publications with industry	0.03	0.05	0.06	0.12	0.15	0.18	0	0	0	1	1	1
Time devoted to KTT	8.22	11.59	14.75	11.95	13.63	15.41	0	0	0	100	100	100
Disclosed IP	0.40	0.90	1.22	1.42	1.82	2.23	0	0	0	16	16	16
Work experience outside academia	1.37	1.72	2.08	1.45	1.52	1.45	0	0	0	4	4	4
Control variables												
Female (=1)	0.37	0.27	0.26	0.48	0.45	0.44	0	0	0	1	1	1
Risk willingness	6.52	7.12	7.39	2.18	2.06	2.01	1	1	3	11	11	11
Organizational focus: between basic and applied	0.64	0.59	0.54	0.48	0.49	0.50	0	0	0	1	1	1
Organizational focus: basic	0.15	0.12	0.10	0.36	0.33	0.30	0	0	0	1	1	1
Organizational focus: applied	0.21	0.29	0.36	0.41	0.45	0.48	0	0	0	1	1	1
Discipline: Computer Science and Mathematics	0.11	0.14	0.15	0.31	0.35	0.36	0	0	0	1	1	1
Discipline: Engineering	0.16	0.21	0.24	0.37	0.41	0.43	0	0	0	1	1	1
Discipline: Humanities	0.10	0.08	0.08	0.30	0.27	0.27	0	0	0	1	1	1
Discipline: Life Sciences	0.15	0.13	0.09	0.36	0.34	0.29	0	0	0	1	1	1
Discipline: Medicine	0.10	0.08	0.07	0.30	0.27	0.25	0	0	0	1	1	1
Discipline: Physics and Chemistry	0.19	0.23	0.22	0.40	0.42	0.42	0	0	0	1	1	1
Discipline: Social Sciences	0.19	0.13	0.15	0.39	0.34	0.36	0	0	0	1	1	1

Note: There are 1,149 observations for T1, 249 observations for T2 and 145 observations for T3.

Table 3: Logit regression results and dominance analysis for the three transitions.

	(1)	(2)	(3)
	Transition 1	Transition 2	Transition 3
	Research to *Opportunity recognition*	*Opportunity recognition* to *Pre-spin-off*	*Pre-spin-off* to *Spin-off*
Academic setting			
Professor (=1)	0.045 (0.237)	1.111** (0.475)	0.563 (0.584)
Time devoted to research	−0.003 (0.004)	0.002 (0.008)	0.002 (0.011)
Number of publications	−0.011 (0.078)	−0.238* (0.139)	−0.367* (0.192)
Average impact factor	−0.173 (0.150)	−0.248 (0.242)	0.389 (0.415)
Basic research	0.408*** (0.126)	0.097 (0.225)	−0.017 (0.302)
Applied research	0.376*** (0.099)	0.064 (0.222)	0.015 (0.310)
Joint R^2_A	**0.046 (35.2%)**	**0.057 (29.6%)**	**0.022 (15.8%)**
Commercial setting			
Share of publications with industry	0.830 (0.878)	1.276 (1.165)	−1.542 (1.589)
Time devoted to KTT	0.005 (0.006)	0.053*** (0.020)	0.028* (0.015)
Disclosed IP	0.942*** (0.193)	0.718** (0.293)	0.168 (0.323)
Work experience outside academia	0.097* (0.058)	0.232** (0.118)	−0.037 (0.148)
Joint R^2_C	**0.056 (42.5%)**	**0.098 (51.0%)**	**0.021 (15.4%)**
Control variables			
Female (=1)	−0.349** (0.178)	0.043 (0.348)	−1.025** (0.501)
Risk willingness	0.101*** (0.038)	0.102 (0.077)	0.145 (0.104)
Organizational focus: basic	−0.260 (0.279)	0.709 (0.477)	0.538 (0.735)
Organizational focus: applied	0.072 (0.223)	0.304 (0.408)	−0.614 (0.499)
Discipline: Engineering	−0.453 (0.306)	−0.154 (0.545)	−0.796 (0.658)
Discipline: Humanities	−0.486 (0.353)	−0.518 (0.665)	0.435 (0.879)
Discipline: Life Sciences	0.007 (0.322)	−0.831 (0.607)	−0.078 (0.823)
Discipline: Medicine	−0.244 (0.341)	−0.026 (0.703)	−0.259 (0.964)
Discipline: Physics n Chemistry	−0.014 (0.297)	−0.106 (0.518)	−0.653 (0.647)
Discipline: Social Sciences	−0.492* (0.293)	0.127 (0.612)	0.721 (0.731)
Joint R^2_Z	**0.029 (22.3%)**	**0.037 (19.4%)**	**0.096 (68.8%)**
Constant	−3.866*** (0.513)	−1.726* (1.037)	−0.928 (1.450)
N	1,149	249	145
Log Likelihood	−522.020	−136.658	−85.699
Akaike Inf. Crit.	1,086.039	315.316	213.399
McFadden R^2	0.131	0.192	0.139

Note: A: Academic setting, C: Commercial setting, Z: Controls. Robust standard errors in parentheses. Significance at $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table 4: Differences in bootstrapped relative dominance based on logit estimates for the three transitions.

	T1 mean	T2 mean	T3 mean	difference mean T2-T1	difference mean T3-T2
Academic setting R^2_A	34.6% (0.09)	29.7% (0.10)	22.5% (0.13)	-4.9%***	-7.2%***
Commercial setting R^2_C	40.1% (0.09)	43.4% (0.12)	17.0% (0.12)	3.3%***	-26.4%***

Note: 5000 bootstrapped replications. Standard errors in parentheses. Differences in means tested by two-sided *t*-tests. Significance at *p<0.1; **p<0.05; ***p<0.01.

means of the bootstrapped relative R^2_A and R^2_C values for the transitions (see Table 4).

4.2.1 Relevance of the academic setting

For hypothesis 1a, we compare Model 1 with Model 2 and the respective contribution of the academic setting (Table 3). For the first transition (T1) in Model 1, the overall McFadden R^2 is 0.131. The dominance analysis decomposes this overall R^2 into the Joint R^2_A of 0.046 for the academic setting, which is a relative contribution of 35.2% to the overall model fit. Among the individual variables that constitute scientists' embeddedness in the academic settings, only the research foci towards *basic research* and *applied research* show significant coefficients. Neither the scientists' position nor their publication output matter for the first transition. With respect to the bootstrapped sample (Figure 2 and Table 4), the Joint R^2_A from the estimation is very close to the bootstrapped median and the average of 34.6%. In Model 2 for the second transition (T2), the overall McFadden R^2 is higher with 0.192 as is the absolute Joint R^2_A with 0.057 compared to Model 1. In relative terms, the R^2_A accounts for only 29.6% in Model 2 and is lower compared to the first model. With respect to the individual variables for the embeddedness in Model 2, being a *professor* has a significant influence on a successful transition. We also observe a negative, but weakly significant coefficient of the *number of publications*. Since the variable acts as a proxy for the relationship between the embeddedness and the transition success, here a higher embeddedness reduces the success.[13] The bootstrapped dominance analysis shows again a similar median as well as a similar average of 29.7% to the Joint R^2_A of 29.6%. Our Hypothesis 1a postulates a lower relative importance of the academic setting for the second transition compared to the first. The negative difference of the Joint R^2_A for the dominance analyses of the two models supports such a relationship. Also, the bootstrapped distribution supports this relationship, but the distribution for the second transition has a higher dispersion than for the first. Furthermore, the *t*-test on the difference between R^2_A from Transition 1 and 2 is statistically significant at the 1% level

[13]Since goodness-of-fit measures do not distinguish between the direction of a coefficient, but we are interested in the influence of a higher embeddedness, we estimated an additional Model 2a without the *number of publications* to remove the negative contribution of the variable to the overall measure of embeddedness. The Joint R^2_A without this variable is slightly lower with 27.6% of the overall model fit (see Table S7).

(Table 4). Overall, we find support for Hypothesis 1a, which suggests a higher relevance of the academic setting for the first transition from the research phase to the opportunity framing phase than for the second transition from the opportunity framing phase to the pre-spin-off phase.

For the hypothesis 1b, we compare Model 2 with Model 3 and the respective contribution of the academic setting (Table 3). In Model 3 for the last transition (T3), the overall McFadden R^2 is 0.139. The Joint R^2_A is comparably small, 0.022 in absolute terms and 15.8% in relative terms. Among the individual variables, the *number of publications* has again a significant but negative coefficient.[14] The other variables show no significant coefficients. The bootstrapped distribution of the relative R^2_A shows slightly deviating results, with a higher median and an average of 22.5%. Our Hypothesis 1b states that the relative importance of the academic setting for the third transition is lower compared to the second. The negative difference of the Joint R^2_A for the dominance analyses of Model 2 and Model 3 supports such a relationship, especially if the influence of the *number of publications* is accounted for. Also, the bootstrapped distribution of the relative R^2_A supports this relationship and a t-test on the difference between R^2_A from transition two and three is statistically significant at the 1% level (Table 4). Overall, we find support for Hypothesis 1b, which implies a higher relevance of the academic setting for the second transition from the opportunity framing phase to the pre-spin-off phase than for the third transition from the pre-spin-off phase to the spin-off phase.

4.2.2 Relevance of the commercial setting

For hypothesis 2a, we compare Model 1 with Model 2 and the respective contribution of the commercial setting (Table 3). In Model 1, the commercial setting R^2_C contributes 0.056 to the overall McFadden R^2 of 0.131, which is 42.5% in relative terms. Among the different variables for the embeddedness in the commercial setting, the *disclosed IP* and *work experience outside academia* have positive and significant coefficients. The other two variables are insignificant. Bootstrapping shows a slightly lower median (Figure 2) and an average of 40.1% for the relative importance of R^2_C (Table 4). In Model 2 (Table 3), the R^2_C is 0.098 in absolute terms and 51.0% in relative terms. The significant variables from Model 1 are again significant in Model 2. Additionally, *time devoted to KTT* has a significant coefficient for the transition to the pre-spin off phase. Similar to Model 1, the bootstrapped distribution shows in the median (Figure 2) and on average a smaller R^2_C (43.4%) (Table 4). The relative R^2_C 51.0% from the initial estimation is above the third quartile of the bootstrapped distribution, showing some considerable deviation. Hypothesis 2a postulates a higher relative impor-

[14] Similar to the previous transition estimation, we estimated an additional Model 3a without the *number of publications* to remove the negative contribution of the variable to the overall measure of embeddedness. The Joint R^2_A without this variable accounts now for only 2.4% of the overall model fit (see Table S7).

tance of the academic setting for the second transition compared to the first. The positive difference of the Joint R^2_C for the dominance analyses of Model 1 and Model 2 supports such a relationship. The bootstrapped distribution supports this relationship as well but on a slightly lower relative level. The t-test on the difference between R^2_C from Transition 1 and Transition 2 is statistically significant at the 1% level (Table 4). Overall, we find support for Hypothesis 2a, which suggests a lower relevance of the commercial setting for the first transition from the research phase to the opportunity framing phase than for the second transition from the opportunity framing face to the pre-spin-off phase.

For the hypothesis 2b, we compare Model 2 with Model 3 and the respective contribution of the commercial setting (Table 3). The commercial setting in Model 3 has only an absolute R^2_C of 0.021 and a relative one of 15.4%, indicating a very low contribution to successful firm foundation. Among the individual variables, only the *time devoted to KTT* has a significant coefficient. The bootstrapped distribution of the relative R^2_C is in its median and mean of 17.0% very similar (Figure 2 and Table 4). Our Hypothesis 2b states that the relative importance of the commercial setting for the third transition is higher compared to the second. The large negative difference of the Joint R^2_C for the dominance analyses of Model 2 and Model 3 indicates a rejection of such a relationship. The bootstrapped distribution of the relative R^2_C does not support the hypothesized relationship, either. The t-test on the negative difference between R^2_C from transition two and three is statistically significant at the 1% level. Overall, we do not find support for Hypothesis 2b on a lower relevance of the commercial setting for the second transition from the opportunity framing phase to the pre-spin-off phase than for the third transition from the pre-spin-off phase to the spin-off phase.

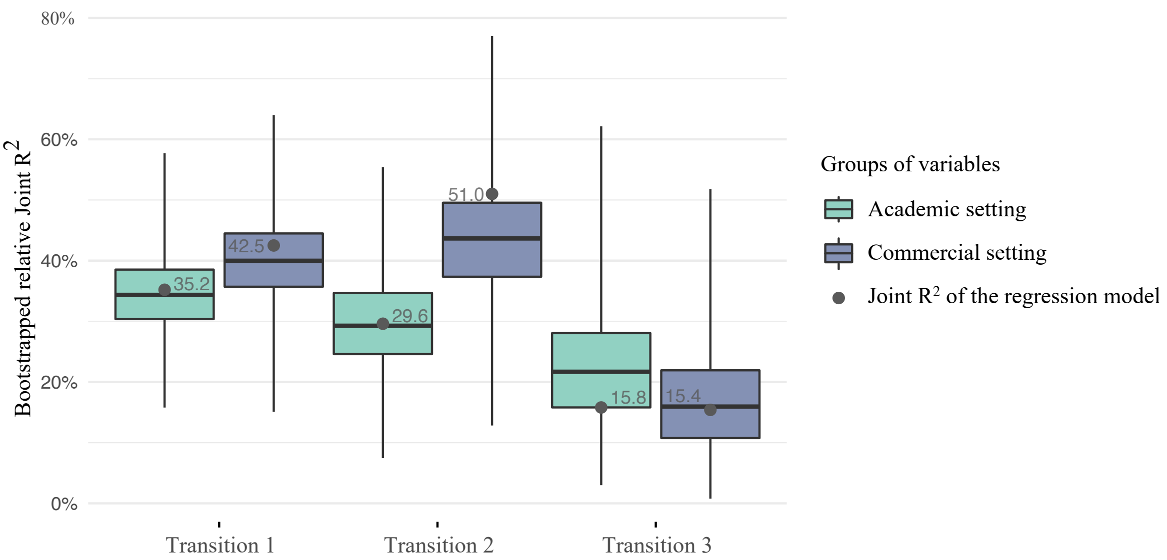

Figure 2: Dominance analysis on logit estimates for the three transitions based on 5,000 replications.

4.2.3 Control variables

The results concerning our control variables show a relative R_Z^2 around 20% for transition 1 and 2. For the last transition in Model 3, it increases to almost 70%. Among the control variables, we observe a significant negative association between female scientists and the recognition of a business opportunity (T1) as well as in successful spin-off creation (T3). Furthermore, the risk willingness influences the success of the first transition only. The organizational focus does not matter. Also, we hardly find any differences between the disciplines. Only in the first transition do researchers from social sciences have a significant, higher likelihood to make a successful transition than the reference group, scientists from Computer Science and Mathematics.

4.3 Robustness tests

We briefly report the results of the three robustness tests with respect to a different operationalization of the spin-off creation process and the use of linear probability models as an alternative estimation approach and add additional organizational fixed effects. Results are presented in the Appendix.

First, we estimate Model 2 and 3 with the overall number of scientists and do not reduce the sample for transition 2 and 3. This maintains the variation in the independent variables constant across the models (Tables A3, A4, Figure A1). The results are qualitatively the same as in the initial analysis. We again see a decrease of the academic setting's relative importance along the spin-off creation process, while at the same time the contribution of the commercial setting increases in transition 2 and declines again for transition 3. However, the decline in the last transition is not as pronounced as in the initial analysis, and the relative contribution is nearly as large as in the first transition (39.6%). Moreover, a few individual covariates show different effects than in the initial analysis, e.g. for transition 2, the variable *professor* is no longer significant, but the research foci towards *basic research* and *applied research* show significant coefficients. Overall, the results provide robustness to our results of the main analysis.

Second, we estimate Models 1-3 with OLS as linear probability models and conduct the dominance analysis based on the R^2 (Tables A5, A6 and Figure A2). The results for the academic setting show the same tendency as in the main specification, but there is only a slight decrease of the relative relevance between Transition 1 and Transition 2 (30.9% vs 30.3%). The *t*-test on the small negative difference between R_A^2 from transition one and two is statistically significant at the 1% level. For the commercial setting, the results for the first two transitions are also very similar. The relative importance for transition 1 increases to 48.9% compared to the main specification and is slightly larger than the relative importance of 48.3% for transition 2. This negative difference is even more pronounced in the bootstrapped sample average and confirmed by the *t*-test. Overall, we find additional evidence in favor of our hypotheses 1a and 1b, but no support for hypotheses 2a because the relative importance in transition 1 is substantially larger in this estimation. Also, we find again no support for 2b.

Third, in order to control for differences between the individual universities and research institutes, we include organizational fixed-effects and replace the control variable for organizational focus (see Tables A7,A8 and Figure A3). The results show the same development as in the previous robustness test in Table A5. Thereby, the absolute R^2 is substantially larger, but nearly entirely attributed to R^2_Z which includes the organizational fixed effects. This indicates that heterogeneity on the organizational level contributes substantially to the success of the individual spin-off creation process. Again, we find evidence in favor of our hypotheses 1a and 1b, but no support for hypotheses 2a and 2b.

Overall, our robustness checks provide additional support for our hypotheses 1a and 1b and some additional support for 2a; for 2b there is still no favorable evidence.

5 Discussion and conclusion

This study contributes to the understanding of academic spin-off creation and analyzes the transition of scientists along this process. In this process, scientists are embedded in an academic setting and have to engage with the commercial setting to successfully found their venture. We hypothesize that the relevance of the two opposing settings changes along the academic spin-off creation process and influences the success of the scientists. The difference between the academic and the commercial settings stems from their inherent logics, which have fundamentally different views on knowledge and its use, and which, in turn, leads to tensions the academic entrepreneurs have to overcome (Ambos et al., 2008; Murray, 2010; Rasmussen, 2011; Samsom & Gurdon, 1993). Based on previous research on the academic spin-off creation process (e.g. Fernández-Alles et al., 2015; Ndonzuau et al., 2002; Rasmussen, 2011; Roberts & Malonet, 1996; Vanaelst et al., 2006; Vohora et al., 2004), we conceptualize and separate the whole process–from its start in research activity and with its end in a founded firm–in four phases: Research, Opportunity framing, Pre-spin-off and Spin-off. In this process, scientists have to make phase-transitions which are influenced by the opposing settings to a different degree. Along the process, we hypothesize that the academic setting becomes less relevant and that the commercial setting increases in relevance.

To test our hypotheses, we conduct a novel, representative survey of scientists in the German state of Thuringia. We elicit the scientists' entrepreneurial activity and reconstruct the spin-off creation process and its phase-specific success or failure. This microdata allows us to empirically analyze the changing relevance of the settings along the whole process and overcome limitations of previous studies that either analyzed small samples with qualitative methods (e.g. Clarysse & Moray, 2004; Hayter, 2016a, 2016b; Vohora et al., 2004), only parts of the process (e.g. Krabel & Mueller, 2009) or only successfully created spin-offs (e.g. Landry et al., 2006). Methodologically, we apply dominance analysis (Azen & Budescu, 2003; Azen & Traxel, 2009; Budescu, 1993), which decomposes an estimation's goodness-of-fit measure in the relative contributions of a set of variables that explain successful transitions. This approach allows us to overcome the limitation of individual predictors to describe a more complex setting. Our empirical results provide the first quantitative analysis of scientists' transition along all phases of the spin-off creation process and the selection process linked to it.

The descriptive results of our data show a strong selection along the process, a widespread phenomenon (e.g. Aldrich & Martinez, 2007; Ndonzuau et al., 2002). Especially for the first transition between the research phase and the opportunity framing phase, not even a quarter of scientists recognized an opportunity for venture creation in the last five years. In the next phases, there is considerable attrition, and in the end, 5.6% of the scientists found a firm, which is similar in magnitude to other studies (Abreu & Grinevich, 2013; D'Este et al., 2019). Along the process, we can observe that certain characteristics of the scientists become prominent. Besides a substantial gender gap in our data, which is observed frequently (Guzman & Kacperczyk, 2019), there is also a considerably lower share of women who establish a firm in the end. One reason for that could be a lower access to venture capital, which seems to be a structural problem for women in Germany (Lins & Lutz, 2016). Another personal characteristic is risk willingness, which is highest among successful scientists, in line with the argument that the academic entrepreneur acts against all odds in a Schumpeterian manner (Cantner et al., 2017). Similar developments are also observable for the variables that constitute the two settings.

Our estimation and dominance analysis show for the academic setting a declining relevance along the process, in accordance with our hypotheses. At the beginning of the process, research and the academic environment serve as sources of entrepreneurial ideas, especially ones derived from basic research with high uncertainty of its feasibility and economic potential (Aghion et al., 2008; Lacetera, 2009). Scientists with a higher research orientation towards basic as well as applied research are especially prone to recognize and frame an entrepreneurial opportunity, which is consistent with the idea of the Pasteur-Scientist who generates new research results and who is at the same time interested in their practical application (Amara et al., 2019; Stokes, 1997). In the later phases, the relevance subsequently declines, in line with the model by Rasmussen (2011) and others. At the end of the process, the academic setting plays hardly any role and can even reduce the likelihood to found a firm. Our estimates show that the higher the publication output of a scientist, the lower is the likelihood to set up a firm in the last phase. This finding is contrary to previous findings that indicate a strong positive relationship between these two variables. However, most of these cases refer to Pasteur-like star scientists (e.g. Ding & Choi, 2011; Zucker et al., 1998).

For the commercial setting, the dominance analysis shows first an increase in the relevance of the setting but then a decrease towards the end of the process. This is only partly consistent with our hypotheses, which propose an increasing relevance of the commercial setting throughout the whole process. In particular, for the first transition the relevance of the commercial setting is quite high, and recognizing an opportunity correlates highly with disclosing intellectual property. Such a relationship between patenting and intentions to found a firm is well established (Goethner et al., 2012; Prodan & Drnovsek, 2010). Along with a positive influence of previous work experience (in line with Gulbrandsen & Thune, 2017), exposure to the commercial setting seems to give scientists a positive mindset towards economic activity and lets them pursue such a direction. The relevance of the commercial setting increases further along the process, and the actual time to conduct such activities also becomes relevant for scientists to substantially invest in the founding activity. However, at the end of the process, the relevance drastically declines. Reasons for this decrease could be related to a higher influence of contextual factors–such as market conditions, available venture capital, technological feasibility or policy support–the interplay of which may influence the nature of the individual venture (Autio et al., 2014; Rizzo, 2015; Wright et al., 2006). We explore the influence of contextual factors in more detail, and the scientist's organization seems to account for a substantial variation in the outcomes, maybe via institutional support for transfer activities (O'Shea et al., 2005; Rasmussen & Borch, 2010) or how such activities are socialized within the organization (Bercovitz & Feldman, 2008; Prodan & Drnovsek, 2010; Stuart & Ding, 2006). Nevertheless, we find no support in our data that the commercial setting has a higher relevance at the end of the process than in earlier phases. This finding also goes against the conceptualization by Rasmussen (2011) and others.

Besides the changing relevance of the two settings, we also observe interesting differences in their magnitude. In the beginning of the process, when scientists frame a commercial opportunity from their research activity, the commercial setting already has a higher relative importance than the academic setting. Such an observation is in contrast to established theories which initially ascribe a lower relevance to the commercial setting than to the academic setting (Rasmussen, 2011). Our finding corresponds to related literature on entrepreneurial opportunity recognition, which already provides evidence for positive associations between business-related competencies as well as commercial experiences and the recognition of entrepreneurial opportunities (Ardichvili & Cardozo, 2000; Ardichvili et al., 2003; Mary George et al., 2016; Shepherd & DeTienne, 2005; Ucbasaran et al., 2009). Integrating the generally higher relevance of the commercial setting in the conceptualization of the spin-off creation process can provide starting points for further theory development.

Our results allow us to derive characteristics on the level of the individual scientist as well. Our results show that because scientists have to engage with both settings, especially early on in the process, they have to change their role and identity as scientists. Jain et al. (2009) show in their qualitative study on scientists' commercialization activity that they develop a hybrid-role identity to successfully handle both logics. To develop such hybridity, scientists need to be ambidextrous to deal with the tension of the opposing settings. Mom et al. (2009) characterize ambidextrous individuals by their ability to deal with contradictions, their adaptability to different roles and their refinement and renewal of their knowledge, skills and expertise. Even though we do not directly test for the scientists' ambidexterity, selection among the scientists' characteristics along the transfer process hints to such an underlying mechanism. In that sense, our findings are similar to the findings by Ambos et al. (2008) who show that ambidextrous scientists can balance the demands from both settings and successfully commercialize research results.

Overall, our contribution to the literature and theory development is threefold. First, we provide the first quantitative evidence on the full academic spin-off creation process and the influence of the two opposing settings on scientists' success. We can thereby confirm some parts of existing theories, especially the declining relevance of the academic setting along the process. With respect to the relevance of the commercial setting, we find some contradictions at the end of the process. Second, we show that the relevance of the commercial setting is already higher than the academic setting in the beginning of the process and can reconcile the theory of the spin-off creation process with the research on entrepreneurial opportunity recognition. Third, we propose that researchers who are successful along the process are ambidextrous, since they manage to balance the contradicting logics of the two settings.

Our results can also motivate policy interventions, even though there is no normative dimension on how many scientists should found a firm. Policy or management in research organizations can intervene and support the spin-off creation process to increase the likelihood that scientists realize a business opportunity but also to reduce failure along the process. First, scientists need exposure to the commercial setting to realize economic opportunities in the first place. Such exposure could be induced by entrepreneurial education, raising awareness by transfer offices or other actors, but also by higher flexibility in the academic system, which would allow easier mobility between an academic and a non-academic employment. Second, along the process, time that can be devoted to establish a firm is necessary. Supporting such activity via reducing administrative or teaching load could reduce failure. Lastly, there needs to be specific support for female scientists, since they face structural disadvantages, especially at the end of the spin-off creation process.

Our results have to be viewed while taking into consideration several limitations. First, our data does not allow for a causal identification of the relevance of the two settings. Second, our survey data is a cross-section from which we reconstruct the spin-off creation process. This requires that the participants are able to remember well into the past. A panel dataset observing scientists over time would mitigate such limitations. Third, we only surveyed scientists who are still affiliated to a research organization. We therefore neglect successful entrepreneurs who left academia, which could bias the relative contribution of the two settings. Fourth, we conduct our analysis on the individual scientists, neglecting team structures which are important in the venture creation process. Lastly, we do not have information on the established firms and firm characteristics such as industry, product or service firms, and others could be perceived differently in the two settings.

Further research on the academic spin-off creation process should have a focus with a broader empirical basis. So far, our empirical insights provide only a first assessment on the changing relevance of the different settings, and broader empirical support is needed. Furthermore, we consider the two settings in isolation, but they are present simultaneously. A next step could consider the interaction of the two settings conceptually and empirically. Further research should also be devoted to the ambidexterity of the scientists and if it is endogenous to the process. More generally, the two contradicting logics of the settings not only influence scientists who want to establish a firm, but they also influence general transfer activities. Testing for the influence of the two settings on other transfer channels can provide further insights.

Appendix

Table A1: List of variables and their construction.

Variable	Source	Explanation	Measurement
Dependent variables:			
Transition 1 (=1)	Own survey: *Development of an idea to found a firm, e.g. discussion of the idea with others, assessment of the economic potential or application of creative techniques?*	Respondent discovered and framed at least one business opportunity	1 if frequency is > 0 (binary)
Transition 2 (=1)	*Own survey: Foundation preparation, e.g. development of a prototype, preparation of a business plan or acquisition of resources?*	Respondent further developed at least business opportunity towards its launch	1 if frequency is > 0 (binary)
Transition 3 (=1)	Own survey: Completed foundation of a firm, i.e. the launch of business activities?	Respondent at least once successfully completed the process of a spin-off creation since 2015	1 if frequency is > 0 (binary)
Academic variables:			
Professor (=1)	Own survey: *Which of the following options describes your current position best?*	Position: Professors, Jun. Professors, Directors and Head of Departments (group 1) vs. remaining positions (group 2)	1 if group 1 (binary)
Time devoted to research	Own survey: *How was your scientific working time distributed on average during the last 5 years [regarding research]?*	Fraction of weekly working hours spent on research activities	0…100% (metric)
Number of publications	Self-constructed based on Scopus and Web of Science	Logarithmized number of scientist's publications	(metric)
Average impact factor	Self-constructed based on Scopus	Average of the journals' Source Normalized Impact per Paper a scientist published in	(metric)
Basic research	Own survey: *Please assess the extent to which you contribute with your research to scientific progress in your discipline and thus shift the research frontier in your discipline further.*	Extent of basic research	4-Likert-scale: "Not at all" to "To a large extent" (treated as metric)
Applied research	Own survey: *Please assess the extent to which your research is targeted towards practical application.*	Extent of applied research	4-Likert-scale: "Not at all" to "To a large extent" (treated as metric)
Commercial variables:			
Share of publications with industry	Self-constructed based on Scopus and Web of Science	Share of scientist's publications in co-authorship with at least one firm	0…100% (metric)
Time devoted to KTT	Own survey: *How was your scientific working time distributed on average during the last 5 years [knowledge and technology transfer]?*	Fraction of weekly working hours spent on knowledge and technology transfer (KTT) activities	0…100% (metric)
Disclosed IP	Own survey: *Disclosure of an idea or invention (that can be attributed to potential commercial exploitation or can be legally protected) to the employer (Number since 2015).*	Logarithmized number of disclosed protectable ideas within the last 5 years	1 if Yes, 0 if No (binary)
Work experience outside academia	Own survey: *How many years of work experience outside the public science sector have you gained overall?*	Prior work experience outside the public science sector	5 categories (in years): 1: 0; 2: < 1; 3: one to three; 4: More than three and less than ten; 5: More than ten (treated as metric)
Control variables:			
Female (=1)	Own survey: Please indicate your gender.	Gender	1 if female, 0 if other (binary)
Risk willingness	Own survey: *How do you see yourself:Are you generally a person who is fully prepared to take risks or are you trying to avoid risks?*	Indviduals' willingness to take risks	11-Likert scale: "Risk averse" to "Fully prepared to take risks" (treated as metric)
Organizational focus	Self-constructed	Distinction between Organizational focus: basic vs. applied research	1: basic, 2: between basic and applied, 3: applied (nominal)
Discipline	Self-constructed based on scientist's web pages	Discipline	Computer Science & Mathematics, Engineering, Humanities, Life Science, Medicine, Physics & Chemistry, Social Sciences (nominal)

Table A2: Descriptive statistics of the variables for the actual founders (T3=1).

	Founders (T3=1)			
	mean	sd	min	max
Academic setting				
Professor (=1)	0.33	0.47	0	1
Time devoted to research	45.36	26.05	0	100
Number of publications	14.73	31.09	0	207
Average impact factor	0.73	0.70	0	2.40
Basic research	2.81	0.75	1	4
Applied research	3.28	0.72	2	4
Commercial setting				
Share of publications with industry	0.04	0.13	0	0.80
Time devoted to KTT	16.83	17.46	0	100
Disclosed IP	1.09	1.63	0	7
Work experience outside academia	2.11	1.39	0	4
Control variables				
Female (=1)	0.20	0.41	0	1
Risk willingness	7.78	1.96	3	11
Organizational focus: between basic and applied	0.60	0.50	0	1
Organizational focus: basic	0.12	0.33	0	1
Organizational focus: applied	0.28	0.45	0	1
Discipline: Computer Science & Mathematics	0.17	0.38	0	1
Discipline: Engineering	0.17	0.38	0	1
Discipline: Humanities	0.09	0.29	0	1
Discipline: Life Sciences	0.11	0.31	0	1
Discipline: Medicine	0.05	0.21	0	1
Discipline: Physics & Chemistry	0.19	0.39	0	1
Discipline: Social Sciences	0.22	0.42	0	1

Note: T3 founders refer to the scientists who actually founded a firm where n(T3=1) = 64.

Table A3: Logit regression results and dominance analysis for the three transitions with complete sample at each transition.

	(1)	(2)	(3)
	Transition 1	Transition 2	Transition 3
	Research to *Opportunity recognition*	*Opportunity recognition* to *Pre-spin-off*	*Pre-spin-off* to *Spin-off*
Academic setting			
Professor (=1)	0.045 (0.237)	0.382 (0.291)	0.641 (0.399)
Time devoted to research	−0.003 (0.004)	−0.003 (0.005)	−0.003 (0.007)
Number of publications	−0.011 (0.078)	−0.113 (0.100)	-0.311^{**} (0.140)
Average impact factor	−0.173 (0.150)	−0.261 (0.191)	−0.078 (0.265)
Basic research	0.408^{***} (0.126)	0.378^{**} (0.155)	0.281 (0.232)
Applied research	0.376^{***} (0.099)	0.379^{***} (0.131)	0.369^{*} (0.204)
Joint R^2_A	**0.046 (35.2%)**	**0.061 (30.9%)**	**0.057 (28.1%)**
Commercial setting			
Share of publications with industry	0.830 (0.878)	1.041 (1.061)	0.032 (1.150)
Time devoted to KTT	0.005 (0.006)	0.019^{***} (0.007)	0.028^{***} (0.009)
Disclosed IP	0.942^{***} (0.193)	1.055^{***} (0.210)	1.012^{***} (0.271)
Work experience outside academia	0.097^{*} (0.058)	0.203^{***} (0.073)	0.127 (0.092)
Joint R^2_C	**0.056 (42.5%)**	**0.096 (48.1%)**	**0.080 (39.6%)**
Control variables			
Female (=1)	-0.349^{**} (0.178)	−0.276 (0.224)	-0.740^{**} (0.349)
Risk willingness	0.101^{***} (0.038)	0.159^{***} (0.051)	0.265^{***} (0.073)
Organizational focus: basic	−0.260 (0.279)	−0.125 (0.375)	0.166 (0.520)
Organizational focus: applied	0.072 (0.223)	0.149 (0.285)	−0.340 (0.428)
Discipline: Engineering	−0.453 (0.306)	−0.633 (0.406)	-1.172^{*} (0.632)
Discipline: Humanities	−0.486 (0.353)	-0.794^{*} (0.444)	−0.574 (0.594)
Discipline: Life Sciences	0.007 (0.322)	−0.357 (0.441)	−0.235 (0.570)
Discipline: Medicine	−0.244 (0.341)	−0.253 (0.446)	−0.600 (0.666)
Discipline: Physics & Chemistry	−0.014 (0.297)	0.019 (0.378)	−0.333 (0.504)
Discipline: Social Sciences	-0.492^{*} (0.293)	−0.356 (0.362)	0.039 (0.452)
Joint R^2_Z	**0.029 (22.3%)**	**0.042 (21.0%)**	**0.066 (32.3%)**
Constant	-3.866^{***} (0.513)	-5.157^{***} (0.689)	-6.200^{***} (1.043)
N	1,149	1,149	1,149
Log Likelihood	−522.020	−348.961	−196.862
Akaike Inf. Crit.	1,086.039	739.923	435.723
McFadden R^2	0.131	0.199	0.203

Note: A: Academic setting, C: Commercial setting, Z: Controls. Robust standard errors in parentheses. Significance at *p<0.1; **p<0.05; ***p<0.01.

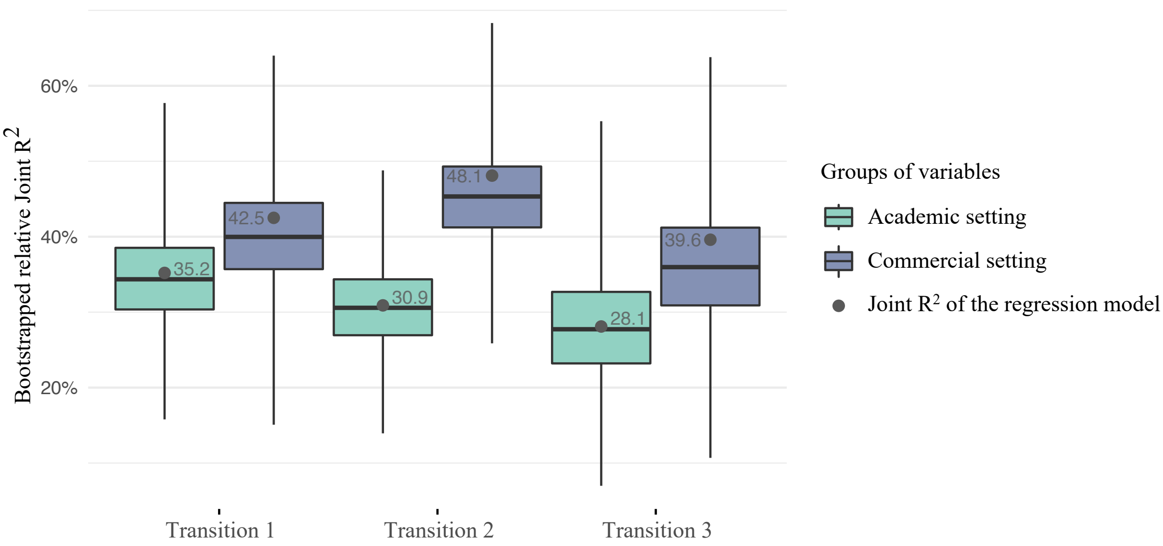

Figure A1: Dominance analysis on logit estimates for the three transitions with the complete sample based on 5,000 replications.

Table A4: Differences in bootstrapped relative dominance based on logit estimates for the three transitions with the complete sample.

	T1 mean	T2 mean	T3 mean	difference mean T2-T1	difference mean T3-T2
Academic setting R^2_A	34.557 (0.086)	30.707 (0.076)	28.123 (0.099)	-3.85***	-2.584***
Commercial setting R^2_C	40.108 (0.093)	45.307 (0.083)	36.123 (0.106)	5.199***	-9.184***

Note: 5000 bootstrapped replications. Standard errors in parentheses. Differences in means tested by two-sided *t*-tests. Significance at *p<0.1; **p<0.05; ***p<0.01.

Table A5: OLS regression results and dominance analysis for the three transitions.

	(1)	(2)	(3)
	Transition 1	Transition 2	Transition 3
	Research to *Opportunity recognition*	*Opportunity recognition* to *Pre-spin-off*	*Pre-spin-off* to *Spin-off*
Academic setting			
Professor (=1)	0.014 (0.037)	0.177** (0.085)	0.124 (0.115)
Time devoted to research	−0.0004 (0.0005)	0.0001 (0.002)	0.001 (0.002)
Number of publications	−0.004 (0.012)	−0.039 (0.024)	−0.077** (0.037)
Average impact factor	−0.023 (0.019)	−0.044 (0.044)	0.087 (0.083)
Basic research	0.060*** (0.019)	0.005 (0.043)	−0.003 (0.063)
Applied research	0.050*** (0.014)	0.029 (0.045)	0.001 (0.064)
Joint R^2_A	**0.044 (30.9%)**	**0.066 (30.3%)**	**0.028 (15.8%)**
Commercial setting			
Share of publications with industry	0.150 (0.157)	0.231 (0.212)	−0.335 (0.312)
Time devoted to KTT	0.001 (0.001)	0.006** (0.003)	0.006** (0.003)
Disclosed IP	0.199*** (0.037)	0.129*** (0.047)	0.035 (0.063)
Work experience outside academia	0.016* (0.009)	0.049** (0.022)	−0.006 (0.030)
Joint R^2_C	**0.070 (48.9%)**	**0.106 (48.3%)**	**0.027 (15.5%)**
Control variables			
Female (=1)	−0.048** (0.024)	0.004 (0.065)	−0.204** (0.092)
Risk willingness	0.014*** (0.005)	0.023 (0.014)	0.030 (0.021)
Organizational focus: basic	−0.041 (0.038)	0.121 (0.091)	0.113 (0.153)
Organizational focus: applied	0.012 (0.036)	0.053 (0.073)	−0.129 (0.098)
Discipline: Engineering	−0.081 (0.052)	−0.038 (0.103)	−0.171 (0.133)
Discipline: Humanities	−0.077 (0.054)	−0.094 (0.128)	0.091 (0.188)
Discipline: Life Sciences	−0.006 (0.051)	−0.161 (0.117)	−0.008 (0.177)
Discipline: Medicine	−0.047 (0.052)	−0.019 (0.142)	−0.052 (0.187)
Discipline: Physics & Chemistry	−0.008 (0.050)	−0.013 (0.100)	−0.146 (0.132)
Discipline: Social Sciences	−0.081* (0.046)	0.027 (0.111)	0.154 (0.144)
Joint R^2_Z	**0.029 (20.2%)**	**0.047 (21.4%)**	**0.122 (68.7%)**
Constant	−0.127* (0.067)	0.169 (0.205)	0.294 (0.289)
N	1,149	249	145
Residual Std. Error	0.385 (df = 1128)	0.455 (df = 228)	0.487 (df = 124)
R^2	0.143	0.219	0.177

Note: A: Academic setting, C: Commercial setting, Z: Controls. Robust standard errors in parentheses. Significance at $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

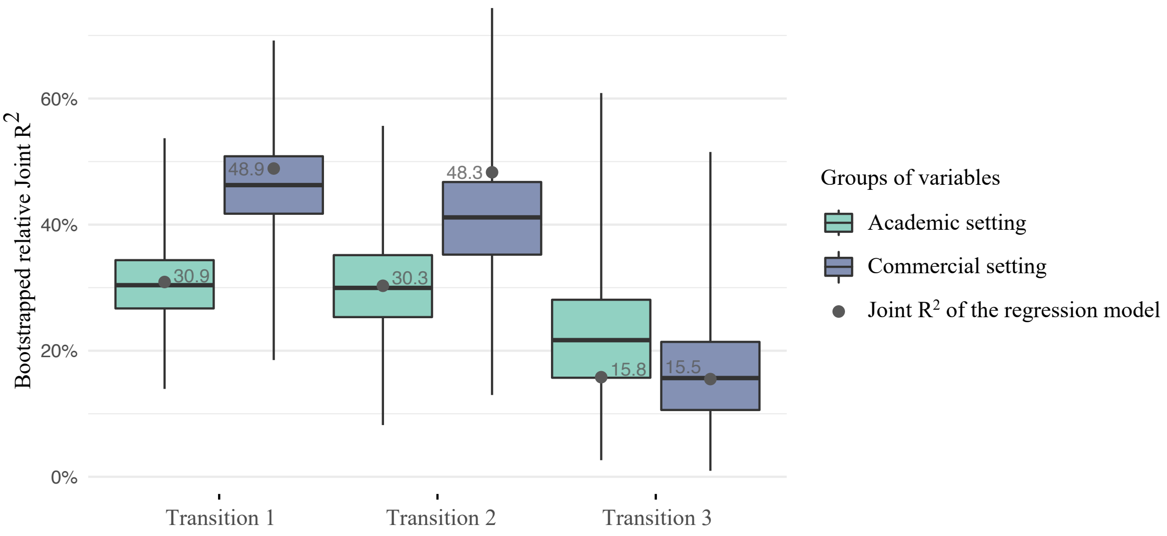

Figure A2: Dominance analysis on OLS estimates for the three transitions based on 5,000 replications.

Table A6: Differences in bootstrapped relative dominance based on OLS estimates for the three transitions.

	T1 mean	T2 mean	T3 mean	difference mean T2-T1	difference mean T3-T2
Academic setting R_A^2	30.656 (0.08)	30.32 (0.102)	22.48 (0.127)	-0.336***	-7.84***
Commercial setting R_C^2	46.213 (0.096)	41.086 (0.116)	16.598 (0.111)	-5.127***	-24.487***

Note: 5000 bootstrapped replications. Standard errors in parentheses. Differences in means tested by two-sided *t*-tests. Significance at *p<0.1; **p<0.05; ***p<0.01.

Table A7: OLS regression results and dominance analysis for the three transitions with organizational fixed effects.

	(1) Transition 1 *Research* to *Opportunity recognition*	(2) Transition 2 *Opportunity recognition* to *Pre-spin-off*	(3) Transition 3 *Pre-spin-off* to *Spin-off*
Academic setting			
Professor (=1)	0.016 (0.038)	0.222^{**} (0.086)	0.087 (0.134)
Time devoted to research	−0.0005 (0.0005)	0.001 (0.002)	0.001 (0.002)
Number of publications	−0.003 (0.012)	−0.031 (0.025)	-0.072^{*} (0.036)
Average impact factor	-0.033^{*} (0.018)	−0.051 (0.043)	0.103 (0.085)
Basic research	0.064^{***} (0.019)	−0.012 (0.042)	0.016 (0.066)
Applied research	0.050^{***} (0.014)	0.041 (0.046)	−0.028 (0.076)
Joint R^2_A	**0.045 (23.5%)**	**0.068 (20.6%)**	**0.026 (7.7%)**
Commercial setting			
Share of publications with industry	0.188 (0.149)	0.027 (0.190)	−0.457 (0.353)
Time devoted to KTT	0.002^{*} (0.001)	0.008^{***} (0.003)	0.008^{***} (0.003)
Disclosed IP	0.188^{***} (0.039)	0.180^{***} (0.051)	0.064 (0.073)
Work experience outside academia	0.013 (0.009)	0.040^{*} (0.024)	0.010 (0.034)
Joint R^2_C	**0.065 (34.3%)**	**0.106 (32.0%)**	**0.034 (10.2%)**
Control variables			
Female (=1)	-0.054^{**} (0.024)	0.023 (0.065)	-0.196^{*} (0.102)
Risk willingness	0.015^{***} (0.005)	0.027^{**} (0.014)	0.031 (0.021)
Organization	Yes	Yes	Yes
Discipline: Engineering	−0.093 (0.059)	−0.139 (0.141)	−0.170 (0.184)
Discipline: Humanities	−0.115 (0.071)	−0.225 (0.190)	0.021 (0.330)
Discipline: Life Sciences	0.032 (0.068)	0.018 (0.208)	−0.234 (0.283)
Discipline: Medicine	0.016 (0.069)	−0.141 (0.210)	−0.015 (0.304)
Discipline: Physics & Chemistry	0.078 (0.069)	−0.056 (0.195)	−0.160 (0.271)
Discipline: Social Sciences	−0.057 (0.056)	−0.036 (0.137)	0.014 (0.197)
Joint R^2_Z	**0.080 (42.2%)**	**0.158 (47.4%)**	**0.272 (82.1%)**
Constant	-0.194^{**} (0.078)	0.109 (0.262)	0.220 (0.365)
N	1,149	249	145
Residual Std. Error	0.380 (df = 1095)	0.451 (df = 199)	0.491 (df = 99)
R^2	0.190	0.332	0.332

Note: A: Academic setting, C: Commercial setting, Z: Controls. Robust standard errors in parentheses. Significance at *p<0.1; **p<0.05; ***p<0.01.

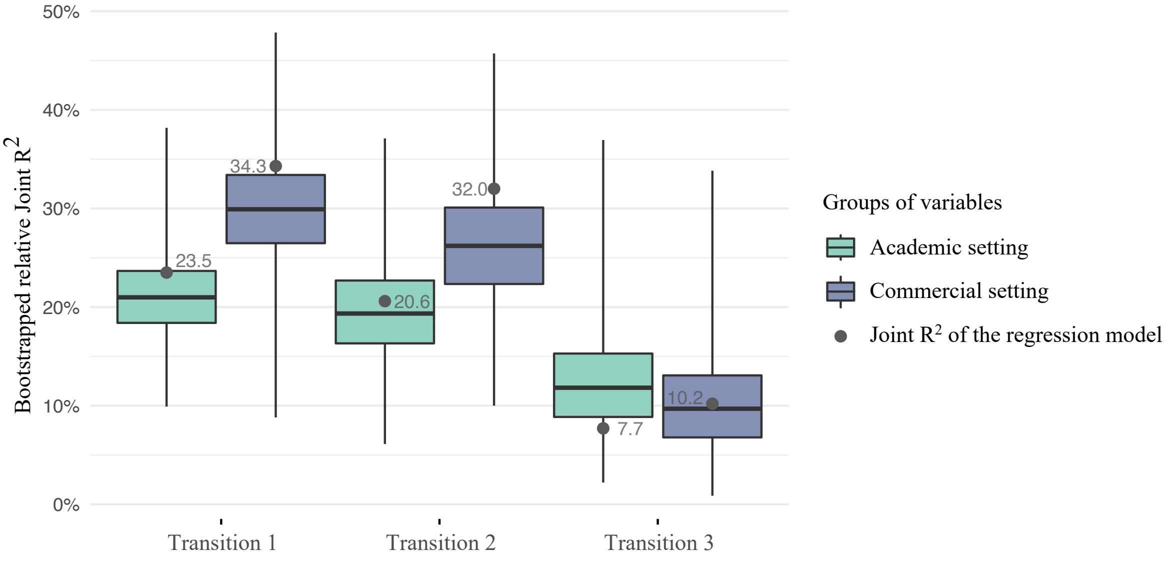

Figure A3: Dominance analysis on OLS estimates for the three transitions with organizational fixed effects based on 5,000 replications.

Table A8: Differences in bootstrapped relative dominance based on OLS estimates with for the three transitions with organizational fixed effects.

	T1 mean	T2 mean	T3 mean	difference mean T2-T1	difference mean T3-T2
Academic setting R^2_A	21.16 (0.056)	19.603 (0.067)	12.342 (0.067)	-1.557***	-7.261***
Commercial setting R^2_C	30.006 (0.074)	26.272 (0.078)	10.276 (0.066)	-3.734***	-15.996***

Note: 5000 bootstrapped replications. Standard errors in parentheses. Differences in means tested by two-sided *t*-tests. Significance at *p<0.1; **p<0.05; ***p<0.01.

Supplementary material

Sample representativeness

Table S1: Non-response analysis.

Variable	Approached (%)	Sample (%)	Sample - Approached
Professor (=1)	16.49	18.28	1.79
Female (=1)	37.56	36.73	-0.83
Basic	16.06	15.23	-0.83
Between basic and applied	63.85	63.97	0.12
Applied	20.09	20.80	0.71
Computer Science & Mathematics	10.11	10.53	0.42
Engineering	14.04	16.36	2.32**
Humanities	12.78	9.66	-3.12***
Life Science	13.50	14.97	1.47
Medicine	15.65	9.75	-5.9***
Physics & Chemistry	18.87	19.67	0.8
Social Sciences	15.05	19.06	4.01***
n	7785	1149	

Note: Group comparison based on Wilcoxon rank-sum tests as non-parametric alternative to two-sided *t*-test. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table S2: Representativeness.

Variable	Germany (Universities) (%)	Sample (Universities) (%)
Professor (=1)	18.63	20.99
Female (=1)	40.20	37.27

Note: The comparison is only between the respondents affiliated to universities
and universities of applied science, not to research organizations.
Data for the overall population of scientists at universities in Germany is taken from (Statistisches Bundesamt, n.d.).

Variable specifications and correlation tables

Table S3: List of approached organizations and their research focus.

Number	Organization	Organizational focus
	Universities and universities of applied sciences	
1	Bauhaus-Universität Weimar	between basic and applied
2	Duale Hochschule Gera-Eisenach	applied
3	Ernst-Abbe-Hochschule Jena	applied
4	Fachhochschule Erfurt	applied
5	Friedrich-Schiller-Universität Jena	between basic and applied
6	Hochschule für Musik FRANZ LISZT Weimar	applied
7	Hochschule Nordhausen	applied
8	Hochschule Schmalkalden	applied
9	SRH Hochschule für Gesundheit	applied
10	Technische Universität Ilmenau	between basic and applied
11	Universität Erfurt	between basic and applied
	Research institutes	
12	Forschungsinstitut für Mikrosensorik	applied
13	Forschungszentrum für Medizintechnik und Biotechnologie	applied
14	Fraunhofer-Institut für Angewandte Optik und Feinmechanik	applied
15	Fraunhofer-Institut für Digitale Medientechnologie	applied
16	Fraunhofer-Institut für Keramische Technologien und Systeme	applied
17	Fraunhofer-Institut für Optronik, Systemtechnik und Bildauswertung Institutsteil Angewandte Systemtechnik	applied
18	Friedrich-Loeffler-Institut für bakterielle Infektionen und Zoonosen	applied
19	Friedrich-Loeffler-Institut für molekulare Pathogenese	applied
20	Gesellschaft für Fertigungstechnik und Entwicklung	applied
21	Günter-Köhler-Institut für Fügetechnik und Werkstoffprüfung	applied
22	Helmholtz-Institut Jena	basic
23	Innovent	applied
24	Institut für Angewandte Bauforschung	applied
25	Institut für Bioprozess- und Analysenmesstechnik Heiligenstadt	applied
26	Institut für Datenwissenschaften	applied
27	Institut für Mikroelektronik- und Mechatronik-Systeme	applied
28	Leibniz-Institut für Alternsforschung - Fritz-Lipmann-Institut e.V.	basic
29	Leibniz-Institut für Naturstoff-Forschung und Infektionsbiologie Hans-Knöll-Institut	basic
30	Leibniz-Institut für Photonische Technologien	basic
31	Materialforschungs- und -prüfanstalt	applied
32	Max-Planck-Institut für Biogeochemie	basic
33	Max-Planck-Institut für chemische Ökologie	basic
34	Max-Planck-Institut für Menschheitsgeschichte	basic
35	Textilforschungsinstitut Thüringen-Vogtland	applied
36	Thüringer Landessternwarte Tautenburg	basic
37	Thüringisches Institut für Textil- u. Kunststoff-Forschung	applied

Table S4: Pearson correlation coefficients between the variables of transition 1 (n=1149).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	Dependent variable																						
1	Transition 1 (=1)																						
	Academic setting																						
2	Professor (=1)	0.08***																					
3	Time devoted to research	-0.05*	-0.35***																				
4	Number of publications	0.07**	0.32***	-0.06**																			
5	Average impact factor	-0.04	0.07**	0.14***	0.28***																		
6	Basic research	0.15***	0.11***	0.20***	0.15***	0.14***																	
7	Applied research	0.22***	0.05*	-0.07**	-0.04	-0.15***	0.15***																
	Commercial setting																						
8	Share of publications with industry	0.08***	0.00	0.01	0.01	0.06**	-0.03	0.13***															
9	Time devoted to KTT	0.15***	0.02	-0.25***	-0.03	-0.03	0.09***	0.31***	0.07**														
10	Disclosed IP	0.19***	0.13***	-0.05*	0.18***	0.04	0.12***	0.19***	0.09***	0.20***													
11	Work experience outside academia	0.13***	0.20***	-0.25***	-0.05*	-0.22***	-0.01	0.23***	0.05*	0.12***	0.04												
	Control variables																						
12	Female (=1)	-0.10***	-0.12***	0.03	-0.12***	-0.07**	-0.03	-0.03	-0.07**	0.00	-0.07**	-0.11***											
13	Risk willingness	0.14***	0.10***	0.02	0.06**	0.00	0.23***	0.13***	0.03	0.04	0.07**	0.19***	-0.04										
14	Organizational focus: between basic and applied	-0.05*	-0.04	-0.03	0.00	-0.05*	-0.03	-0.12***	-0.10***	-0.14***	-0.12***	-0.11***	0.03	-0.04									
15	Organizational focus: basic	-0.05	-0.14***	0.27***	0.12***	0.26***	0.14***	-0.15***	-0.01	-0.01	-0.03	-0.16***	0.01	0.04	-0.56***								
16	Organizational focus: applied	0.11***	0.18***	-0.20***	-0.11***	-0.17***	-0.08***	0.28***	0.13***	0.18***	0.17***	0.26***	-0.04	0.01	-0.68***	-0.22***							
17	Discipline: Computer Science and Mathematics	0.07**	-0.01	0.01	-0.04	-0.02	0.02	0.10***	0.06**	-0.01	0.00	0.00	-0.14***	0.00	0.16***	-0.15***	-0.06*						
18	Discipline: Engineering	0.07**	0.03	-0.09***	-0.11***	-0.15***	-0.03	0.24***	0.17***	0.15***	0.18***	0.14***	-0.08***	0.03	-0.17***	-0.19***	0.37***	-0.15***					
19	Discipline: Humanities	-0.03	0.01	-0.04	-0.10***	-0.13***	0.09***	-0.08**	-0.05*	0.03	-0.05*	0.12***	0.10***	0.04	-0.04	0.05*	0.00	-0.11***	-0.14***				
20	Discipline: Life Sciences	-0.03	-0.07**	0.15***	0.04	0.15***	0.01	-0.13***	-0.01	-0.05*	-0.06**	-0.13***	0.06**	-0.01	-0.19***	0.34***	-0.08***	-0.14***	-0.19***	-0.14***			
21	Discipline: Medicine	-0.03	0.00	-0.04	0.17***	0.12***	-0.06**	0.00	-0.03	-0.05*	-0.04	-0.01	0.11***	-0.01	0.18***	-0.14***	-0.09***	-0.11***	-0.15***	-0.11***	-0.14***		
22	Discipline: Physics and Chemistry	0.03	-0.09***	0.18***	0.16***	0.16***	0.07**	-0.08***	-0.05*	0.03	0.07**	-0.17***	-0.07**	0.00	-0.12***	0.25***	-0.08***	-0.17***	-0.22***	-0.16***	-0.21***	-0.16***	
23	Discipline: Social Sciences	-0.08***	0.13***	-0.17***	-0.12***	-0.13***	-0.09***	-0.06*	-0.07**	-0.09***	-0.12***	0.07**	0.04	-0.04	0.22***	-0.21***	-0.08***	-0.17***	-0.21***	-0.16***	-0.20***	-0.16***	-0.24***

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table S5: Pearson correlation coefficients between the variables of transition 2 (n=249).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	Dependent variable																						
1	Transition 2 (=1)																						
	Academic setting																						
2	Professor (=1)	0.17***																					
3	Time devoted to research	-0.18***	-0.39***																				
4	Number of publications	-0.06	0.30***	-0.03																			
5	Average impact factor	-0.16**	0.15**	0.07	0.28***																		
6	Basic research	0.05	0.09	0.10	0.10	0.13**																	
7	Applied research	0.24***	0.10*	-0.09	-0.10	-0.13**	0.10																
	Commercial setting																						
8	Share of publications with industry	0.07	-0.01	0.02	-0.03	0.14**	-0.08	0.06															
9	Time devoted to KTT	0.27***	0.03	-0.36***	0.00	0.00	0.13**	0.31***	0.01														
10	Disclosed IP	0.21***	0.19***	-0.13**	0.12*	0.07	0.15**	0.20***	0.09	0.28***													
11	Work experience outside academia	0.28***	0.21***	-0.25***	0.04	-0.31***	0.01	0.26***	0.05	0.12*	-0.03												
	Control variables																						
12	Female (=1)	-0.03	-0.05	0.00	-0.03	-0.07	0.06	-0.01	-0.10	-0.04	-0.03	-0.04											
13	Risk willingness	0.15**	0.12*	0.04	0.03	-0.04	0.16***	0.11*	0.03	0.02	0.03	0.19***	-0.02										
14	Organizational focus: between basic and applied	-0.11*	-0.10	0.07	0.04	-0.08	0.09	-0.14**	-0.13**	-0.16***	-0.11*	-0.08	-0.04	0.05									
15	Organizational focus: basic	-0.09	-0.15**	0.22***	0.12*	0.25***	0.06	-0.22***	0.08	-0.06	-0.07	-0.18***	0.08	0.01	-0.44***								
16	Organizational focus: applied	0.18***	0.22***	-0.23***	-0.13**	-0.09	-0.13**	0.31***	0.08	0.22***	0.17***	0.22***	-0.01	-0.06	-0.77***	-0.24***							
17	Discipline: Computer Science and Mathematics	0.02	0.04	0.09	-0.06	-0.01	0.05	0.17***	-0.03	-0.02	-0.02	0.01	-0.12*	0.01	0.16**	-0.15**	-0.06						
18	Discipline: Engineering	0.08	-0.09	-0.06	-0.13**	-0.11*	-0.05	0.20***	0.09	0.12*	0.21***	0.07	-0.08	-0.03	-0.11*	-0.19***	0.25***	-0.21***					
19	Discipline: Humanities	-0.02	-0.06	0.01	-0.08	-0.02	0.14**	-0.12**	0.00	0.00	-0.03	0.06	0.18***	0.02	-0.08	0.21***	-0.06	-0.12*	-0.15**				
20	Discipline: Life Sciences	-0.14**	0.04	0.10	0.03	0.14**	-0.03	-0.12*	0.11*	-0.12*	-0.12*	-0.08	0.09	0.05	-0.22***	0.34***	-0.01	-0.16**	-0.20***	-0.11*			
21	Discipline: Medicine	-0.05	0.11*	-0.11*	0.24***	0.07	-0.06	-0.10*	-0.06	-0.11*	-0.02	-0.01	0.05	-0.01	0.13**	-0.11*	-0.06	-0.12*	-0.15**	-0.09	-0.11*		
22	Discipline: Physics and Chemistry	0.00	-0.05	0.07	0.14**	0.15**	0.06	-0.05	-0.07	0.10	0.07	-0.13**	-0.09	-0.01	-0.03	0.10	-0.04	-0.22***	-0.28***	-0.16**	-0.20***	-0.16**	
23	Discipline: Social Sciences	0.07	0.06	-0.12*	-0.11*	-0.22***	-0.09	-0.04	-0.05	-0.04	-0.14**	0.11*	0.05	-0.02	0.18***	-0.14**	-0.09	-0.16**	-0.20***	-0.12*	-0.15**	-0.12*	-0.21***

Note: *p<0.1; **p<0.05; ***p<0.01.

Table S6: Pearson correlation coefficients between the variables of transition 3 (n=145).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	Dependent variable																						
1	Transition 3 (=1)																						
	Academic setting																						
2	Professor (=1)	0.05																					
3	Time devoted to research	-0.03	-0.37***																				
4	Number of publications	-0.14*	0.26***	-0.06																			
5	Average impact factor	-0.02	0.17**	0.02	0.30***																		
6	Basic research	0.04	0.20**	0.08	0.14*	0.16*																	
7	Applied research	0.03	0.08	-0.06	-0.08	-0.07	0.19**																
	Commercial setting																						
8	Share of publications with industry	-0.08	0.00	-0.03	-0.03	0.18**	-0.14*	0.07															
9	Time devoted to KTT	0.12	-0.04	-0.37***	0.01	0.03	0.18**	0.26***	-0.02														
10	Disclosed IP	-0.05	0.19**	-0.12	0.17**	0.17**	0.19**	0.13	0.08	0.24***													
11	Work experience outside academia	0.02	0.17**	-0.22***	0.02	-0.30***	0.00	0.23***	0.11	0.06	-0.10												
	Control variables																						
12	Female (=1)	-0.12	-0.12	0.08	-0.01	-0.22***	0.09	-0.02	-0.16*	-0.05	-0.01	-0.06											
13	Risk willingness	0.18**	0.14*	0.21**	0.03	0.11	0.14*	0.13	0.03	-0.01	0.00	0.08	-0.01										
14	Organizational focus: between basic and applied	0.09	-0.15*	0.11	0.04	0.03	0.20**	-0.12	-0.13	-0.20**	-0.13	-0.11	-0.09	0.02									
15	Organizational focus: basic	0.09	-0.16**	0.19**	0.11	0.04	-0.06	-0.13	0.03	-0.01	-0.01	-0.13	0.12	0.19**	-0.36***								
16	Organizational focus: applied	-0.14*	0.26***	-0.23***	-0.11	-0.06	-0.17**	0.20**	0.12	0.21**	0.14*	0.20**	0.01	-0.14*	-0.82***	-0.24***							
17	Discipline: Computer Science and Mathematics	0.05	0.01	0.13	-0.08	-0.07	0.08	0.15*	-0.02	-0.08	-0.04	-0.04	-0.08	0.00	0.15*	-0.14*	-0.08						
18	Discipline: Engineering	-0.14*	-0.09	-0.01	-0.11	0.00	-0.07	0.19**	0.10	0.13	0.17**	0.05	-0.12	-0.11	-0.16**	-0.18**	0.28***	-0.24***					
19	Discipline: Humanities	0.06	-0.08	0.03	-0.07	-0.13	0.02	-0.03	-0.01	0.00	0.01	0.04	0.30***	0.07	-0.05	0.17**	-0.05	-0.12	-0.16*				
20	Discipline: Life Sciences	0.06	0.06	0.11	-0.07	0.00	-0.07	-0.12	0.16*	-0.07	-0.10	-0.02	-0.02	0.12	-0.05	0.31***	-0.13	-0.13	-0.18**	-0.09			
21	Discipline: Medicine	-0.08	0.18**	-0.08	0.30***	0.13	-0.03	-0.15*	-0.04	-0.18**	-0.03	-0.11	0.02	0.03	0.08	-0.09	-0.03	-0.12	-0.15*	-0.08	-0.09		
22	Discipline: Physics and Chemistry	-0.07	-0.10	0.04	0.15*	0.19**	0.14*	-0.06	-0.13	0.17**	0.08	-0.09	-0.05	0.01	-0.08	0.16**	-0.02	-0.23***	-0.30***	-0.15*	-0.17**	-0.14*	
23	Discipline: Social Sciences	0.17**	0.10	-0.21**	-0.07	-0.15*	-0.08	-0.08	-0.03	-0.08	-0.16**	0.14	0.05	-0.05	0.15*	-0.14*	-0.08	-0.18**	-0.24***	-0.12	-0.13	-0.12	-0.23***

Note: *p<0.1; **p<0.05; ***p<0.01.

Additional estimations

Table S7: Logit regression results and dominance analysis for the three transitions (without number of publications.

	(2a) Transition 2 *Opportunity recognition* to *Pre-spin-off*	(3a) Transition 3 *Pre-spin-off* to *Spin-off*
Academic setting		
Professor (=1)	0.860* (0.456)	0.202 (0.543)
Time devoted to research	0.002 (0.008)	0.002 (0.011)
Average impact factor	−0.528** (0.228)	−0.065 (0.346)
Basic research	0.059 (0.221)	−0.043 (0.300)
Applied research	0.100 (0.223)	0.061 (0.298)
Joint R_A^2	**0.051 (27.6%)**	**0.003 (2.4%)**
Commercial setting		
Share of publications with industry	1.223 (1.147)	−1.788 (1.548)
Time devoted to KTT	0.051** (0.020)	0.027* (0.015)
Disclosed IP	0.610** (0.283)	0.040 (0.298)
Work experience outside academia	0.226* (0.118)	−0.036 (0.142)
Joint R_C^2	**0.095 (51.5%)**	**0.021 (17.7%)**
Control variables		
Female (=1)	0.068 (0.342)	−0.955** (0.485)
Risk willingness	0.112 (0.077)	0.158 (0.103)
Organizational focus: basic	0.680 (0.478)	0.462 (0.726)
Organizational focus: applied	0.394 (0.403)	−0.453 (0.478)
Discipline: Engineering	−0.067 (0.531)	−0.731 (0.621)
Discipline: Humanities	−0.452 (0.675)	0.482 (0.846)
Discipline: Life Sciences	−0.830 (0.625)	−0.003 (0.806)
Discipline: Medicine	−0.206 (0.661)	−0.642 (0.895)
Discipline: Physics and Chemistry	−0.115 (0.523)	−0.781 (0.620)
Discipline: Social Sciences	0.284 (0.596)	0.856 (0.738)
Joint R_Z^2	**0.038 (20.9%)**	**0.096 (79.9%)**
Constant	−1.977* (1.033)	−1.290 (1.484)
N	249	145
Log Likelihood	−138.055	−87.579
Akaike Inf. Crit.	316.110	215.159
McFadden R^2	0.184	0.12

Note: A: Academic setting, C: Commercial setting, Z: Controls. Robust standard errors in parentheses. Significance at *p<0.1; **p<0.05; ***p<0.01.

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