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Determinants of academic entrepreneurship development: A multi-level perspective

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Summary

The crucial role of academic entrepreneurship in accelerating technological innovation and promoting local and national economic development has been globally recognised (Berbegal-Mirabent et al., 2015; Guerrero et al., 2015; Visintin and Pittino, 2014). As one of the various forms of academic entrepreneurial activities, academic spin-offs (ASOs), also known as university spin-offs, are considered an important means (Miranda et al., 2018). This ongoing phenomenon has drawn numbers of scholars' attention to explore the factors that influence the venturing processes of ASOs, whereas the exploration of the entire scope of academic entrepreneurship remains far from complete.

This dissertation adopts a multi-level perspective to investigate factors that influence the entrepreneurial intentions and behaviours of academics; it focuses on both the personal characteristics of academics and external environmental factors. Both approaches demonstrate significant effects. The primary reasoning behind this thesis is that entrepreneurship research needs to address the heterogeneity of entrepreneurial personalities and consider different sub-groups to gain insight into academic start-ups. Furthermore, it is important to consider the joint impacts and interactions between determinants across different levels. To comprehensively explain the variance of effects, both qualitative and quantitative methods are applied in this dissertation, which comprises of five empirical studies; each study deepens the existing understanding of academic entrepreneurship from a specific perspective (Chapters 2–6). The research motivation and conclusion of this dissertation are summarised in Chapters 1 and 7.

Chapter 2 provides a comprehensive overview of the current state of research on academic entrepreneurship. Following the procedure for conducting a systematic literature review according to Tranfield et al. (2003), Chapter 2 develops a conceptual framework demonstrating that academics' entrepreneurial intentions, as well as the venturing processes of ASOs, are determined by factors and stakeholders from multiple levels. This chapter offers a basic understanding of academic entrepreneurship and outlines several promising avenues for future research.

Fritsch and Krabel (2012) indicate that a large intention–action gap exists amongst academics; based on their results, 28% of all university scientists have entrepreneurial intentions, whereas only 3.2% implement these plans. As such, Chapters 3 and 4 focus on

the characteristics of individual academics and explore the determinants of the ASO venturing process from two opposing perspectives. Chapter 3 focuses on the effects of specific motivating factors on the venturing progress of academic entrepreneurship and answers the questions of which individual motives are most crucial in the venturing process and how these motives affect process. Whereas existing studies have advanced understanding of what drives academics to launch their own businesses (e.g. Hayter, 2015a; Iorio et al., 2017; Lam, 2011), a paucity of research has explored why many academic entrepreneurs cease or postpone pursuing their business ideas. Chapter 4 furthers the exploration of this phenomenon by analysing the psychological mechanisms that trigger such by analysing the psychological mechanisms that trigger such avoidance reactions. The results highlight that psychological factors such as individual decision paralysis, self-efficacy, attitudes towards science and risk-taking propensity significantly affect academics' decision-making behaviours and how they perceive potential entrepreneurial obstacles. In sum, Chapters 3 and 4 contribute to the literature on the intention–action gap in the academic entrepreneurship context and provide university administrators and policymakers advice on how to develop differentiated support programmes to promote academic entrepreneurship.

To date, empirical evidence considering the individual, as well as the institution-specific structural and environmental, factors that affect scientists' entrepreneurial intentions remains scarce. The joint impacts of and interplay between different predictors across various levels, as well as within specific levels, remain under-researched. As such, Chapters 5 and 6 fill this gap by adopting an integrated approach to analyse the heterogeneity of academic entrepreneurship. Chapter 5 focuses on stakeholders, from both the micro- and meso-levels, and tests how and to what extent the entrepreneurial propensities of academics are simultaneously affected by specific personal and occupational characteristics. Chapter 6 develops a multi-level model that explains the interplay between the individual characteristics of scientists, the organisational (university) context and the collaboration between scientists and external stakeholders.

Taken together, the findings of dissertation deepen the existing understanding of academic entrepreneurship and offer valuable insights for scholars, university administrators and external stakeholders aiming to promote the development of academic entrepreneurship.

Summary in German (Zusammenfassung)

Die bedeutende Rolle des akademischen Unternehmertums bei der Beschleunigung technologischer Innovationen und der Förderung der lokalen und nationalen Wirtschaftsentwicklung wurde weltweit wahrgenommen (Berbegal-Mirabent et al., 2015; Guerrero et al., 2015; Visintin und Pittino, 2014). Als eine der verschiedenen Formen akademischer unternehmerischer Aktivitäten gelten akademische Spin-offs (ASOs), auch bekannt als Universitäts-Spin-offs (USOs). Sie gelten als wichtige Vermittler (Miranda et al., 2018). Dieses anhaltende Phänomen hat Wissenschaftlern dazu veranlasst, jene Faktoren zu untersuchen, welche die Entwicklung von ASOs beeinflussen, während das Gesamtbild des akademischen Unternehmertums noch lange nicht vollständig erforscht ist.

Diese vorliegende Dissertation verfolgt eine mehrstufige Perspektive, um Faktoren zu analysieren, welche die Gründungsneigung und das Verhalten von Wissenschaftlern beeinflussen. Dabei konzentriert sich diese Arbeit sowohl auf den individuellen Merkmalen von Akademikern als auch auf externe Umweltfaktoren. Beide Ansätze zeigen signifikante Auswirkungen. Das Hauptargument dieser Arbeit besteht darin, dass die gegenwärtige Entrepreneurship Forschung sich stärker mit der Heterogenität der Unternehmerpersönlichkeiten befassen und verschiedene Untergruppen berücksichtigen muss, um den bestehenden Erkenntnisstand zu erweitern. Des Weiteren ist es auch wichtig, die gemeinsamen Aus- und Wechselwirkungen zwischen den Bestimmungsfaktoren auf verschiedenen Ebenen zu berücksichtigen. Die vorliegende Dissertation schließt diese Lücke und analysiert die Wechselwirkungen dieser Effekte sowohl mit Hilfe der qualitativen als auch der quantitativen Methoden. Die vorliegende Arbeit umfasst fünf empirischen Studien, die das bestehende Verständnis des akademischen Unternehmertums aus einer spezifischen Perspektive beleuchten (Kapitel 2-6). Die Forschungsmotivation und Schlussfolgerungen dieser Dissertation werden in Kapitel 1 und 7 dargestellt.

Ausgehend von einer systematischen Literaturrecherche nach Tranfield et al. (2003), verschafft Kapite2 einen konzentrierten Überblick über den aktuellen Forschungsstand im Bereich des akademischen Unternehmertums. Dabei wird ein konzeptioneller Rahmen entwickelt, der darauf hindeutet, dass die Gründungsintentionen von Akademikern sowie der Gründungsprozess eines ASOs von Faktoren und Akteuren auf mehreren Ebenen

determiniert werden. Dieses Kapitel soll dem Leser ein grundlegendes Verständnis des akademischen Unternehmertums vermitteln und zukünftige Forschungswege aufzeigen.

Kapitel 3 und 4 befassen sich mit den Charakteristika einzelner Akademiker und untersuchen die Einflussfaktoren des Gründungsprozesses von ASOs aus zwei entgegengesetzten Perspektiven. Fritsch und Krabel (2012) weisen darauf hin, dass eine große Diskrepanz zwischen der Gründungsneigung und dem Gründungsvollzug von Akademikern besteht. Ausgehend von diesen Ergebnissen haben zwar 28% aller Universitätswissenschaftler eine Gründungsneigung, jedoch werden lediglich 3,2% aller Wissenschaftler auch tatsächlich gründungsaktiv. In Kapitel 3 wird die Auswirkung spezifischer Motivationsfaktoren auf den Gründungsfortschritt von ASOs untersucht und die Frage beantwortet, welche individuellen Motive eine wichtigere Rolle bei der Entwicklung von ASOs spielen und wie sich diese Motive auf den Gründungsfortschritt auswirken.

Obwohl vorangegangene Studien bereits ein sehr fortgeschrittenes Verständnis dessen haben, was Akademiker dazu bewegt, ihr eigenes Unternehmen zu gründen (z.B. Hayter, 2015a; Iorio et al., 2017; Lam, 2011), wurden die Ursachen, warum viele akademische Unternehmer die Umsetzung ihrer Geschäftsideen aufgeben oder verschieben bisweilen kaum untersucht. Kapitel 4 trägt zur Erforschung dieses Phänomens bei, indem es die psychologischen Mechanismen analysiert, die solche Vermeidungsreaktionen auslösen. Die Ergebnisse zeigen, dass psychologische Faktoren wie die individuelle Entscheidungsparalyse, die Selbstwirksamkeit, die Einstellung zur Wissenschaft und die Risikobereitschaft das Entscheidungsverhalten von Akademikern und die Art und Weise signifikant beeinflussen, wie sie potenzielle unternehmerische Hindernisse wahrnehmen. Zusammenfassend lässt sich sagen, dass Kapitel 3 und 4 einen wichtigen Beitrag zur Literatur über die Intentions-Verhaltenslücke in der Academic Entrepreneurship Forschung leisten. Des Weiteren liefern die Ergebnisse Universitätsverwaltungen und politischen Entscheidungsträgern die notwendige Hilfe bei der Entwicklung differenzierter Unterstützungsprogramme zur Förderung des akademischen Unternehmertums.

Bisweilen gibt es kaum empirische Studien, die sowohl individuelle als auch institutionsspezifischen Strukturen- und Umweltfaktoren bei der Erforschung der Gründungsneigung von Wissenschaftlern berücksichtigen. Das Zusammenspiel verschiedener Einflussfaktoren über mehrere Ebenen hinweg sind nur wenig erforscht. Daher sollen Kapitel 5 und 6 diese Lücke durch einen integrierten Ansatz schließen. Kapitel 5 befasst sich mit den Akteuren der Mikro- und Mesoebene und untersucht, wie und in

welchem Ausmaß die Gründungsneigung von Akademikern durch persönliche und berufliche Merkmale der Gründer beeinflusst wird. In Kapitel 6 wird ein Mehrebenenmodell entwickelt, mit dem das Zusammenspiel zwischen den einzelnen Charakteristika von Wissenschaftlern, dem organisatorischen (universitären) Kontext und der Zusammenarbeit zwischen Wissenschaftlern mit externen Akteuren erklärt wird.

Zusammenfassend erweitern die Ergebnisse dieser Dissertation das bestehende Verständnis des akademischen Unternehmertums und bieten wertvolle Perspektiven für Wissenschaftler, Universitätsadministratoren und externen Stakeholdern, welche die Entwicklung des akademischen Unternehmertums fördern wollen.

1 Introduction

1.1 Motivation

The crucial role of academic entrepreneurship in accelerating technological innovation and promoting local and national economic development has been globally recognised (Berbegal-Mirabent et al., 2015; Guerrero et al., 2015; Visintin and Pittino, 2014). As one of the various forms of academic entrepreneurial activities, academic spin-offs (ASOs), also known as university spin-offs, are considered an important means (Miranda et al., 2018). An ASO is a new company established to promote the exploitation of a core technology or technology-based idea generated within a university, with which the founding member(s)may or may not be affiliated to the academic institution (Smilor et al., 1990; Nicolaou and Birley, 2003a; 2003b).

ASOs have contributed to economic development, particularly local economic development in several ways. Firstly, spin-offs generate significant financial value and, more importantly, they enhance economic stability by extending the diversity of the economy (Shane, 2004a; O'Shea et al., 2008). Secondly, ASOs stimulate technical innovation by producing new products and services to meet customers' diverse needs (Dahlstrand, 1997). In addition, ASOs are particularly important to local economic development (Guerrero et al., 2016); since ASOs are more likely to be located very close to their parent universities, such geographical proximity creates more job opportunities for local residents, particularly for highly educated individuals (Audretsch and Stephan, 1996; Shane, 2004a). Moreover, ASOs serve as 'magnets' and form industrial clusters by bringing more similar new firms to an area and attracting venture capital investment, which further enhances local economic development (Feldman et al., 2005; Shane, 2004a).

The venturing process of an ASO is a long, complex, dynamic and multi-level process that involves individuals, opportunity and context (Rasmussen, 2011; Druilhe and Garnsey, 2004). Roberts and Malone (1996) indicate that four major stakeholder groups are involved in the spin-off process: the technology originator, entrepreneur, R&D organisation and venture investor. As the important creators of new knowledge and a vital stakeholder group of ASOs, academics play an essential role in their formation (Hayter, 2011). Since entrepreneurship is a process and human agency is involved (Shane et al., 2003), the success

of academic entrepreneurial activities depends, to a great extent, upon the involvement and commitment of the academics who decide to pursue entrepreneurial opportunities (Czarnitzki et al., 2014; Shane et al., 2003). Variations in entrepreneurial motivations differ in both degree and form of impact on individuals' decisions and behaviours (Shane et al., 2003). Studies indicate that a wide gap remains between the intention to start a company and the actual behaviour of academics (Fritsch and Krabel, 2012; Kautonen et al., 2015). According to Fritsch and Krabel (2012), 28% of all university scientists possess entrepreneurial intentions, whereas only 3.2% actually implement these plans.

Amongst the stakeholders of ASOs, the university exerts the most critical organisational influence on their creation and development (Smilor et al., 1990; Zhang, 2009), and, as the parent organisations of ASOs, universities also benefit from the establishment of ASOs. The missions that universities conduct have expanded since the second academic revolution of the late 20th century (Etzkowitz, 2003). In addition to the traditional functions of teaching and scholarly research, a 'third mission' has been integrated into the functions of universities that involves engagement in formal commercialisation activities, such as patenting, licensing and spin-off creation, as well as informal commercialisation activities, such as cooperation with industrial sectors, including contract research and consulting (Visintin and Pittino, 2014). Hence, universities play a broader role in social and economic development and serve as 'regional innovation organisers' (Etzkowitz, 2003; Göktepe-Hulten and Mahagaonkar, 2009; Huyghe and Knockaert, 2015). As an outcome of the integration of this 'third mission', spin-offs help universities fulfil their goals in several different ways: firstly, spin-offs support academic research by providing additional funding (Smilor et al., 1990; Steffensen et al., 2000); secondly, spin-offs help attract and retain valuable faculties by offering compensation; thirdly, spin-offs help students prepare for the future commercial world by disseminating practical and up-to-date knowledge about starting companies; fourthly, ASOs serve as an important channel to transfer scientific knowledge and technology into the commercial market. (Van Geenhuizen and Soetanto, 2009), as they help commercialise early-stage university technologies that would otherwise remain unexploited due to extreme uncertainty (Shane, 2004a).

The development of academic entrepreneurship also depends on the participation of various external stakeholders (Davey et al., 2016). For example, the role of external financial investors is becoming increasingly important as well. According to Frank and Schröder (2018), in 2018, German university start-up support was predominantly third-party funded. Of the total €109 million provided, about €82 million originated from third-party capital, of which private third-party funding accounted for approximately €31 million.

In light of this ongoing, and still relatively under-researched phenomenon, this dissertation addresses several important issues regarding the determinants, incentive mechanisms and collaborations that involve stakeholders from multiple dimensions, to help scholars better identify the factors that affect academic entrepreneurial decisions, and to help universities and other academic institutions, such as public research organisations (PROs), facilitate academic entrepreneurship more effectively and efficiently.

1.2 Research questions

1.2.1 Venturing process of academic spin-offs: an overview of determinants (Chapter 2)

The crucial role of ASOs in accelerating technological innovation and promoting economic development has enticed many scholars to explore the factors that influence their development (Block et al., 2017; Santini, 2017; Vincett, 2010). The body of literature pertaining to this topic is growing, whereas the findings are still relatively controversial and fragmented, due to the nature of the specific sample, time or context. Moreover, several existing reviews pertaining to this topic (e.g. Miranda et al., 2018; Rothaermel et al., 2007) only describe the general phenomenon instead of focussing on specific subjects. More importantly, these reviews have not outlined the entire review process, which reduces the credibility of their findings. This calls for a more transparent and in-depth review. To close this gap, the first objective of this dissertation is to provide a holistic exploration of the factors that drive, impede and are critical for the success of ASOs, by focussing on the following three research questions in **Chapter 2**:

RQ 1.1: *What drives academics to become entrepreneurs?*

RQ 1.2: *Which barriers must academics overcome during the venturing process?*

RQ 1.3: *Which factors influence the success of academic spin-offs?*

1.2.2 Micro-level determinants (Chapters 3 and 4)

Fritsch and Krabel (2012) provide empirical evidence indicating a large intention–action gap amongst academics: according to their results, 28% of all university scientists possess entrepreneurial intentions, whereas only 3.2% put their plans into action. This phenomenon calls for more attention in academic entrepreneurship research. Thus, Chapters 3 and 4 focus on individual academics and explore the determinants of the ASO venturing process from two opposing perspectives. Previous studies indicate that scientists' motives for becoming entrepreneurs are critical in overcoming the intention–action gap, because scientists with higher entrepreneurial intentions are also more committed to their goals and plans and therefore more likely to act upon their intentions (Gollwitzer, 1999; Lee et al., 2011; Obschonka et al., 2010). However, academics are driven by a variety of motives when engaging in entrepreneurial activities. To date, a debate concerning how and the extent to which various individual motives affect the venturing progress in academic entrepreneurship context is ongoing (Lam, 2011; Miranda et al., 2018). As such, **Chapter 3** focuses on the effects of specific motivating factors and addresses the following two research questions:

RQ 2.1: *Which motivating factors play the most significant roles for academic entrepreneurship?*

RQ 2.2: *How do these motivating factors affect the venturing progress of academic entrepreneurship?*

Following the intention–action gap, existing studies have advanced understanding of what drives academics to start their own businesses (e.g. Hayter, 2015a; Iorio et al., 2017; Lam, 2011), whereas only a paucity of research has explored why many academic entrepreneurs stop or postpone pursuing their business ideas (e.g., Kollmann et al., 2016; Hossinger et al., 2020). The psychological mechanisms behind such researchers' avoidance reactions deserve more attention; in particular, certain responsive psychological factors that are more common in academia exert critical effects on the entrepreneurial obstacles perceived, which in turn can lead to different subsequent entrepreneurial decisions regarding opportunity evaluation and exploitation. In light of this, **Chapter 4** aids in closing this gap in the research literature by addressing the following question:

RQ 3: *How do the psychological factors of university scientists affect the extent to which they perceive entrepreneurial obstacles?*

1.2.3 Interplay between micro- and meso-level determinants (Chapter 5)

Given the peculiar genetic nature of ASOs, they generally have close ties with their parent organisations, particularly with universities (Rasmussen et al., 2014). Consequently, the venturing processes of ASOs are not only influenced by the individual characteristics and traits of academics but also significantly affected by the objectives and policies of parent organisations (Colombo and Piva, 2012; Rasmussen et al., 2014; Smilor et al., 1990). Favourable entrepreneurial milieus within universities and departments can encourage academics to engage in spin-off creation and other entrepreneurial activities (Foo et al., 2016; Grimm and Jaenicke, 2012; Huyghe and Knockaert, 2015; Rasmussen et al., 2014). In addition, well-established and comprehensive university support mechanisms can facilitate the venturing process of ASOs (Fini et al., 2011). However, up-to-date, empirical evidence that considers individual, as well as institution-specific structural and environmental factors that affect scientists' entrepreneurial intentions remains scarce. The joint impacts of and, the interplay between different predictors across various levels, as well as within specific levels remain under-researched. Little is known, for example, about whether and how specific incentive schemes provided by universities efficiently stoke the start-up inclinations of the scientific staff. As such, **Chapter 5** aids in filling this gap by analysing the following research question:

RQ 4: *How do individual working conditions, institutions, and networks affect the likelihood of engaging in entrepreneurial activities (nascent entrepreneurship) amongst academics?*

1.2.4 Bridging divides across various levels (Chapter 6)

Moreover, the success of an ASO also depends on the macro-environmental context in which it is closely embedded (Davey et al., 2016). Since a 'third mission' has been integrated into the functions of universities, academic institutions around the world are currently implementing far-reaching changes to become more entrepreneurial (Audretsch, 2014; Guerrero and Urbano, 2012; 2014; Block et al., 2017). These changes have attracted the attention of researchers willing to commercialise their research and policymakers with the mandate to foster entrepreneurial-oriented atmospheres and exploit university innovations (Guerrero et al., 2016; Link and Scott, 2019). As a result, a growing need can be observed for universities and industries to develop more 'rapid'

linkages between scientists at universities and external stakeholders (Algieri et al., 2013; Cunningham and Link, 2015; Miller et al., 2014), including new stakeholders, such as incubators, private industry, business partners, venture capitalists and professional associations (Rasmussen et al., 2011; Bradley et al., 2013). However, the alignment between the micro-, meso-, and macro-levels of analysis in academic entrepreneurship also poses challenges to scientists who aim at the knowledge spill-over of academic entrepreneurship (Siegel et al., 2003; Siegel and Wright, 2015) and support practices geared towards start-up activities (Lerner, 2004). Very limited evidence exists demonstrating how universities complement and assist collaborations between scientists and a range of external stakeholders through available organisation channels to advance the knowledge spill-over of academic entrepreneurship. Hence, **Chapter 6** intends to bridge the micro, meso and macro divide in university knowledge transfer by addressing the following research question:

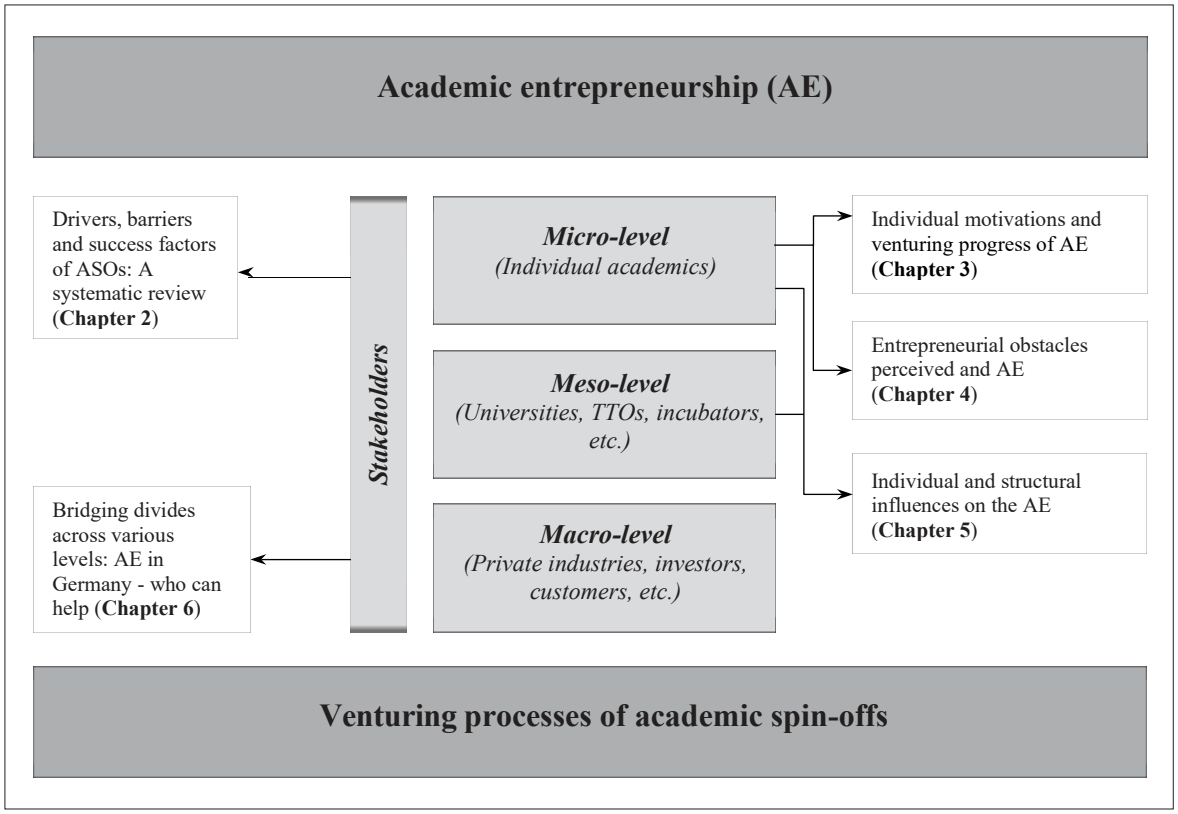
RQ 5: *How does the interplay between scientists, organizational (university) context and the collaboration between external stakeholders advance academic entrepreneurship?*

1.3 Chapter outlines

This dissertation is structured in seven chapters; Figure 1.1 provides a chapter overview. The remaining chapters are outlined briefly below.

Chapter 2 provides a comprehensive overview of the current state of research in the field of academic entrepreneurship. Following the basic procedure for conducting a systematic literature review according to Tranfield et al. (2003), Chapter 2 outlines a selection, evaluation, summary and synthesis of 193 relevant articles in the field. These articles were coded based on their research objectives and units of analysis. The results were summarised in a conceptual framework, which highlights the drivers, barriers and success factors of academic entrepreneurship from the micro-, meso- and the macro-levels. Thus, compared to prior systematic literature reviews in the field, Chapter 2 provides a more transparent procedure and more in-depth findings. This chapter is intended to provide a basic understanding of academic entrepreneurship, and it offers several potential promising directions for future research.

Figure 1.1: Structure of the dissertation.



Source: Own illustration.

Chapters 3 and 4 focus on the stakeholders at the micro-level, including an analysis of the individual psychological factors that motivate and impede academic entrepreneurs in the pursuit of their business ideas. **Chapter 3** focuses on the effects of specific motivating factors on the venturing progress of academic entrepreneurship. Building upon the previous research stream, a variety of individual motives have been classified into three major categories: transfer motives, economic motives and lifestyle motives. Using a comprehensive two-wave cross-sectional dataset of academic entrepreneurs from Germany, Chapter 3 answers the following two research questions: which individual motives are most critical in the venturing progress of academic entrepreneurship, and how do these motives affect the venturing progress? Overall, Chapter 3 contributes to the understanding of the intention–action gap in the academic entrepreneurship context and provides universities and policy makers the necessary help to develop differentiated support programmes to meet the diverse needs of academic entrepreneurs.

Chapter 4 analyses the phenomenon of why many academic entrepreneurs postpone or cease the pursuit of their business ideas, and in particular, the effects of certain responsive psychological factors on the extent of entrepreneurial obstacles perceived, by building on

three well-known psychological theories: the decision conflict theory from Janis and Mann (1977), theory of planned behaviour (Ajzen, 1991) and the institutional theory drawn from Meyer and Rowan (1977). Chapter 4 finds that the extent of entrepreneurial obstacles perceived depends positively on the degree of individual decision paralysis and attitudes towards science and negatively on entrepreneurial self-efficacy and individual risk-taking propensity. In summary, Chapter 4 helps to clarify whether and to what extent these psychological factors affect a scientist's perception of start-up obstacles and, thus, can assist university administrators and policymakers develop more effective support programmes.

Chapter 5 focuses on the stakeholders from both the micro- and meso-levels and tests how and to what extent the entrepreneurial propensities of academics are simultaneously affected by specific personal and occupational characteristics. Using unique data collected from 5,992 academic scientists in 73 German universities, Chapter 5 fills the research gap by analysing the joint impacts and, interplay between different predictors across various levels, as well as within specific levels. It provides a holistic view of the impact of several university-specific structural factors on entrepreneurial intentions amongst German academics, by simultaneously focussing on individual and institutional working conditions from different faculties.

Chapter 6 aims to bridge the micro, meso and macro divide in university knowledge transfer by combining a range of external partners with available organisational channels for knowledge commercialisation. Building on the endogenous economic growth and the knowledge spill-over theory of entrepreneurship, Chapter 6 provides a multi-level model that explains the interplay between scientists' individual characteristics, the organisational (university) context and the collaborations between scientists and external stakeholders. The empirical findings confirm the variety of combinations of organisational structures and external stakeholders that could most effectively facilitate start-up activity amongst academics. Chapter 6 also provides implications for scholars, scientists, university managers and investors aiming to support start-up activities and invest in research commercialisation.

Finally, **Chapter 7** concludes with a summary and discussion of the main results of the previous chapters and outlines the major implications of this thesis for theory and practice. The dissertation ends with a brief description of its limitations and an outlook of future research avenues.

1.4 Publication status of the chapters and contribution of the author

Table 1.1 provides an overview of the publication status of the chapters included in this dissertation. The following people (in alphabetical order) have also co-authored the chapters: David Audretsch, Joern H. Block, Teita Bijedić, Maksim Belitzki, Stefan M. Hossinger, Frank Maaß, Arndt O. Werner and, Christian Schröder. Out of the five chapters, one has been published in an international peer-reviewed journal that is ranked by the 2015 VHB-JOURQUAL 3[1]. Two of them have been submitted for publication and are currently under review. The remaining two are under preparation for submission as well. The following paragraphs describe the contributions of the author to these papers.

Chapters 1 and 7: Both chapters were written independently by the author of the dissertation.

Chapter 2: The author of this dissertation wrote the majority of the introduction, the findings and the implication part. The author also participated in the data collection process and developed the conceptual framework. This manuscript was presented and nominated for the best paper award at the G-Forum conference 2018 in Stuttgart. The manuscript is published in *Management Review Quarterly*. The publishing process involved three rounds of major and minor revisions, which were led and largely conducted by the author of this dissertation.

Chapter 3: The majority of this chapter was written by the author of this thesis. The author wrote large parts of the introduction, the theoretical background, the hypothesis development as well as the conclusion. In addition, the author also greatly contributed to conducting and improving the empirical analysis. This paper was submitted to *The Journal of Technology Transfer* in February 2020 and has received an invitation to revise-and resubmit for a second-round review.

Chapter 4: Large parts of this chapter were completed by the author. The author drafted and wrote the introduction and large parts of the theoretical background and hypothesis development parts. In addition, the author helped conduct both the descriptive and multivariate statistics and also interpreted and discussed the findings. This paper was presented and nominated for the best paper award at the 16th IECER entrepreneurship conference 2018 in Innsbruck. This chapter was also presented at the G-Forum conference

[1] The VHB-JOURQUAL 3 is a journal ranking that evaluated by the association Verband der Hochschullehrer für Betriebswirtschaft e.V. (VHB).

2018 in Stuttgart, the Babson College Entrepreneurship Research Conference 2019 in Boston (US) as well as the 17th IECER entrepreneurship conference in Utrecht (NL). This manuscript is currently being prepared for submission to a journal.

Chapter 5: In this chapter, the author contributed to improving and revising the theoretical background and hypothesis development, as well as the interpretation of the empirical results. Moreover, the author also made contributions in improving the illustration of empirical evidence. This manuscript is currently being prepared for submission to a journal.

Chapter 6: In this chapter, the author drafted and wrote the introduction and large parts of the theoretical background. Moreover, the author was responsible for the development of the empirical models and for conducting the empirical analysis. The author also contributed to the development of the conceptual framework and the interpretation and discussion of the empirical results. Additionally, the author helped to improve and revise the theory and hypothesis. This paper was submitted to *Research Policy* in January 2020. An initial decision of the chief editor is pending.

Table 1.1: Publication status of the manuscripts used in this dissertation.

Chapter	Chapter title	Publication status	Co-authors
Manuscripts used in this dissertation			
2	Drivers, barriers and success factors of academic spin offs: A systematic literature review	Published in: *Management Review Quarterly*	Hossinger, S.M., Werner, A.O.
3	What drives the venturing progress of academic entrepreneurship? The role of individual motivations	Submitted to: *The Journal of Technology Transfer* Received an invitation to revise-and-resubmit for a second-round review	Hossinger, S.M., Block, J.H., Werner, A.O.
4	Entrepreneurial obstacles and academic entrepreneurship: determinants of avoidance reactions in a decision-making process	Being prepared for submission	Hossinger, S.M., Belitzki, M., Werner, A.O.
5	Individual and structural influences on the entrepreneurial activities of academics	Being prepared for submission	Bijedić, T., Maaß, F., Schröder, C., Werner, A.O.
6	Academic entrepreneurship in Germany - who can help	Submitted to: *Research Policy*	Audretsch, D.B., Belitski, M., Hossinger, S.M., Werner, A.O.

2 Drivers, barriers and success factors of academic spin-offs: a systematic literature review[2]

Abstract

The considerable economic contribution of academic spin-offs (ASOs) has drawn numerous scholars' attention to explore the factors that influence their development. The body of literature pertaining to this topic is growing, though the findings remain relatively controversial and fragmented. Existing literature reviews only describe the general phenomenon instead of focusing on precise areas. Therefore, the main objective of this review is to provide a holistic and in-depth exploration of the factors that drive, impede and are critical for the success of ASOs by posing three specific questions: (1) What drives academics to become entrepreneurs? (2) Which barriers must they overcome during the venturing process? (3) Which factors influence the success of academic spin-offs? Following the basic procedure outlined by Tranfield et al. (2003) for conducting a systematic literature review, this research selected, evaluated, summarised and synthesised 193 relevant articles. The findings indicated that individual factors carried significantly higher explanatory power in relation to the entrepreneurial behaviour of academics. However, the venturing process and the success of ASOs are influenced not only by factors at the micro-level, but also strongly depend on factors at the meso and macro-levels such as relationships with parent organisations and regional contexts. Furthermore, factors that impede the ASO venturing process and factors at the macro-level are still under-researched and deserve further investigation. In addition, this review discusses several potential promising theoretical and practical implications for stakeholders at different levels, which should be helpful to further promote the development of ASOs in the future.

Keywords Academic spin-offs · Academic entrepreneurship · Technology transfer · Literature review

JEL Classification M130 · O310 · O320

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2.1 Introduction

A ‘third mission’ has been integrated into the traditional functions of universities since the second academic revolution. This new mission attempts to transfer the knowledge from different research fields to the industrial sector and society (Van Looy et al., 2011; Visintin and Pittino, 2014). As one of the various forms of academic entrepreneurial activities, academic spin-offs (ASOs), also commonly known as university spin-offs (USOs), are considered important mediators in achieving this mission (Miranda et al., 2017). An ASO is a new company that is established by the exploitation of a core technology or technology-based idea generated within a university, where the founding member(s) may or may not be affiliated to the academic institution (Smilor et al., 1990; Nicolaou and Birley, 2003a). Meanwhile, considering their substantial economic contributions, including creating employment opportunities, enhancing economic stability, forming industrial clusters, as well as stimulating innovation processes, the crucial role that ASOs play in accelerating technology innovation and promoting economic development has been globally recognised (Block et al., 2017; Visintin and Pittino, 2014; Berbegal-Mirabent et al., 2015; Guerrero et al., 2015). Nevertheless, the venturing process of an ASO is complex, long-term and dynamic, involving influencing factors from multiple dimensions (Rasmussen, 2011; Miranda et al., 2018). Fritsch and Krabel (2012) indicated that even though one third of scientists believe it is very attractive to establish a spin-off, just one in three of these eventually devotes him or herself to the process. The fact is that the formation of ASOs requires not only the existence of individual motivations, but also the involvement of parent organisations and various participants from society (Rasmussen et al., 2014).

Despite an extensive volume of studies devoted to exploring the ASO phenomenon over the last decade, the findings have been reasonably controversial and fragmented. This is due to the nature of specific samples, the time or context. Different research designs and definitions have also undermined the consistency of findings, which have consequently reduced the fulfilment of their objectivities. This investigation found several bibliographical reviews on the subject (O'Shea et al., 2004; Mustar et al., 2006; Rothaermel et al., 2007; Djokovic and Souitaris, 2008; Miranda et al., 2018). However, these reviews either only described the general phenomenon or screened too few samples. More importantly, they did not outline the entire review process, which reduced the credibility of their findings. Thus, this research gap calls for a more transparent and in-depth review with respect to the aforementioned questions. Compared to the most recent review by Miranda et al. (2018), the

review herein adopted a more targeted coding strategy and seeks to present a more holistic overview by focusing on three specific questions: (1) What drives academics to become entrepreneurs? (2) Which barriers must they overcome during the venturing process? (3) Which factors influence the success of ASOs? By evaluating, extracting and summarising the content of each article included, common themes will be clustered into several dimensions. Based on the variables identified in each cluster, synthesis of further content will be conducted in order to establish a conceptual framework, which will deepen the understanding of those drivers, barriers and factors in multiple dimensions that determine the successful development of ASOs.

The review findings show that the ASO venturing process is influenced by factors at multiple levels. Factors that impede the development of ASOs and factors at the macro-level are still under-researched and deserve further investigation in the future. From a theoretical perspective, this paper attempts to provide researchers with potentially valuable research opportunities for the future. From a practical perspective, it aims to assist university administrators, policy makers and investors in more effectively recognising factors that determine the venturing process and performance of ASOs so that they may develop and implement more appropriate strategies to facilitate academic entrepreneurship.

The structure of this paper is as follows: section two elaborates the review process in detail, followed by a presentation of the descriptive results and in-depth content analysis in section three. A conceptual framework will be presented in section four and the final section will reveal the implications.

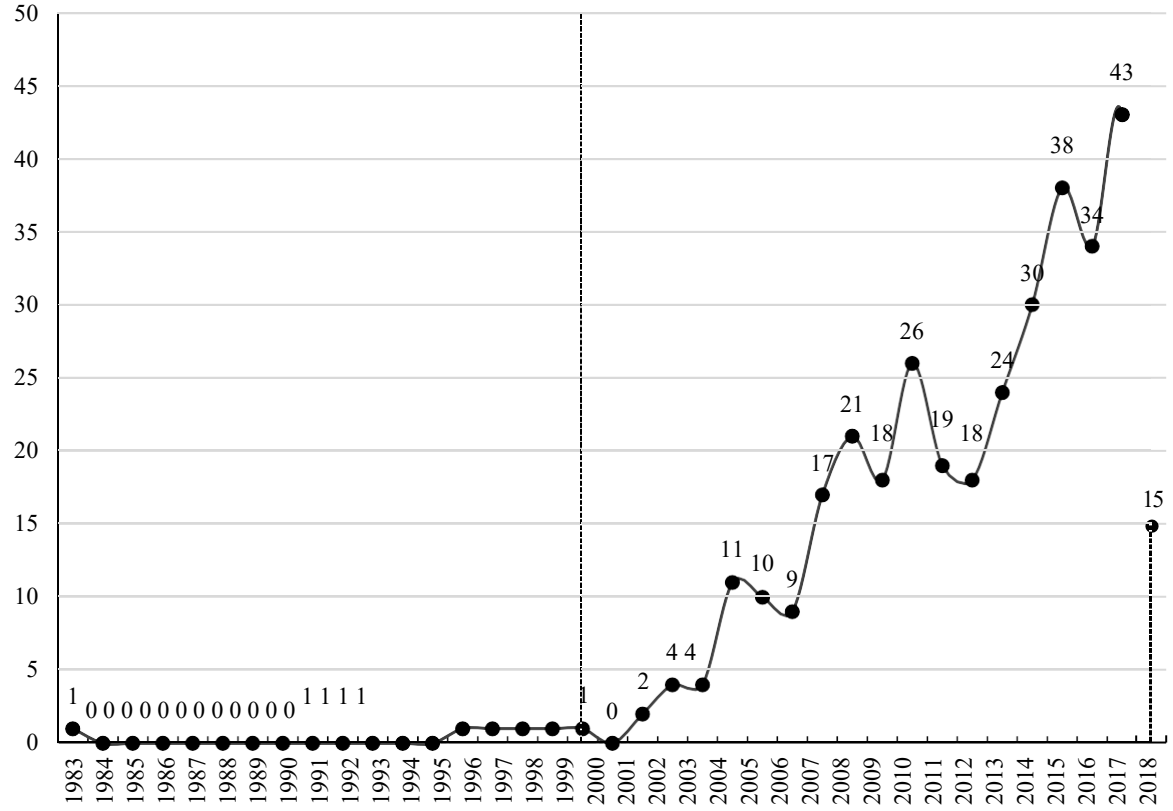
2.2 Methodology

This paper followed the basic procedure summarised by Tranfield et al. (2003) for conducting a systematic literature review. Such a review comprises three principal stages: planning, conducting and reporting. Each stage is divided into multiple sub-phases with different purposes (Tranfield et al., 2003). Prior to conducting the review, a rigorous and explicit search protocol was developed in order to retrieve sufficient relevant evidence for a transparent and holistic investigation. The search began by restricting the literature type to English language scholarly articles published in refereed journals on topics relating to academic spin-offs. Six recognised scientific electronic databases were used:

(1) EBSCO Business Source Complete; (2) Elsevier Science Direct; (3) Springer Link; (4) Emerald; (5) Wiley Online Library; (6) ISI Web of Knowledge. These were searched using the following terms: ('academic spin-off' OR 'university spin-off'; 'academic spin*' OR 'university spin*'; 'academic entrepreneur*' OR 'university entrepreneur'; 'academic' AND 'entrepreneurial intention' OR 'entrepreneurial motivation' OR 'entrepreneurial inclination'; 'determinant' OR 'success' OR 'performance' OR 'obstacle' OR 'barrier' OR 'inhibitor' AND 'university spin*'). The preliminary selection was refined by screening the titles and abstracts to ascertain their eligibilities; articles were excluded when they failed to answer the specific research questions of this review or due to duplication. Consequently, 349 articles were identified after the initial screening.

Further selection was conducted by applying the following two inclusion criteria. The first was journal quality – articles were included if they were published in journals listed as having an impact factor in Thomson Reuters' 2017 journal citation reports or if they were ranked by the Association of Business Schools (ABS) or the Verband der Hochschullehrer für Betriebswirtschaftlehre (VHB). The second criterion was the publication timeframe – articles were included if they were published from 2000 onwards. The main reason for choosing this criterion was that the number of published articles on the topic of academic entrepreneurship have increased exponentially since 2000 (as shown in Figure 2.1). Therefore, commencing from the year 2000 was deemed long ago enough to maximise the likelihood of capturing up-to-date articles whilst simultaneously minimising the effects of publication biases.

Figure 2.1: Number of articles published since 1983



Note: Given the fact that the year 2019 is still ongoing, only articles published till March 2019 have been included.

Source: Own illustration.

Based on the pre-defined search strategies, the combined results ultimately yielded 193 articles for further in-depth analysis. Before summarising and synthesising the findings of the selected articles, a data extraction sheet was created with detailed information regarding the author(s), year, title, journal, type of work, research method, unit of analysis, geographical scope(s), and key findings, which served as a solid foundation for the subsequent data synthesis for identifying common issues that had been addressed and categorising them accordingly.

The articles included were coded based on their research objectives and units of analysis. Starting from the research questions, the articles were classified into three general categories: drivers, barriers and success factors. Articles that focused on drivers and investigated the key determinants promoting the formation of ASOs fell into the first category. Articles that focused on examining the barriers and their effects during the different ASO development stages were coded as 'barrier' research, whilst the third category included articles that focused on success factors and analysed the influencing factors critical

to sustainable ASO development. For a better understanding of the coding underlying the conducted review, see Table 2.1. Each general category consisted of three sub-classifications according to the units of analysis, namely: micro-, meso- and macro-level. Articles at the micro-level (55.44%) addressed individual academic entrepreneurs or ASOs. Meso-level articles (25.91%) focused on parent organisations such as universities or other academic institutions. Macro-level articles (6.22 %) analysed the role of the social economic environment in the ASO venturing process. Accordingly, articles that covered multiple dimensions (12.43 %) were coded as multi-level studies. With the help of this citation coding, articles could be easily identified and categorised. The patterns and recurring themes revealed in the resulting data will be discussed in detail in the following section.

Table 2.1: Sample research questions for coding.

	Multi-dimension: (12.43%)		
	Micro-level: (55.44%)	**Meso-level: (25.91%)**	**Macro-level: (6.22%)**
Drivers: (43.52%)	*'How does entrepreneurial self-efficacy affect the emergence of entrepreneurial intentions in academics?'*	*'What influence does the organizational structure of universities have on the entrepreneurial intentions of scientists?'*	*'Which contextual factors encourage or discourage academics to engage in entrepreneurial activities?'*
Barriers: (8.81%)	*'Why do tendencies towards paralysis lead to a stronger perception of obstacles in the early stages of spin-out creation?'*	*'Are university support programs able to reduce perceived barriers in the spin-off process?'*	*'How do barriers in the regional and national contexts influence the performance of academic spin-offs?'*
Success factors: (47.67%)	*'To what extent does human capital leverage the effect of bridging ties on the early growth of academic spin-offs?'*	*'Do university-level support mechanisms complement or substitute for each other in fostering the creation of academic spin-offs?'*	*'How do government-funded academic spin-offs perform compared to peers and does the EBSG have a positive impact on firms' performance?'*

2.3 Findings

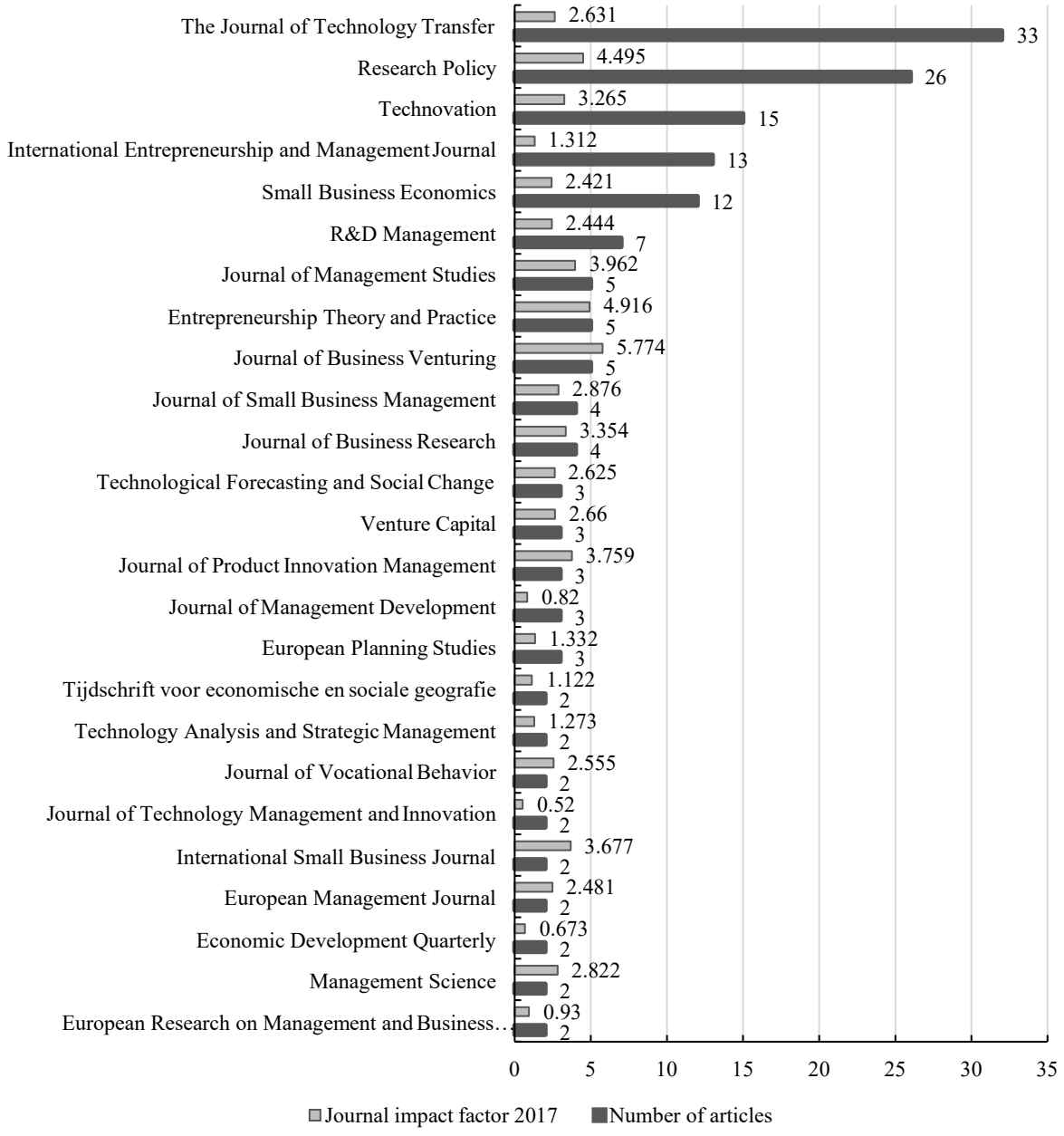
The findings are presented in two main sections: the first provides an overview of the characteristics of all the articles included in terms of their publication distribution, research methods used, geographical distribution and units of analysis. The second section provides the in-depth content findings, which form the core of this review.

2.3.1 Descriptive characteristics

Publication distribution: With respect to the total number of articles published in this research field (349 since 1983), Figure 2.1 shows that their number increased exponentially over the last two decades. While little research on this topic was conducted during the period from 1983 to 2000, the number of publications increased slightly till the end of the year 2004. Following a notable increase in articles published during the period 2006 to 2011, there was a decline in 2012. As shown in Figure 2.1, a total of 26 articles was published in 2011 compared to only 19 in 2012. At first glance, this represents a decline of around 27% from the previous year, 2011. Upon closer examination, however, considering Research Policy published a special issue on academic entrepreneurship in 2011, of which nine articles from this single edition were captured, it seems that there was, in fact, a significant increase from 2010 to 2011 due to this outlier. Looking at the timeframe from 2012 to 2019, Figure 2.1 shows that the number of articles increased exponentially from 2013, which indicates that researchers were paying ever more attention to the topic of academic entrepreneurship over the ensuing five years. If the entire timeframe is taken into account, only approximately 13% (46) of the total number of articles pertaining to this topic were published in the first three decades (1983 to 2007). However, the number of publications rose rapidly from 2007. Around 87% of the articles were published in the last decade (2008 to 2019), which corresponds to a total of 303 articles. Overall, these statistical results are in line with the findings of Miranda et al. (2018).

The database used for the final analysis comprised 193 articles published in 55 different journals. As shown in Figure 2.2, considering at least two of the articles published are a cut-off point, the distribution among the journals was fairly skewed. The three journals with the largest output were The Journal of Technology Transfer (17.10%), followed by Research Policy (13.47%) and Technovation (7.77 %). Roughly 38% of the articles reviewed were published in these three journals alone; accordingly, the other 62% were published in the remaining 52 journals.

Figure 2.2: Number of articles published by journal.



Source: Own illustration.

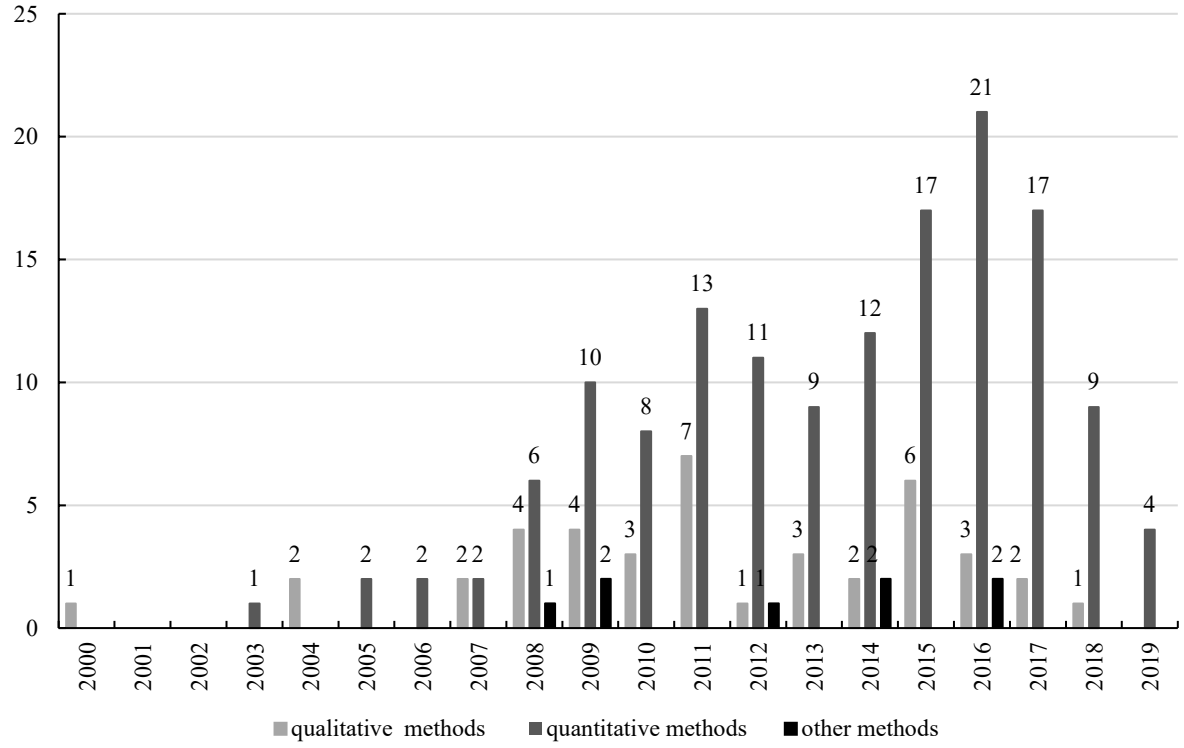
Regarding journal quality, based on the latest rankings in the German VHB Index of 2017, the majority of the journals in the underlying samples were rated as a 'B' (47.06%) whilst two journals were rated as 'A*' (5.88%), namely Administrative Sciences and Management Science. With respect to the three journals with the largest outputs, Research Policy was given an 'A' rating, The Journal of Technology Transfer a 'B' rating and Technovation a 'C'. A further criterion for evaluating journal quality is to assess the impact factor according to the Thomson Reuters (2017) journal citation reports. As shown in Figure 2.2, 53 journals presented an average impact factor of 2.570 with 21 journals exceeding this factor. The most highly ranked journal in the selected samples was the Journal of Business Venturing with an impact factor of 5.774. As can be seen from Figure 2.2, a great majority of the reviewed articles were published in journals ranked as 'C' or higher.

This finding indicates that ASO research is well-recognised and represents a current study topic in academia. Moreover, the results show that the impact factors of the included journals were, on average, relatively high, which suggests that published articles in the ASO field are often cited by other scholars. More importantly, the distribution among the journals provides information for academics about which journals are most relevant to the ASO topic, enabling them to develop an improved publication strategy. With regard to the number of published articles, the results show that the most relevant journals in this research field were Research Policy and The Journal of Technology Transfer.

Research method: The majority of the articles reviewed adopted the quantitative method (74.61%), whereas 41 articles (21.24%) relied on the qualitative and a mere eight articles were theory-based (4.15%). Considering this finding, Figure 2.3 shows the number of articles reviewed based on the research methods adopted over time. It is noticeable that the gap between qualitative and quantitative research widened even further over time. This indicates that researchers increasingly shifted their attention from qualitative to quantitative research methods over the last decade. A possible explanation for this phenomenon, according to Rothaermel et al. (2007), may be that in the early stages of academic entrepreneurship research, scholars lacked fine-grained reliable data, theories and frameworks by which to conduct quantitative analyses; therefore, the qualitative method was a more effective means of describing phenomena and exploring influencing factors. However, with a deeper understanding and growing maturity in this research field coupled with the availability of high-quality quantitative data from institutions such as the European Patent Office (EPO), the Association of University Technology Managers (AUTM),

different theories and frameworks emerged and were constructed by scholars. Consequently, scholars have shifted their research attention from qualitative to quantitative analysis in more recent decades (Rothaermel et al. 2007).

Figure 2.3: Number of articles reviewed based on research methods.

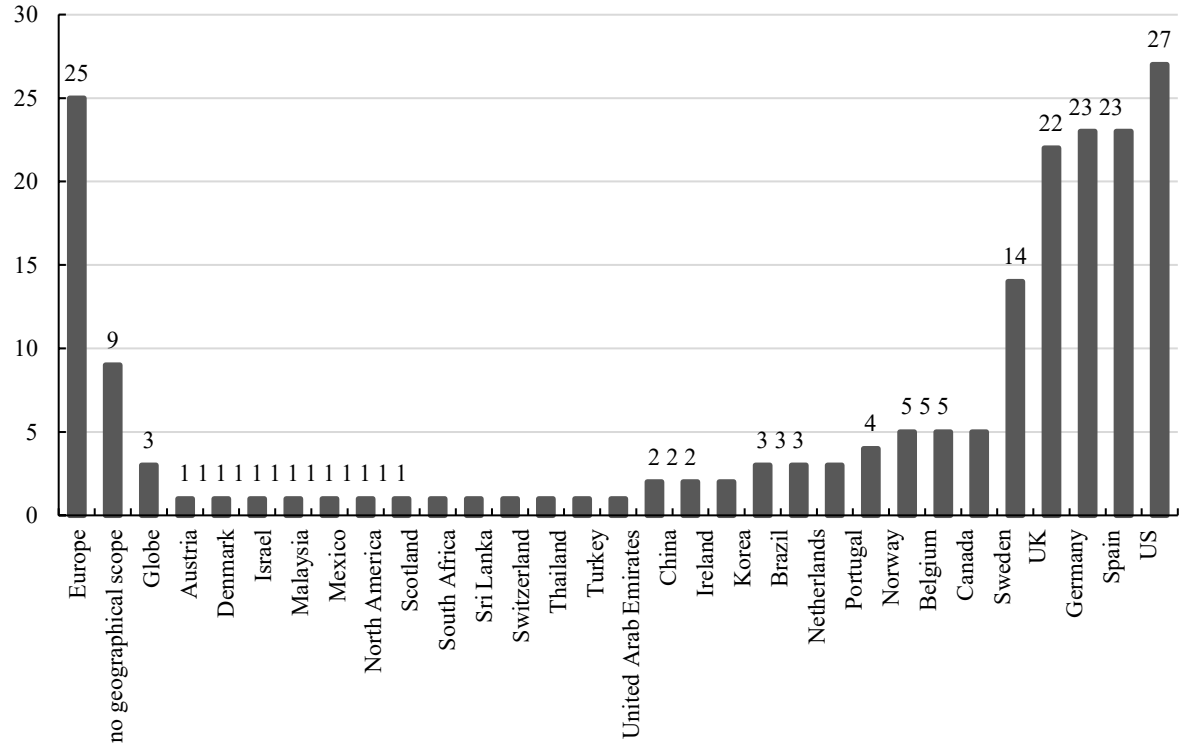


Source: Own illustration.

Geographical distribution: Regarding the geographical distribution of the included articles, Figure 2.4 shows that the total 193 articles covered 28 countries in Europe, the Americas, the Middle East and Asia. Nonetheless, the distribution is reasonably skewed as the great majority of articles focused on European countries, followed by the US, while very few articles were based in Asian or Middle Eastern contexts. This result is consistent with the findings in previous literature reviews on the topic of ASOs (Rothaermel et al., 2007; Miranda et al., 2018; Djokovic and Souitaris, 2008). This said, none of these reviews offered explanations for the skewed distribution.

It appears that there are several possible explanations for this phenomenon. Firstly, the concept of ASOs was known earlier in European countries and in America. Consequently, their development was faster in these areas compared to in other continents. For this reason, scholars paid more attention to these 'hotspots' where ASO development was more mature and fruitful. Secondly, the skewed distribution may also be explained by the origins of the authors and universities. The most prolific scholars in the sample are mostly of European origin and work in European universities. For example, Einar Rasmussen hails from the University of Nottingham (UK), Riccardo Fini from the University of Bologna (IT) and Mike Wright from the Imperial College Business School, London (UK). Considering the available resources and databases, the scholars of Italian or British universities would certainly primarily focus on the development of ASOs in European regions instead of in other remote continents.

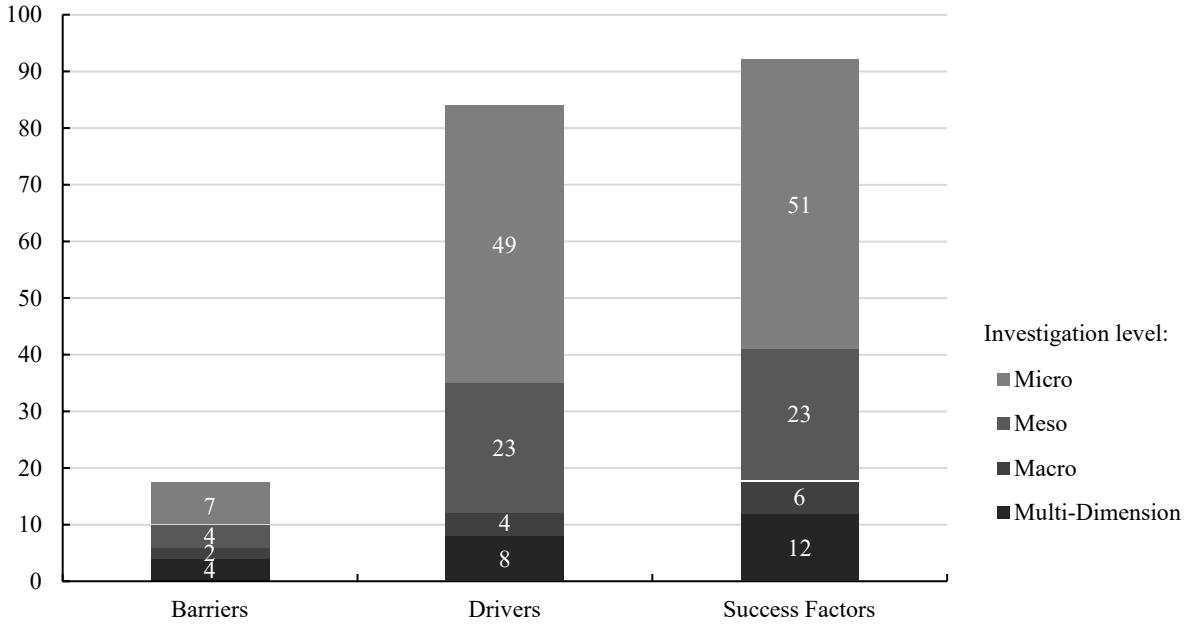
Figure 2.4: Geographical distribution of reviewed articles.



Source: Own illustration.

Unit of analysis: Based on in-depth content analysis of the 193 articles, Figure 2.5 shows that the majority focused on exploring the success factors (47.67%) and drivers (43.52%) of ASOs. In contrast, only 17 articles (8.81%) addressed the barriers. With respect to the level of analysis, Figure 2.5 further illustrates that most of the articles attempted to explore the drivers, barriers and success factors at the micro-level (55.44%), followed by those at the meso- (25.91%), multi- (12.44%) and macro-levels (6.22%). Consequently, these findings indicate that up until now, very little research has scrutinised the central barriers and their effects in both the early and late stages of the spin-out formation process. Furthermore, there is a lack of research on those factors that influence the development of ASOs at the macro-level. The in-depth content analysis of the 193 articles in this study was performed based on the data extraction sheet and common issues were categorised and synthesised for the purposes of drawing general conclusions.

Figure 2.5: Number of articles related to the investigation level.



Source: Own illustration.

2.3.2 Content findings

2.3.2.1 Drivers

Micro-level: Starting at the micro-level, the articles included in this review explored individual motivations via three principal approaches. The first approach emphasised the importance of taking into account both intrinsic ('Puzzle') and extrinsic ('Gold' and 'Ribbon') motivations when interpreting the entrepreneurial behaviours of academics (Lam, 2011). On the one hand, academics decide to engage in entrepreneurial activities so as to pursue an intrinsic source of rewards, such as independence, a sense of achievement, skill enhancement, inner satisfaction, self-realisation and self-esteem (Guerrero et al., 2008; Hoye and Pries, 2009; Hayter, 2011; Lam, 2011; Antonioli et al., 2016; Iorio et al., 2017; Barba-Sánchez and Atienza-Sahuquillo, 2018). In addition, they may feel a sense of social responsibility or of having a 'mission' to be of public service, to improve living standards by applying and disseminating technology or they may have a 'need for utilisation'; these are all potential critical forces driving some academics to establish their own ASOs (Morales-Gualdrón et al., 2009; Berggren, 2017; Iorio et al., 2017). On the other hand, academics' entrepreneurial behaviours are also motivated by rewards that emerge from the external environment. These extrinsic motivations can be generally grouped into two categories based on their tangibility.

An important determinant for a great majority of researchers is the expectation of additional academic benefits from founding spin-off ventures, such as the generation of further stimuli for research activities, access to funding opportunities (grants) or the possibility of obtaining new infrastructures and facilities for their research activities. They consider spin-offs as a platform for obtaining these resources to support their research (Fini et al., 2009; Lam, 2011; Goethner et al., 2012; Hayter, 2015a; Antonioli et al., 2016; Iorio et al., 2017). As for the financial rewards, although 'Gold' does have an influence in motivating academics to engage in entrepreneurial activities; the influence is however limited and its importance often depends on the age and position of the academic or on other personal concerns (Rizzo, 2015; Antonioli et al., 2016). Overall, these factors have been demonstrated as being of relatively little importance compared to other motivating factors and most scientists would not consider them the primary goal, but as collateral compensation for the time and effort they have devoted (Morales-Gualdrón et al., 2009; Hayter, 2011; Lam, 2011; Goethner et al., 2012). Instead, intangible extrinsic rewards, such as traditional academic

recognition, reputation and promotion, are the primary motives for most academics when participating in entrepreneurial activities (Fini et al., 2009; Hayter, 2011; Lam, 2011; Hayter, 2015a).

The second approach adopted a resource-based perspective and highlighted the critical role of academics' human capital and social capital profiles in shaping their spin-off propensity and performance. Compared to general human capital variables such as age, career status and seniority, entrepreneurship-specific human capital variables have higher explanatory power regarding entrepreneurial opportunity exploration and exploitation (Ucbasaran et al., 2008). Prior commercial and entrepreneurial experience, prior industrial work experience, business management experience, domain-specific research experience and a diverse and balanced skillset will improve the entrepreneurial opportunity identification capability of academics and increase the likelihood of actually pursuing these opportunities (Guerrero et al., 2008; Liñán, 2008; Raposo et al., 2008; Ucbasaran et al., 2008; Hoye and Pries, 2009; Krabel and Mueller, 2009; Prodan and Drnovsek, 2010; Clarysse et al., 2011a; Rasmussen, 2011; D'Este et al., 2012; Goethner et al., 2012; Grimm and Jaenicke, 2012; Marion et al., 2012; Abreu and Grinevich, 2013; Goel and Göktepe-Hultén, 2013; Moog et al., 2015; Scholten et al., 2015; Zapkau et al., 2015; Fini and Toschi, 2016; Huyghe et al., 2016b; Miranda et al., 2018). In addition, academics' social capital profile is another critical determinant in promoting spin-off creation propensity (Krabel and Mueller, 2009; Karlsson and Wigren, 2012; Fernández-Pérez et al., 2014; Fernández-Pérez et al., 2015; Hayter, 2015b; Iorio et al., 2017). Professional social networks consisting of elements such as mentors or business associates could offset academics' insufficient market knowledge and financial resources by providing professional assistance; for example, by raising early-age financing and connecting potential business partners and customers (Hayter, 2013; Fernández-Pérez et al., 2014). Nevertheless, personal social networks (e.g. family, friends and colleagues) may provide academics with emotional support by fostering an immediate entrepreneurship-oriented environment (Fernández-Pérez et al., 2014). Similarly, the spin-off process also contributes to the development of academic entrepreneurs' social capital (Borges and Filion, 2013).

The third approach focused on examining the psychological activities of academics that affect their entrepreneurial attitudes, values and behaviours. A great number of scholars employed Ajzen's (1991) theory of planned behaviour (TPB) to examine the entrepreneurial motivations of academics and encountered robust positive empirical support (Krabel and Mueller, 2009; Obschonka et al., 2010; Goethner et al., 2012; Maes et al., 2014). The three independent concepts – namely, attitudes, perceived behavioural control and social norms – have strong explanatory power in relation to the entrepreneurial intentions of academics (Guerrero et al., 2008; Krabel and Mueller, 2009; Díaz-García and Jiménez-Moreno, 2010; Obschonka et al., 2010; Haeussler and Colyvas, 2011; Hayter, 2011; Goethner et al., 2012; Obschonka et al., 2012; Brettel et al., 2013; Mathieu and St-Jean, 2013; Maes et al., 2014; Thomas et al., 2014; Fernández-Pérez et al., 2015; Moog et al., 2015; Obschonka et al., 2015; Feola et al., 2019; Urban and Chantson, 2019). Another psychological theory, the regulatory focus theory (RFT), has been adopted by a number of scholars to explain academics' entrepreneurial behaviours as well. RFT suggests that individuals regulate their behaviours based on one of the following two principles: either by having a promotion focus (i.e. striving to achieve positive goals) or a prevention focus (i.e. seeking to avoid negative outcomes) (Higgins, 1987). Coupled with favourable working and family environments, a strong promotion focus generally leads to a high propensity to engage in entrepreneurial activities (Guerrero et al., 2008; Johnson et al., 2017).

Besides variables from psychological theories, a great number of scholars also emphasise the vital role that entrepreneurial self-efficacy (ESE) plays in predicting academics' intentions to start their own businesses. Academics with higher ESE are more likely to establish their own firms (Guerrero et al., 2008; Díaz-García and Jiménez-Moreno, 2010; Prodan and Drnovsek, 2010; Mathieu and St-Jean, 2013; Shinnar et al., 2014; Fernández-Pérez et al., 2015; Huyghe and Knockaert, 2015). In addition, individual personality, value orientation and academics' cognitive perception could also affect their entrepreneurial intentions (Krabel and Mueller, 2009; Lam, 2011; Douglas, 2013; Meek and Wood, 2016). Based on the 'big five' personality model, scholars suggest that academics with higher levels of conscientiousness, extraversion, emotional stability, openness to experience and lower levels of agreeableness have a stronger intention to become entrepreneurs (Obschonka et al., 2010; Kolb and Wagner, 2015). Furthermore, academics' spin-off intentions are determined by their value orientations, such as their proactiveness, risk-taking propensity, innovativeness, entrepreneurial passion and commercialisation-

friendly attitudes (Hoye and Pries, 2009; Krabel and Mueller, 2009; Haeussler and Colyvas, 2011; Libaers and Wang, 2012; Mathieu and St-Jean, 2013; Knockaert et al., 2015; Huyghe et al., 2016a). Academics who possess a hybrid role identity (i.e. a focal academic self and a secondary commercial persona) are more likely to engage in entrepreneurial activities (Jain et al., 2009; Obschonka et al., 2015) whilst individual demographic characteristics such as age, gender, career status and seniority could also determine the likelihood of an academic's involvement in different types of entrepreneurial activities (Abreu and Grinevich, 2013). The relationship between gender differences and academics' entrepreneurial intentions is a popular study topic for many scholars. Generally, male and female academics are driven by distinct motivations and interpret supports differently; perceived behavioural control and role models have more influence on the fostering of female academics' entrepreneurial intentions (Fernández-Pérez et al., 2014; Maes et al., 2014; Shinnar et al., 2014; Alonso-Galicia et al., 2015). Haeussler and Colyvas (2011) claimed that senior male academics with close entrepreneurial orientation possess sufficient material and social resources and, therefore, are more likely to engage in various entrepreneurial activities. Moreover, compared to their female counterparts, male academics are more willing to develop external social contacts and demonstrate greater initiative and optimism, which leads to stronger intentions of starting their own businesses (Díaz-García and Jiménez-Moreno, 2010; Abreu and Grinevich, 2013; Alonso-Galicia et al., 2015; Iorio et al., 2017).

Further to the three principal research streams, the faculty quality of academics and their research disciplines also affect their entrepreneurial intentions (Perkmann et al., 2011; Huyghe and Knockaert, 2015; Moog et al., 2015; Fini and Toschi, 2016). Scientists with diverse and balanced skill sets tend to have higher entrepreneurial intentions (Moog et al., 2015). Moreover, academics who work in applied research areas and in the disciplines of science, engineering and physics tend to participate in all types of entrepreneurial activities, while academics in the social science, education and business disciplines prefer to engage in informal commercial activities such as consultancy and contract research (Prodan and Drnovsek, 2010; Abreu and Grinevich, 2013; Moog et al., 2015; Fini and Toschi, 2016). Additionally, the relationship between scientific and entrepreneurial activities is worthy of note. Previous studies have argued that there is a trade-off effect between the two; that is, engaging in knowledge transfer activities comes at the expense of scientific productivity (Czarnitzki et al., 2014). However, the articles included in this review did not provide evidence for such a conflict of interests between these activities, but rather demonstrated a

complementary relationship (Huyghe et al., 2016a). Academic excellence and entrepreneurial activity go hand-in-hand (Clarysse et al., 2011a). Scientific productivity is a precondition for engaging in commercialisation activity, and spin-off experiences enhance academics' opportunity identification capabilities (Goel and Göktepe-Hultén, 2013; Huyghe et al., 2016b). Faculty entrepreneurs demonstrate greater scientific productivity than their colleagues, even prior to founding firms (Abramo et al., 2012). Table 2.2 provides an overview of micro-level drivers.

Table 2.2: Drivers covered by articles reviewed at the micro-level.

Perspective	Key elements (variables)	Representative studies
Intrinsic motivations	Desire for independence, achievement, skill enhancement, intrinsic satisfaction, self-realisation etc.	*Guerrero et al. 2008; Hoye and Pries 2009; Hayter 2011; Lam 2011; Antonioli et al. 2016; Barba-Sánchez and Atienza-Sahuquillo 2018*
Extrinsic motivations	Additional academic benefits, financial rewards, academic recognition, reputation and promotion	*Fini et al. 2009; Lam 2011; Goethner et al. 2012; Rizzo 2015; Hayter 2015a; Antonioli et al. 2016; Iorio et al. 2017*
Human capital	Prior commercial and entrepreneurial experience, prior industrial work experience, business management experience, a balanced skillset etc.	*Clarysse et al. 2011a; D'Este et al. 2012; Abreu and Grinevich 2013; Goel and Göktepe-Hultén 2013; Fini and Toschi 2016*
Social capital	Professional, personal and business social networks	*Krabel and Mueller 2009; Karlsson and Wigren 2012; Fernández-Pérez et al. 2014; Fernández-Pérez et al. 2015; Hayter 2015b; Iorio et al. 2017*
Psychological factors	Theory of planned behaviour, regulatory focus theory, entrepreneurial self-efficacy, cognitive perception, role identity etc.	*Jain et al. 2009; Krabel and Mueller 2009; Díaz-García and Jiménez-Moreno 2010; Obschonka et al. 2010; Goethner et al. 2012; Douglas, 2013; Obschonka et al. 2015*
Personality and demographic characteristics	Extraversion, emotional stability, openness to experience, age, gender, career status and seniority	*Obschonka et al. 2010; Fernández-Pérez et al. 2014; Maes et al. 2014; Alonso-Galicia et al. 2015; Kolb and Wagner 2015*
Faculty quality, research types and disciplines	Diverse and balanced skillsets, applied research, science, engineering and physics disciplines	*Prodan and Drnovsek 2010; Perkmann et al. 2011; Abreu and Grinevich 2013; Huyghe and Knockaert 2015; Moog et al. 2015; Fini and Toschi 2016*

Meso-level: Due to the peculiar nature of ASOs, the venturing process is influenced not only by factors at the micro-level, but also depends significantly upon its relationship with parent organisations, particularly universities. Walter et al. (2013) argued that academics' entrepreneurial intentions may be increased by four factors at the organisational level, namely entrepreneurship support programmes, industry ties, research orientation and entrepreneurship education. This conclusion was found to be generally consistent with the findings of this review. As shown in Table 2.3, the influencing factors at the meso-level can be broadly classified into three major categories: university characteristics, research orientations, and university support mechanisms. Firstly, the characteristics and orientations of a university could significantly shape the entrepreneurial decisions of academics and influence the venturing process of ASOs. It has been demonstrated that universities with a focus on applied research and with prior industry cooperation experiences and traditions have a higher propensity to engage in technology transfer activities (Arvanitis et al., 2008; Fischer et al., 2017). Universities with solid resource bases with regard to the financial, human, social, physical and technological have also been shown to markedly facilitate the formation and further development of ASOs (O'Shea et al., 2005; Algieri et al., 2013; Heblich and Slavtchev, 2014; Avnimelech and Feldman, 2015; Berbegal-Mirabent et al., 2015; Ramaciotti and Rizzo, 2015; Jung and Kim, 2017) Moreover, some investors consider the reputation and prestige of universities as positive signals for commercial technology potential (Gras et al., 2008). Therefore, a university's status facilitates academic entrepreneurs in acquiring resources and networks to start their businesses by enhancing their credibility in the market (Avnimelech and Feldman, 2015).

Another critical determinant is the entrepreneurial culture and climate within universities and departments. A favourable university entrepreneurial milieu could encourage academics to engage in spin-off creation and other entrepreneurial activities (Hayter, 2011; Grimm and Jaenicke, 2012; Huyghe and Knockaert, 2015; Foo et al., 2016; Feola et al., 2019; Zollo et al., 2017). Besides the positive influence of university entrepreneurial culture and climate, Rasmussen et al. (2014) emphasised that the influence of departmental support should also not be neglected and that this is equally, perhaps even more, important in the initial ASO development phase compared to general university support. Riviezzo et al. (2018) indicated that the number of spin-offs generated is positively related to the entrepreneurial orientation, age and size of a department. Furthermore, departments could provide more direct assistance in enhancing opportunity identification,

championing and increasing the resource acquisition competencies of academics and ASOs (Rasmussen et al., 2014). Supporting this view, Huyghe et al. (2015) noted that department membership explains more variations with regard to the entrepreneurial intentions of academics than the university as a whole, with the adhocracy culture of departments found to be positively related to the entrepreneurial intentions of academics. This effect becomes even stronger for universities with well-established entrepreneurial infrastructures (Huyghe et al., 2015). Antonioli et al. (2016) confirmed that the immediate working environment moderates the entrepreneurial intentions of academics. In a similar vein, Bercovitz and Feldman (2008) also emphasised that the individual behaviours of academics are strongly affected by the social norms within departments. The orientation and behaviour of department leaders ('role model') and peers ('peer effect') play a vital part in influencing an academic's individual entrepreneurial behaviour (Bercovitz and Feldman, 2008; Nelson, 2014; Alonso-Galicia et al., 2015; Nicolaou and Souitaris, 2016; Johnson et al., 2017) and academics are more likely to participate in entrepreneurial activities when they cooperate with entrepreneurship-oriented peers (Stuart and Ding, 2006; Moog et al., 2015). Informal support such as encouragement and professional assistance from former colleagues also increases academics' entrepreneurial intentions (Müller, 2010).

Thirdly, having a well-established university entrepreneurship support mechanism is also critical in facilitating the formation of ASOs (Landry et al., 2006). Fini et al. (2011) examined the joint impact of university-level support mechanisms (ULSMs) and local-context support mechanisms (LCSMs) in fostering the creation of ASOs and suggested that both have a significant influence in this regard. The marginal effect produced by ULSMs in incentivising the creation of ASOs is more efficient and effective when the regional context is also largely in favour of high-tech entrepreneurship (Fini et al., 2011). Moreover, university internal policies and regulations could play a crucial role in influencing the ASO venturing process (Meoli et al., 2017). The immediate working conditions in which academics are embedded are shaped by the design of internal university policies and regulations, which necessarily affect the decisions of academics who are contemplating founding their own firms (Muscio et al., 2016). Clear and specific regulations and policies that favour academic entrepreneurship, such as conflict of interest policies (Muscio et al., 2016), leave of absence policies (Caldera and Debande, 2010), inventor ownership policies (Kenney and Patton 2011), legislative regulations (Fini et al., 2011), and administrative support (Meoli and Vismara, 2016) may significantly stimulate the enthusiasm of scholars

to participate in spin-off creation activities. Furthermore, establishing an entrepreneurship-oriented reward system within a university could also affect academics' spin-off intentions (Huyghe and Knockaert, 2015; Kolb and Wagner, 2015).

Another important element of the university entrepreneurship support mechanism is the availability of well-established and well-functioning incubation infrastructures and services, as well as easy accessibility (Landry et al., 2007; O'Shea et al., 2007; Guerrero et al., 2008; Algieri et al., 2013; Conceição et al., 2017; Fini et al., 2017). Incubation infrastructures such as technology transfer offices (TTOs) and science parks are established to encourage the transformation of research results into commercial markets (Algieri et al., 2013) and to foster the creation of ASOs (Gras et al., 2008; Caldera and Debande, 2010; Grimm and Jaenicke, 2012; Abreu and Grinevich, 2013; Berbegal-Mirabent et al., 2015; Moog et al., 2015; Fini et al., 2017). The technology transfer performance of universities has also been found to be positively associated with the size and experience of TTOs as well as the quality and expertise of TTO staff (O'Shea et al., 2005; Powers and McDougall, 2005; Gras et al., 2008; Caldera and Debande, 2010; Van Looy et al., 2011; Berbegal-Mirabent et al., 2015; Ramaciotti and Rizzo, 2015; Jung and Kim, 2017). Many scientists consider TTOs to be an important source of delegation in exchange for the preservation of their role identity (Jain et al., 2009; Hayter, 2016).

More importantly, TTOs significantly improve the performance of ASOs by providing a set of valuable services such as complementary technical and management support (Fernández-Alles et al., 2015; Rodríguez-Gulías et al., 2016; Slavtchev and Göktepe-Hultén, 2016), contacts to external funding sources (Berbegal-Mirabent et al., 2015), and training and mentoring to foster entrepreneurial mind-sets (Gras et al., 2008). Also worthy of note is the role of entrepreneurship education programmes provided by universities in affecting academics' propensity for business creation and performance (Raposo et al., 2008). Numerous scholars have emphasised the significant contribution of entrepreneurship education in the improvement of academics' ESE and EI (Liñán, 2008; Turker and Selcuk, 2009; Prodan and Drnovsek, 2010; Shinnar et al., 2014; Alonso-Galicia et al., 2015; Moog et al., 2015; Huynh, 2016). Regarding the content of entrepreneurship education, academics tend to prefer more practical-oriented curriculums (Shah and Pahnke, 2014; Piperopoulos and Dimov, 2015). Meanwhile, some push factors at the organisational level should also be noted, considering some academics leave universities to found their own firms due to reasons such as current workloads, high levels of bureaucracy and low-risk

orientation in the parent organisation (Morales-Gualdrón et al., 2009). Table 2.3 provides an overview of meso-level drivers.

Table 2.3: Drivers covered by articles reviewed at the meso-level.

Perspective	Key elements (variables)	Representative studies
University characteristics	Applied research, prior industry cooperation experiences, solid resource bases, reputation, university prestige	*O'Shea et al. 2005; Arvanitis et al. 2008; Gras et al. 2008; Algieri et al. 2013; Heblich and Slavtchev 2014; Avnimelech and Feldman 2015; Berbegal-Mirabent et al. 2015*
Entrepreneurial orientations	Entrepreneurial culture and climate within universities and departments	*Hayter 2011; Grimm and Jaenicke 2012; Huyghe and Knockaert 2015; Foo et al. 2016; Feola et al. 2019; Zollo et al. 2017*
Support mechanisms	University regulations, incubation services, financial support and entrepreneurship education	*Landry et al. 2006; Caldera and Debande 2010; Fini et al. 2011; Algieri et al. 2013; Alonso-Galicia et al. 2015; Muscio et al. 2016; Meoli et al. 2017*

Macro-level: With respect to factors at the macro-level (Table 2.4), Davey et al. (2016) claimed that the extent of academic entrepreneurship is closely associated with the level of regional economic development, as well as cultures and histories. The existence of a favourable entrepreneurial atmosphere and support mechanisms within a region, including the availability of individuals with open-minded attitudes (regional openness) may significantly promote the creation of ASOs (Guerrero et al., 2008; Fini et al., 2011; Grimm and Jaenicke, 2012; Davey et al., 2016; Ghio et al., 2016). Further the presence of agglomeration economies within a region may be an important determinant in explaining the variation in ASO formation and their geographical distribution (Conceição et al., 2017).

In terms of the national context, it is also possible that government instruments and policies may shape the entrepreneurial intentions of academics by providing necessary resources, networks, infrastructures and favourable regulations (Rasmussen, 2008; Botelho and Almeida, 2010). Government support programmes contribute to reducing agency problems in adverse selections and moral hazards in the relationships between the government and the actors involved in the commercialisation of research (Rasmussen and Gulbrandsen, 2012). Lifting or easing restrictive regulations could also stimulate the creation of ASOs (Kroll and Liefner, 2008).

Table 2.4: Drivers covered by articles reviewed at the macro-level.

Perspective	Key elements (variables)	Representative studies
Regional context	Level of economic development, culture and histories, geographical location and entrepreneurial environment	*Guerrero et al. 2008; Fini et al. 2011; Grimm and Jaenicke 2012; Davey et al. 2016; Ghio et al. 2016; Conceição et al. 2017*
National context	Government instruments, regulations and support programs	*Kroll and Liefner 2008; Rasmussen 2008; Botelho and Almeida 2010; Rasmussen and Gulbrandsen 2012*

2.3.2.2 Barriers

Micro-level: The development of ASOs is constrained by several internal and external barriers. Van Geenhuizen and Soetanto (2009) examined the nature of obstacles faced by ASOs during different development phases and to what extent these obstacles affect the performance of highly innovative spin-offs compared to other types of spin-offs. They suggested that different types of obstacles to growth exist and that these may be market-related (e.g. marketing knowledge, sales skills and customer base), finance-related (e.g. cash flow and capital investment), management-related (e.g. management capacity) and physically related (e.g. accommodation and infrastructure). For ASOs, market-related obstacles tend to be the most resistant over time whilst financial thresholds may be overcome fairly quickly. Compared to other types, highly innovative spinoffs could solve the credibility and sustainable returns problem more quickly due to first-mover advantages (Vohora et al., 2004; Van Geenhuizen and Soetanto, 2009; Zhou et al., 2011; Agarwal and Shah, 2014). Additionally, several studies have demonstrated that insufficient resources for technology transfer, the costs associated with innovation and a lack of applicability of knowledge impede the emergence of individual entrepreneurial intentions and the performance of ASOs (O'Gorman et al., 2008; Davey et al., 2016; Neves and Franco, 2016). Moreover, conflicted objectives, internal corporate governance issues, as well as a lack of entrepreneurial competences among the founding teams may disrupt the consistent development of ASOs (Vohora et al., 2004; Zhou et al., 2011; Davey et al., 2016; Neves and Franco, 2016). With regard to the individual attitude of academic founders, Singh Sandhu et al. (2011) found that risk and stress aversion as well as the fear of failure were also key barriers in the early stages of the venturing process. Consistent with this view, Maes et al. (2014) pointed out that female researchers perceive entrepreneurial obstacles in the spin-out formation process much more acutely than male researchers (Abreu and Grinevich, 2017).

Consequently, female researchers are less likely to become entrepreneurs than their counterparts (Ebersberger and Pirhofer, 2011). Additionally, homogeneous social network composition was found to be a hurdle to entrepreneurship (Hayter et al., 2017).

A further major barrier for scientists in the initial stages of the spin-off formation process is the academic system itself. Scientific acceptance and recognition within the scientific community may be achieved almost exclusively through the publication of research results; therefore, the success and recognition of a scientist is measured primarily by the number and ranking of his publications ('publish or perish'). Due to the fact that the scientific community has up to now rarely been made aware of the issues of starting a business, there is a lack of appreciation for the commercialisation of research results. Subsequently, scientists focus more on publishing their research findings and less on the opportunity to commercialise them. As a consequence, some start-up projects are not further substantiated and are even rejected (O'Gorman et al., 2008; Lacetera, 2009; Wright et al., 2009). Table 2.5 provides an overview of the micro-level barriers.

Table 2.5: Barriers covered by articles reviewed at the micro-level.

Perspective	Key elements (variables)	Representative studies
Lack of entrepreneurial capabilities, knowledge and resources	Marketing knowledge, sales skills, customer base and financial resources	*Vohora et al. 2004; Van Geenhuizen and Soetanto 2009; Zhou et al. 2011; Agarwal and Shah 2014*
Lack of applicability of knowledge	Type of research	*Davey et al. 2016; Neves and Franco 2016; O'Gorman et al. 2008*
Internal governance conflicts	Conflicting objectives	*Vohora et al. 2004; Zhou et al. 2011; Davey et al. 2016; Neves and Franco, 2016*
Attitude of the founders	Fear of failure, risk and stress aversion	*Maes et al. 2014; Hayter et al. 2017; Abreu and Grinevich 2017*
Academic system	'Publish or perish'	*O'Gorman et al. 2008; Lacetera 2009; Wright et al. 2009*

Meso-level: Regarding barriers at the meso-level (Table 2.6), a few studies have suggested that an organisation with rather weak entrepreneurial culture, infrastructure and support mechanisms has a significant negative impact on the emergence of entrepreneurial intentions as well as the growth potential of ASOs (Botelho and Almeida, 2010; Zhou et al., 2011; Bhayani, 2015; Neves and Franco, 2016). Supporting this, several studies in the review

indicated that bureaucratic procedures, a lack of organisational support and encouragement for researchers engaging in the adaptation of new knowledge, as well as negative pressure from colleagues, may inhibit the emergence of individual entrepreneurial intentions and the sustainable development of ASOs (Davey et al., 2016; Neves and Franco, 2016). Furthermore, internal governance issues and Management style within the faculty were also found to be a hurdle for academics to entrepreneurship (Bhayani, 2015).

Table 2.6: Barriers covered by articles reviewed at the meso-level.

Perspective	Key elements (variables)	Representative studies
Organisational characteristics	Weak entrepreneurial culture, lack of incubation infrastructure and services	*Botelho and Almeida 2010; Zhou et al. 2011; Neves and Franco 2016*
Bureaucracy	Bureaucratic procedures	*Davey et al. 2016; Neves and Franco 2016*
Internal governance issues	Conservative management style	*Bhayani 2015*

Macro-level: With regard to the macro-level, the limited availability of private funding sources represents a major barrier to effectively commercialising university technologies (Munari et al., 2018). Attracting external venture capital (EVC) support is seen as the biggest challenge with most ASOs due to the problem of information asymmetries from both the demand and the supply sides. On the one hand, it is difficult for academic entrepreneurs to attract suitable EVC investments. On the other hand, different types of venture capitalists have distinct preferences regarding investment in targeted selections. In addition, the heterogeneity of ASOs renders it more difficult for investors to make correct investment decisions (Knockaert et al., 2010; Zhou et al., 2011).

Another barrier to the success of ASOs is applying for and receiving state subsidies. Because scientists' start-up projects are normally technologically based and highly capital-intensive, in most circumstances, applications for funding have to be submitted and granted before the start-up project proceeds. However, the application process is often extremely complex and time-consuming with various bureaucratic formalities that have to be observed during the process. Compared to private venture capital funding, the inferior financial contracting structure of public funding programmes may also negatively affect the commercial performance of ASOs (Ayoub et al., 2017). Hence, a lack of state subsidies can be seen as a context-specific barrier that may decrease the entrepreneurial intention of

scientists, whilst also compromising the successful development of ASOs (Bhayani, 2015; Davey et al., 2016).

Furthermore, with regard to the perception of barriers in the ASO venturing process, the empirical evidence in the reviewed articles suggested the existence of country- and regional-specific differences. Countries and regions with superior market and financial situations are considered to have more successful opportunities for entrepreneurship. As such, the perceived entrepreneurial barriers are lower than in less-developed countries and regions (Davey et al. 2016; Neves and Franco, 2016). Table 2.7 provides an overview of these barriers at the macro-level.

Table 2.7: Barriers covered by articles reviewed at the macro-level.

Perspective	Key elements (variables)	Representative studies
Financial supports	Limited availability of federal and private funding sources	*Knockaert et al. 2010; Zhou et al. 2011; Munari et al. 2018*
Bureaucracy	Complicated and time-consuming application and granting process	*Bhayani 2015; Davey et al. 2016; Ayoub et al. 2017*
Country- and regional-specific differences	Level of economic development	*Davey et al. 2016; Neves and Franco 2016*

2.3.2.3 Success factors

Before analysing the influencing factors that are critical to the success of ASOs, it is necessary to understand how scholars have evaluated their success in the past. As shown in Table 2.8, most scholars have only adopted conventional performance indicators such as survival rate, growth rate and profitability when assess them, which is consistent with the findings of Corsi and Prencipe (2015).

Table 2.8: Measurements of ASO success.

	Success measurement indicator(s)	Author(s)
Financial performance	• Total Sales • Return on net assets • Number of products and or service innovation • Cash flow • Profitability • Market share • Commercialisation	*Hayter 2013; Helm et al. 2016; Huynh 2016*
Growth rate	• Growth rate in terms of sales • Growth rate in terms of employees	*Clarysse et al. 2011b; Van Geenhuizen and Soetanto, 2013*
Survival rate	• Survival rate	*Zhang 2009*

Micro-level: With regard to the factors that are critical for the sustainable development of ASOs, the articles included in this review revealed that a great majority of researchers had adopted a resource-based approach to explore the relevant determinants, which could be generally categorised into internal conditions (ASO resources, strategies and capabilities) and external conditions (relationship with parent organisations and external supports). In terms of internal variables (Table 2.9), firstly, successful ASO development could be explained by firms' genetic characteristics as well as their initial competence endowments. Sufficient and diverse human, social and technological knowledge resource bases are key predictors of ASO success (Clarysse et al., 2011b; Colombo and Piva, 2012; Cho and Sohn, 2017; Hayter et al., 2017). Another determinant is innovation capability (such as the number of patents) (Ferri et al., 2018). A higher level of innovativeness helps ASOs overcome credibility and sustainable returns thresholds more quickly and easily (Van Geenhuizen and Soetanto, 2009; Helm et al., 2016).

Secondly, the composition and characteristics of the founding team also play a critical role in determining ASO performance. Roberts (1991) claimed that spin-offs with multiple founders outperform those with only one founder in terms of multiple performance indicators. Supporting this view, the articles in this study indicated the importance of having a founding team with a balanced demographic structure and diverse expertise in order to achieve ASO success. A founding team that includes members with both academic and non-academic backgrounds facilitate ASOs in balancing the relationship between pursuing research and economic goals (Visintin and Pittino, 2014). Such composition also significantly improves ASO performance in terms of survival and growth by providing complementary human and social capital such as business management expertise or market

and technological knowledge, which are exactly what most ASOs lack but need (Toole and Czarnitzki, 2009; Gimmon and Levie, 2010; Knockaert et al., 2011; Wennberg et al., 2011; D'Este et al., 2012; Borges and Filion, 2013; Criaco et al., 2014; Visintin and Pittino, 2014; De Cleyn et al., 2015; Fernández-Pérez et al., 2015; Nielsen, 2015; Ciuchta et al., 2016; Helm et al., 2016; Huynh, 2016; Huynh et al., 2017; Ben-Hafaïedh, Micozzi and Pattitoni, 2018; Ferretti et al., 2018b). Gimmon and Levie (2010) discovered that founders' human capital, such as business management, technological expertise and academic status, could enhance their ability to attract external investments and improve ASO survival rate. Consistent with this, Huynh (2016) highlighted the importance of industrial, managerial and entrepreneurial experience of founding teams for improving early-age ASO fundraising ability. Such capabilities could be seen as valuable signals to investors (Huynh, 2016).

In addition, the quality, diversity, density and reciprocity of founding teams' social capital help ASOs overcome the problems of uncertainty and asymmetric information in the fundraising process (Huynh, 2016). Mosey and Wright (2007) addressed the notion that differences in the human capital of academic entrepreneurs could influence their ability to develop social capital and thus overcome barriers to venture development. Academics who have business ownership experience are more adept at building relationships with experienced managers and potential equity investors (Mosey and Wright, 2007). The development of ASOs' entrepreneurial competencies and innovativeness are also positively associated with the network ties of academic founders (Rasmussen et al., 2011; Walter et al., 2011; Rasmussen et al., 2015; Scholten et al., 2015). It is worth noting that founding teams co-evolve with ASO development and that such evolvement also influences ASO performance in terms of survival and growth (Clarysse and Moray, 2004).

Besides the characteristics of founding teams, an ASO management team comprised of heterogeneous knowledge and perspective may also enhance the entrepreneurial orientation and performance of ASOs (Knockaert et al., 2011; Hayter, 2013; Diánez-González and Camelo-Ordaz, 2016; Prencipe, 2016). Recruiting experienced professional non-academic managers in the management team could offset the commercial experience deficiency by providing ASOs with valuable commercial mind-sets and perspectives; such a combination may significantly improve ASO performance (Diánez-González and Camelo-Ordaz, 2016). However, Ferretti et al. (2018b) suggested that despite all the benefits brought about by a heterogeneous team composition, the ratio of academic to non-academic individuals requires careful attention.

Thirdly, ASO performance could be shaped by the strategies and objectives that they adopt and a firm's structure (Zahra et al., 2007; Van Geenhuizen and Soetanto, 2009; Rasmussen, 2011; Colombo and Piva, 2012; Freitas et al., 2013; Hayter, 2013; Hayter, 2015b; Huynh, 2016; Soetanto and Jack, 2016). Given the genetic differences between ASOs and non-ASOs, the financing and collaboration strategies adopted by each are also different (Roininen and Ylinenpää, 2009; Colombo and Piva, 2012). ASOs prefer internal investments and collaboration with various external existing and potential partners to enlarge their technical advantages (Van Geenhuizen and Soetanto, 2009; Colombo and Piva, 2012; Hayter, 2013; Hayter, 2015b; Huynh, 2016). Various performance objectives such as proactiveness, risk-taking and competitive aggressiveness could also lead to varied ASO performance in the areas of growth and survival (Huynh, 2016). As regards a firm's structure, ASOs may improve early-stage fundraising ability by convincing investors of well-established mechanisms – for example internal communication and formal control mechanisms – coupled with a well-designed staff training process (Huynh, 2016). Diánez-González and Camelo-Ordaz (2017) noted that the structure of social networks also decisively influences ASO entrepreneurial orientation and behaviour. Consequently, such influence should not be ignored, especially when it could eventually affect ASO strategies and objectives. Table 2.9 provides an overview of the micro-level success factors.

Table 2.9: Success factors covered by articles reviewed at the micro-level.

Perspective	Key elements (variables)	Representative studies
Initial competence endowments	Sufficient and diverse human, social and technological knowledge resource bases, innovation capability	*Van Geenhuizen and Soetanto 2009; Clarysse et al. 2011b; Colombo and Piva 2012; Cho and Sohn 2017; Ferri et al. 2018*
Characteristics of founding and management teams	A team with a balanced demographic structure and diverse expertise	*Knockaert et al. 2011; D'Este et al. 2012; Hayter 2013; Visintin and Pittino 2014; Ciuchta et al. 2016; Huynh et al. 2017; Ferretti et al. 2018b*
Firm strategies, objectives and structures	Financing and collaboration strategies, different performance objectives	*Van Geenhuizen and Soetanto 2009; Rasmussen 2011; Colombo and Piva 2012; Freitas et al. 2013; Hayter 2013; Hayter 2015b; Huynh 2016*

Meso-level: As for external variables, the relationship with parent organisations in terms of size, density, strength, duration and multiplicity play an extremely important role in determining ASO performance regarding growth, survival rate and early-age fundraising ability (Steffensen et al., 2000; Rasmussen, 2011; Soetanto and Van Geenhuizen, 2015; Fackler et al., 2016; Huynh, 2016; Rao and Mulloth, 2017; Lukeš et al., 2019; Soetanto and Van Geenhuizen, 2019). Rasmussen et al. (2014) observed that ASOs demonstrate differing performance due to variations in initial departmental supports and that they gain momentum and exhibit superior performance if the department contributes to the development. of entrepreneurial competencies. In contrast, a lack of department supports constrains the development of spin-offs regardless of the university's policies and practices. (Rasmussen et al., 2014). Different interaction patterns with parent organisations resulted in distinct modes of technology transfer (Wood, 2009; Treibich et al., 2013). Moreover, the social networks established through contacts with universities create a synergy effect and facilitate ASOs in obtaining the necessary technological knowledge and financial support (Huynh, 2016). ASOs with a higher level of university research cooperation and located in close proximity to parent organisations demonstrate superior innovation performance compared to non-ASOs (Stephan, 2014; Calcagnini et al., 2016; Ghio et al., 2016; Jung and Kim, 2017). Nonetheless, having the ability to balance the level of proximity to universities also affects ASO performance (Semadeni and Cannella, 2011; Soetanto and Van Geenhuizen, 2019). Ferretti et al. (2018a) also suggested a proper strategy that is 'neither absent nor too present' is necessary for parent universities to support the sustainable development of ASOs.

Moreover, sustainable ASO development depends on a university's capabilities (Rasmussen and Borch, 2010). Different capabilities play complementary roles at different development stages of the ASO venturing process (Rasmussen and Borch, 2010). Universities with excellent scientific productivity and innovation capability demonstrate superior entrepreneurial performance (Rasmussen and Borch, 2010; Van Looy et al., 2011; Bonaccorsi et al., 2014; Jung and Kim, 2017). Having the capability to integrate newly obtained resources could facilitate the ASO venturing process (Rasmussen and Borch, 2010; Borges and Filion, 2013). Furthermore, universities with more R&D expenditure increase the probability of spin-off generations (Patzelt and Shepherd, 2009; Avnimelech and Feldman, 2015). Table 2.10 provides an overview of the success factors at the meso-level.

Table 2.10: Success factors covered by articles reviewed at the meso-level.

Perspective	Key elements (variables)	Representative studies
Relationship with parent organization	Size, density, strength, duration and multiplicity	*Steffensen et al. 2000; Rasmussen et al. 2014; Soetanto and Van Geenhuizen 2015; Fackler et al. 2016; Huynh 2016; Lukeš et al. 2019; Soetanto and Van Geenhuizen 2019*
University capabilities	Scientific productivity, innovation capability, resource integration capability etc.	*Rasmussen and Borch 2010; Van Looy et al. 2011; Borges and Filion 2013; Bonaccorsi et al. 2014; Jung and Kim 2017*

Macro-level: Regarding the macro-level factors, Sternberg (2014) suggested that compared to regional government support programmes, the regional environment in which an individual establishes a firm demonstrates more explanatory power in ASO success. This was consistent with the findings of Van Geenhuizen and Soetanto (2013) who indicated that even within urban regions, ASO performance may vary between metropolitan areas and isolated small cities. Metropolitan areas could maximise the potential of learning networks to benefit ASO open innovation and performance in employment growth. This said, firms in isolated small cities are constrained by limited resources and contacts (Soetanto and Van Geenhuizen, 2009; Van Geenhuizen and Soetanto, 2013). In addition, the presence of high levels of human and social capital, as well as the innovation intensity of a region, could also significantly determine the location choice for ASOs (Calcagnini et al., 2016; Conceição et al., 2017). Governmental support policies affect ASO survival and growth performance more effectively when the entrepreneurial environment is weak within a region (Botelho and Almeida, 2010). Specific funding programmes with different rationales provided by governments have proved to be effective instruments in helping ASOs overcome financing problems (Rasmussen and Sørheim, 2012). Three different government programmes have been identified: Proof-of-Concept (PoC), pre-seed funding and seed funding. Each programme plays a different role in different stages of ASO development (Rasmussen and Sørheim, 2012). The PoC programme is aimed at reducing the uncertainty of initial university technologies, while the pre-seed programme enhances the commercial competence of ASOs. The purpose of both is to attract the attention of investors by enhancing the ASO entrepreneurial capacities (Rasmussen and Sørheim, 2012). In addition, government finance may be obtained for ASOs through a seed-funding programme, which fulfils the financial gap faced by most ASOs (Rasmussen and Sørheim, 2012).

Another important determinant is EVC support. As important financial resource providers for ASOs in their early-stage development, sufficient EVC support facilitates ASOs to reach economic milestones more efficiently (Knockaert et al., 2010). ASOs with EVC support demonstrate higher survival rates as well as superior employment and revenue growth than non-venture capital-backed spin-offs (Zhang, 2009; Bock et al., 2018). In certain circumstances, the presence of VC partners also enhances the growth of ASOs (Rodríguez-Gulías et al., 2017; Rodríguez-Gulías et al., 2018). Bock et al. (2018) noted that this superior performance could be attributed to venture capitalists' coaching capabilities. Furthermore, venture capitalists serve as valuable resource intermediaries connecting ASOs to other resource providers (Hayter, 2013) and may, themselves, provide academic entrepreneurs with valuable managerial skills (Ortín-Ángel and Vendrell-Herrero, 2010). Meanwhile, positive evaluation by EVCs has the power to enhance ASO credibility in the market, which also facilitates their ability to acquire additional key resources and services for their evolution in later development stages (Chugh et al., 2011; Fernández-Alles et al., 2015). Table 2.11 provides an overview of the macro-level success factors.

Table 2.11: Success factors covered by articles reviewed at the macro-level.

Perspective	Key elements (variables)	Representative studies
Regional context	Level of economic development, geographic location, entrepreneurial culture, support from VCs	*Zhang 2009; Knockaert et al. 2010; Chugh et al. 2011; Van Geenhuizen and Soetanto 2013; Sternberg 2014; Fernández-Alles et al. 2015; Calcagnini et al. 2016; Bock, Huber and Jarchow 2018*
National context	Government policies, funding programmes	*Botelho and Almeida 2010; Rasmussen and Sørheim 2012*

2.4 Conceptual framework

As previously noted, an ASO's venturing process is complex, long-term and dynamic, involving influencing factors from multiple dimensions (Rasmussen, 2011). The following conceptual framework developed from previous findings provides an overview of ASO drivers, barriers and success factors at three different levels (see Table 2.12). It should serve as a helpful instrument for stakeholders embroiled in this process to make appropriate decisions. Starting with the driving factors, academics' entrepreneurial intentions and behaviours could be motivated by distinct intrinsic (Puzzle) and extrinsic (Ribbon and Gold) rewards (Lam, 2011). Furthermore, psychological and cognitive factors such as attitude,

perceived behavioural control, ESE, role identity and value orientation could significantly affect academics' entrepreneurial propensity (Krabel and Mueller, 2009; Prodan and Drnovsek, 2010; Prodan and Lam, 2011; Knockaert et al., 2015). Another key determinant is an academic's human and social capital. In addition, research disciplines and the type of research also affect the likelihood of academics becoming entrepreneurs.

Meanwhile, given their peculiar nature, ASO creation may be determined by the characteristics and orientation of parent organisations. The existence of well-established university support mechanisms could significantly facilitate the ASO venturing process (Fini et al., 2011). At the macro-level, performance and intensity variations in academic entrepreneurship may be attributed to the different levels of regional economic development (Davey et al., 2016), location factors (Van Geenhuizen and Soetanto, 2013; Calcagnini et al., 2016), government support instruments and specific policies (Rasmussen, 2008; Botelho and Almeida, 2010). Specialised government funding programmes with different rationales could help ASOs overcome thresholds encountered in different development phases (Rasmussen and Sørheim, 2012).

With regard to the barriers, the sustainable development of ASOs is constrained by several internal and external barriers. Different types of obstacles to growth exist that are market-related (e.g. marketing knowledge, sales skills and customer base), finance-related (e.g. cash flow and capital investment), management-related (e.g. management capacity) and physical-related (e.g. accommodation and infrastructure) (Van Geenhuizen and Soetanto, 2009). Furthermore, the limited availability of private funding sources represents a major barrier to effectively commercialising university technologies (Munari et al., 2018). Attracting EVC support is seen as the biggest challenge faced by most ASOs due to the problem of information asymmetries from both the demand and the supply sides. Complicated and time-consuming application and granting processes for governmental subsidies also impede the ASO venturing process. In addition, conflicting objectives, internal corporate governance issues, as well as a lack of entrepreneurial competences among founding teams may interfere with the consistent development of ASOs. Academics with conservative attitudes towards entrepreneurship, such as being risk and stress averse or fearful of failure, are less likely to start their own businesses. A further major barrier for scientists in the early stage of the spin-off formation process is the academic system itself, which has a lack of appreciation for commercialisation activities in academia. As for external barriers, the emergence of entrepreneurial intentions as well as ASO growth potential may

be restricted when the parent organisation consists of a rather weak entrepreneurial culture, infrastructure and support mechanisms. Meanwhile, a paucity of state subsidies tends to be considered another major development barrier and specific regional and country contexts also determine the perception of barriers in the ASO venturing process.

In terms of factors that are critical for sustainable development, ASO performance is closely related to the endogenous factors and external conditions that it encounters. Due to the 'peculiar genetic characteristics' of ASOs, they are endowed with different initial competence configurations in terms of resources, capabilities and business models compared to non-ASOs, which determine their development strategies, and their objectives are different from their counterparts (Zahra et al., 2007; Colombo and Piva, 2012; Soetanto and Jack, 2016). Moreover, the composition and characteristics of the founding and management teams play a vital role in determining the development path and success of ASOs (Knockaert et al., 2011; Visintin and Pittino, 2014). A balanced demographic structure coupled with heterogeneous and complementary expertise backgrounds could lead to superior ASO performance in regard to survival rate and growth (Gimmon and Levie, 2010; Hayter, 2013; Fernández-Alles et al., 2015; Nielsen, 2015). Rich industrial, managerial and entrepreneurial experience of founding team members, combined with close industry ties could be viewed as positive signals to investors, which significantly increases the possibility of ASOs obtaining early-age funding support (Huynh, 2016). With respect to external factors, ASO performance could be influenced by the ties with the parent organisation in terms of intensity, duration and multiplicity (Rasmussen, 2011; Fackler et al., 2016; Huynh, 2016).

Geographical proximity to research institutions and industrial districts could develop synergy and cluster effects, which further enhance ASO innovativeness (Stephan, 2014; Soetanto and Jack, 2016). Furthermore, venture capitalists play a critical role throughout the venturing process as important financial resource providers for ASOs in their early development stages (Samila and Sorenson, 2010). Venture capitalists also serve as valuable resource intermediaries connecting ASOs to other resource providers (Hayter, 2013). A positive evaluation by VCs could enhance ASO credibility in the market, facilitating their ability to acquire additional key resources and services for their evolution in later development stages (Chugh et al., 2011; Fernández-Alles et al., 2015).

Table 2.12: Conceptual framework.

	Micro-level	Meso-level	Macro-level
Drivers:	*Individual academic* • Intrinsic and extrinsic motivations • Human and social capital • Demographic characteristics • Psychological factors: Attitude, ESE, etc. • Cognitive factors: role identity, value orientation • Personality characteristics • Research type, quality, discipline	*University* • University characteristics • Research orientations • Support mechanisms: policies, incubation services, financial support and entrepreneurship education programmes	*Regional and national context* • Level of economic development • Geographical location, Entrepreneurial environment • Government instruments, Subsidy programmes and policies
Barriers:	*Individual academic* • Lack of entrepreneurial capabilities, knowledge and resources • Lack of applicability of knowledge • Team or governance conflicts • Fear of failure • Aversion to risk and stress • Attitude towards science: 'Publish or perish'	*University* • Lack of entrepreneurial culture • Bureaucracy • Management style • Lack of incubation services	*Regional and national contexts* • Limited availability of federal and private funding sources • Complicated and time-consuming application and granting processes for state subsidies • Country- and regional-specific differences
Success factors:	*A firm's internal factors* • Initial competence endowments • Composition and characteristics of founding and management teams • Firm strategies, objectives and structures	*University* • Relation with parent organisations, geographical proximity • University capabilities: scientific productivity, resource integration, innovation etc.	*Regional and national contexts:* • Regional environment and openness • Governmental policies • Support from venture capitals (VCs)

2.5 Implications

2.5.1 Theoretical implications

According to the conceptual framework, this review has suggested several potential promising directions for future research. Firstly, as the ASO phenomenon is becoming more mature and ASO life cycles are becoming more transparent, further studies should adopt a more dynamic view to analyse the ASO venturing process. Researchers should primarily consider longitudinal analysis in the future given the fact that entrepreneurship is a long, complex and multi-level process. Academics' human and social capital, cognitive styles and capabilities evolve over time during the spin-off process; hence, longitudinal analysis could be adopted to track how the evolution of academics' profiles affect this process. Furthermore, researchers should adopt a more integrated perspective, paying more attention to joint impact, the interplay between different predictors across various levels (i.e. of the individual, firm, organisation and macro-environment), as well as within a certain level, so that an optimal combination might be found (Nolzen, 2018).

Secondly, it is worth noting the relationship between scientific output and entrepreneurial engagement. The papers included in this review emphasise the complementary relationship between these two activities. However, to what extent and in exactly what way academics and universities benefit from technology transfer activity deserves further investigation. Meanwhile, knowledge transfer also depends on certain contingent factors. Therefore, more empirical research is needed to explicitly identify and explain these factors in order to better predict the process (Landry et al. 2007). With regard to ASO performance, besides conventional performance measures, ASO heterogeneity in terms of objectives and types suggests that future research should consider expanding the selection scope of performance indicators and include those that are more in line with the peculiar characteristics of ASOs to better evaluate the benefits of different ASO types.

Thirdly, besides focusing on success factors, future studies should also shed more light on the obstacles and thresholds that impede ASO development by learning about the mistakes made by failed firms. This could, on the one hand, prevent ASOs from repeating past errors, while on the other hand, it could offer administrators and policy makers a more comprehensive overview for developing improved support mechanisms and programmes by which to facilitate commercialisation activities (Hueske and Guenther, 2015). In terms of theories, a great number of researchers have employed Ajzen's (1991) theory of planned

behaviour to explain the entrepreneurial intentions and behaviour of academics from a psychological perspective. Further studies should consider whether there are new psychological characteristics such as habits or preferences that are more suitable to explain academics' entrepreneurial intentions and behaviours. Moreover, based on the genealogical imprinting theories adopted by Ciuchta et al. (2016), explicitly exploring the following questions would prove promising: What is the link between the genetic characteristics of the parental organisation and ASO performance? To what extent do inherited characteristics affect ASO development paths? To what extent do department and university ethics affect the value orientation of academics? What are the consequences – what kinds of ASOs are most likely to establish second generation spin-offs?

Finally, more attention should be paid to multi-national comparisons, especially of those less researched but rapidly developing continents such as Asia (Fisch et al., 2016). Considering the variety of regional and national cultures and traditions, academics with different backgrounds could be motivated to start their own businesses for distinct reasons.

2.5.2 Practical implications

There are also several practical implications for stakeholders at different levels. Firstly, differentiated and customised policies and support programmes are required to adapt to the different regional contexts and to meet the diverse needs of different types of ASOs. As for human factors, university administrators should specifically target academics who exhibit strong inclinations towards engagement in entrepreneurial activities. University internal policies based on diverse individual objectives and motives, such as leave of absence, conflict of interest and intellectual property (IP) ownership, could more effectively recruit and retain high-quality personnel. Such entrepreneurship-oriented policies could also significantly stimulate the entrepreneurial propensities of academics and facilitate them to start their own businesses.

Moreover, with regard to tenure and promotion policies, academics' promotion and tenure assessments remain primarily based upon scientific productivity and quality such as publications. Such orientation constrains the entrepreneurship involvement of academics, particularly those who are younger and non-tenured. Hence, to encourage academics to participate in commercialisation activities, university administrators should reconsider existing promotion policies and consider adjusting reward systems by including more entrepreneurial accomplishments as measurable indicators for promotion and tenure. In

addition, to facilitate ASO creation, government and university policymakers should consider reducing transaction costs, such as simplifying bureaucratic administrative procedures, breaking down organisational hierarchies and providing tax incentives. More importantly, the benefits or outcomes created by ASOs might also be observed over a long period of time. Subsequently, it is necessary for policymakers to adopt a long-term and dynamic perspective when designing and implementing policies.

Furthermore, policies need to adapt over time rather than remain static. Besides merely focusing on designing policies and support mechanisms, establishing follow-up mechanisms to evaluate the effectiveness and efficiency of implemented policies and support mechanisms at different stages could, in time, help policymakers and university administrators adjust their support, thereby maximising the utility of policies in the long run. Fostering favourable department and university environments towards entrepreneurship could be achieved by appointing department leaders who are strong role models. For academics who are more sensitive to the influence of their peers, university administrators should increase the awareness of role models among their subordinates. Spiritual and material support are equally or perhaps more important for female academics because they perceive support from their colleagues as more valuable. Another solution for university administrators is to create more industry collaboration opportunities for academics, especially for those in technology-oriented disciplines, and maintain these relationships in the long-term. Universities aiming at increasing entrepreneurial involvement should also encourage academics to participate in both informal and formal commercialisation activities.

In addition to exerting external influences by developing and implementing policies and support mechanisms, fostering academics' entrepreneurial mind-sets and enhancing their internal entrepreneurial potential could also significantly increase their propensities for self-employment. Introducing entrepreneurship education is an effective way to achieve this goal. Not only could the entrepreneurial skills of academics be strengthened through education and training programmes, but also their "entrepreneurial drive" would be fostered (Walter and Block, 2016; Raposo et al., 2008). Besides providing tailored entrepreneurship education programmes, different entrepreneurship-related events, such as lectures from successful academic entrepreneurs, workshops and seminars, should be regularly introduced. Such events not only impart new knowledge to academics, but also provide them with valuable opportunities to extend their networks. However, university administrators should be aware that the consequences of participation in commercialisation activities are not

always positive. Therefore, they should not promote entrepreneurial activities blindly and unconditionally. Instead, it is necessary for them to carefully consider the entrepreneurial proposals and interests of both academics and universities before they decide to take the step.

To ensure the sustainable development of ASOs, ASO managers should pay more attention to the composition of the founding and management team, recruiting experienced individuals with a commercial background outside academia would offset the market knowledge deficiencies among academics. In addition, ASO managers should be aware of the social norms that academics inherited from their parent organisations as different objectives and orientations among team members could jeopardise the development consistency of ASOs (Visintin and Pittino, 2014).

As one of the most important external supporters, ASOs often failed to attract venture capital investments due to the existence of the information asymmetry problem (Köhn, 2018). Therefore, from the demand side, ASOs and universities should eliminate this barrier to convince potential investors by proactively signalling their capabilities and objectives. From the supply side, before venture capitalists make investment decisions, applying more comprehensive measures to assess the characteristics and compositions of ASO founding teams during the due diligence process would be needed. In addition to the skills and capabilities of the founding team, evaluating the cognitive styles and objectives of founder(s) is liable to predict the future development paths of ASOs, which could predict whether the results are in line with the expectations of VCs.

3 What drives the venture progress of academic entrepreneurs? The role of individual motivations[3]

Abstract

Academics who decide to engage in entrepreneurial activities are influenced by a variety of entrepreneurial motives. Currently, however, there is a debate concerning how and how strongly different motives affect the venture progress in academic entrepreneurship. Using a comprehensive two-wave dataset of academic entrepreneurs from Germany, we find that knowledge transfer motives matter most, followed by economic and lifestyle motivations. For example, and in line with our hypotheses, we show that the desire for self-realization and knowledge application as well as necessity motives affect the venture progress positively, whereas the desire for the better utilization of professional knowledge and financial income motives have a negative effect. In sum, our study contributes to the understanding of the intention-action gap in academic entrepreneurship and can therefore help universities and policy makers make their support programs that foster academic entrepreneurship more effective.

Keywords Academic spin-offs · Academic entrepreneurship · Motivation · Venture progress

[3] This chapter has been submitted to *The Journal of Technology Transfer* in February 2020, and it has received an invitation to revise-and-resubmit for a second-round review.

3.1 Introduction

While knowledge- and technology-based spin-offs are regarded as central drivers of eco-nomic, social and ecological development (Block et al., 2017; Santini, 2017; O'Shea et al., 2008; Guerrero et al., 2015), the antecedents of entrepreneurial venture progress have been mostly analysed in the context of a binary choice model. This approach, however, neglects the fact that only some nascent entrepreneurs continue to work on their business ideas, while others postpone them or abandon them altogether (Grilo and Thurik, 2008; Parker and Belghitar, 2006; Van Gelderen et al., 2011; 2015; Werner, 2011). In the academic entrepreneurship context, Fritsch and Krabel (2012) provide empirical evidence pointing to a large intention-action gap. According to their results, 28% of all university scientists have entrepreneurial intentions, whereas only 3.2% put their plan into action. Based on their findings, Fritsch and Krabel (2012) conclude that the antecedents of the intention-action gap should deserve more intention in academic entrepreneurship research.

Our study responds to this call and tries to fill an important gap in this stream of research literature by focusing on entrepreneurial motives and how these motives affect the entrepreneurial venture progress of university scientists. Although there have been some studies on motivations in general, the understanding of entrepreneurial motives as important individual driving forces in the academic context is still in its infancy.

Following implementation intention perspectives, we argue that the motives of scientists to become entrepreneurs play an important role in overcoming the intention-action gap be-cause scientists with higher entrepreneurial intentions are also more committed to their goals and plans and therefore more likely to act on their intentions (Gollwitzer, 1999; Obschonka et al., 2010). In a similar fashion, we draw on the theory of planned behaviour and propose that a scientist's intention to perform a particular behaviour is positively related to a favourable attitude and supportive social norms towards the planned behaviour, combined with a stronger perceived behavioural control (Ajzen, 1991). Thus, following these perspectives, both the direction (to do or not to do) and the intensity (how much time and effort) of taking an action are determined by the individual's entrepreneurial motivation (Sheeran, 2002; Van Gelderen et al., 2011).

While both frameworks have been adopted to examine the entrepreneurial motivations of individuals in general, academia has just recently begun to recognize if, how and how strongly specific entrepreneurial motives affect the venture progress for academic entrepreneurs. Moreover, the results from this broader stream of entrepreneurship literature can only be partially transferred to the case of academic entrepreneurship because academic start-ups and spin-offs are at the intersection of science and entrepreneurship and thus constitute a very special contextual environment (Djokovic and Souitaris, 2008; Nicolaou and Birley, 2003a; 2003b). Accordingly, academic entrepreneurs have to be treated as a special group of entrepreneurs that differ in their motives from other entrepreneurs (Lam, 2011; Miranda et al., 2018).

Using a comprehensive two-wave cross-sectional dataset of 611 academic entrepreneurs from 73 universities in Germany, this paper attempts to answer the following two research questions: 1) which motivating factors play the most significant roles for academic entrepreneurship? and 2) how do these motivating factors affect the venturing progress of academic entrepreneurship? Building on the prior literature stream (Göktepe-Hulten and Mahagaonkar, 2009; Lam, 2011; Hayter, 2011), we classified academic entrepreneurial motivations into three major dimensions, namely, 1) transfer motives (*application of research ideas, self-realization, and knowledge and skill utilization*), 2) economic motives (*monetary rewards and necessity motives*) and 3) lifestyle motives (*work-life balance*). Our findings show that self-realization, knowledge and skill exploitation and the need to apply one's own research ideas are of high importance for academic entrepreneurs, followed by necessity motives. In contrast, monetary and lifestyle motives are found to play a minor role for academic entrepreneurs. With regard to our second research question, we find that self-realization, the desire for application and necessity motives positively affect venture progress, whereas the desire for the exploitation of professional knowledge is found to have a negative effect.

Overall, our study provides several interesting contributions. On the one hand, the persons responsible for universities and their technology transfer programs can learn from our findings how important specific motives are for the individual venture progress of research scientists. Moreover, we show that an interesting group of founders exists in academia that deserves more attention, namely, the necessity founders. University administrators and policy makers should therefore think about offering differentiated support programs to meet the specific needs of necessity founders. On the other hand, our study

contributes to the research literature by focusing on the intention-action gap in entrepreneurship. Based on our findings, universities should prioritize their resources by encouraging and enhancing the motives that are positively related to the venture progress of academic entrepreneurship. By doing so, more effective measures will be implemented to bridge the intention-action gap.

The remainder of the paper is structured as follows. In the second section, the empirical findings of related prior research are summarized, and our theoretical framework and hypotheses are introduced. Subsequently, our empirical study is presented. The final section discusses our findings and presents limitations and suggestions for future research.

3.2 Theoretical background and hypotheses

3.2.1 Motivations in entrepreneurship

The success of entrepreneurship depends to a great extent on individuals' involvement and commitment (Lee et al., 2011; Shane et al., 2003), i.e., variations among people's motivations and abilities lead to different outcomes (Shane et al., 2003). Specifically, previous studies have shown that individuals decide to undertake entrepreneurial activities due to a variety of motives (Hayter, 2015a). Block and Wagner (2010), for example, identify two types of entrepreneurs, namely, the necessity and opportunity entrepreneurs. While opportunity entrepreneurs decide to set up a business voluntarily when they identify a potential entrepreneurial opportunity, necessity entrepreneurs are more likely to be engaged in entrepreneurship because of external factors such as job dissatisfaction and unemployment. Similar to fashion, push and pull perspectives have been adopted to categorize these two central categories of different entrepreneurial motivations. Accordingly, the following three most common pull factors have been found to be central motivators for entrepreneurship, namely, the desire for independence, monetary motivation and the desire for a challenge/need for achievement (Kirkwood, 2009; Rizzo, 2015; Antonioli et al., 2016). Job dissatisfaction, lack of support from an employer and work-life balance issues are found to be the most relevant push factors for entrepreneurship.

Along those lines, Iorio et al. (2017) also suggest that motives can be classified according to the following criteria: intrinsic or extrinsic motivations. Intrinsic motivations refer to behaviours that are driven by internal rewards and thus originate within a person because they naturally satisfy the individual. Examples are intrinsic satisfaction (Lam, 2011),

the desire for independence (Shane, 2004b) and the desire to learn new skills (Benz, 2009; Hayter, 2011). Extrinsic motivations, in contrast, refer to behaviors that are driven by external rewards that arise from external environmental factors such as pursuing pecuniary or other nonpecuniary forms of rewards (e.g., promotion, gain/increase of reputation) (Fini et al., 2009; Göktepe-Hulten and Mahagaonkar, 2009). For entrepreneurs, monetary returns play an important role in being self-employed (Block and Sandner, 2009). However, entrepreneurs could also be strongly attracted by nonmonetary benefits when they engage in entrepreneurial activities. Accordingly, prior studies have suggested that nonmonetary benefits such as pursuing greater autonomy, broader skill utilization, and the possibility of applying one's own ideas also play an important role in entrepreneurship (Benz, 2009; Hundley, 2001). Interestingly, the study of Block and Sandner (2009) finds that monetary motives are more important for necessity entrepreneurs, while nonmonetary returns have a greater impact on opportunity entrepreneurs.

3.2.2 Motivations in academic entrepreneurship

In contrast to entrepreneurs in general, academic entrepreneurs are driven by a special sense of social responsibility as well as a need for utilization when participating in the technology transfer process. In other words, they devote themselves to improving society by transferring and disseminating technology (Morales-Gualdrón et al., 2009; Berggren, 2017; Iorio et al., 2017). Another key characteristic of academic entrepreneurship is that additional benefits are aligned with academic entrepreneurial activities such as creating further stimuli for research activities, obtaining access to funding opportunities (grants) or acquiring new facilities for research activities. These motives are important determinants for academics who are engaged in founding and advancing projects (Goethner et al., 2012; Hayter, 2015a; Antonioli et al., 2016). Moreover, in line with what has been discussed above, Lam (2011) employs the following three concepts to classify factors drawing on intrinsic and extrinsic features for academic entrepreneurship: "gold" (financial rewards), "ribbon" (reputational and career rewards) and "puzzle" (intrinsic satisfaction). Focusing on financial rewards, academic entrepreneurs do not seem to consider these as the primary purpose for engaging in entrepreneurship (Göktepe-Hulten and Mahagaonkar, 2009; Lam, 2011). Based on this, and for hypothesis development, our paper classifies the academic motives influencing the likelihood of scientists to engage in entrepreneurial activity into the following three major dimensions: 1) transfer, 2) economic and 3) lifestyle motivations.

3.2.3 Hypotheses development

3.2.3.1 Transfer motivations

According to the current research literature, a scientist's willingness to start a business is determined by a strong inner conviction for their own research (Lam, 2011). That is, "taking care for one's own research" as well as the desire to put one's own ideas or inventions into practice are regarded as the central drivers for academic entrepreneurship (Morales-Gualdrón et al., 2009; Berggren, 2017; Iorio et al., 2017). As such, transfer motives are closely related to the personal expectations and objectives of academics and, consequently, can be seen as the dominant factors of why academics undertake venture activities. Academics in particular are driven by the desire to put their research ideas into practical use when engaging in entrepreneurial activities, given the reason that the original purpose of research is to serve society at large (Iorio et al., 2017; Ramos-Vielba et al., 2016). Moreover, this factor is also the main reason why universities are becoming increasingly entrepreneurial; i.e., the so-called third mission has been integrated as one important university function because of the growing need in society for universities to transfer knowledge outside of academia and to contribute to social and economic development (Etzkowitz, 2003; Huyghe and Knockaert, 2015; Iorio et al., 2017). Iorio et al. (2017) argue that a large number of academics are driven by pro-social or so-called mission motives when engaging in knowledge transfer activities, considering that the aim of these activities is knowledge dissemination that would in turn improve social well-being. In a similar vein, Ramos-Vielba et al. (2016) also show that applying their own research ideas is the primary reason for academics to engage in knowledge transfer activities. Thus, in sum, we posit the following hypothesis:

Hypothesis 1: The motivation to put one's research ideas into practice is positively associated with the progress of academic entrepreneurship.

Another important transfer motive among academics is the desire for self-realization. Specifically, the need for achievements, the desire for independence and the desire for skill enhancement have been suggested to be among the main reasons why academics engage in venture activities, especially in the earlier gestation phases (Antonioli et al., 2016; D'Este and Perkmann, 2011; Hayter, 2011; Huszár et al., 2016; Müller, 2010). In line with this, a study of German academics shows that the initial purpose of most researchers who engage

in commercial activities is to signal their achievements and gain recognition from their peers and industrial communities (Göktepe-Hulten and Mahagaonkar, 2009). According to Barba-Sánchez and Atienza-Sahuquillo (2012), the need for achievement is seen as an important characteristic of entrepreneurs and has a strong influence on venture progress; individuals with stronger needs for achievement are more likely to make progress. Due to the professional characteristics and backgrounds of academics, they are particularly accustomed to work autonomy and independence. Moreover, academics often pursue their goals with greater ambitions. Thus, academics will also have a higher need for achievement compared with other founder types. Therefore, we formulate the following hypothesis:

Hypothesis 2: Self-realization is positively associated with the progress of academic entrepreneurship.

Academics are also motivated by additional academic benefits, such as the generation of further stimuli for research activities, access to funding opportunities (grants) and the possibility of exchanging new knowledge or obtaining new equipment for research activities. Academics consider spin-offs as platforms for obtaining these resources to support their research (D'Este and Perkmann, 2011; Lam, 2011; Goethner et al., 2012; Antonioli et al., 2016; Iorio et al., 2017; Hossinger et al., 2020; O'Gorman et al., 2008). However, these motivational drivers may also have a negative impact on entrepreneurial progress given that academics only consider these activities as a means for obtaining new resources to better exploit their research and knowledge. In the course of undertaking entrepreneurial activities, we therefore assume that university scientists will concentrate more on their research and less on the actual transfer of knowledge. That is, scientists will use their knowledge and experience more to develop their products and services rather than to concentrate on the commercial exploitation of these products or services. As a result, several important founding steps, such as negotiating with creditors or investors, starting marketing campaigns, evaluating market information or taking care of exploitation rights, will be neglected or postponed, which, in turn, will lead to fewer start-up gestation steps. Based on these arguments, we therefore derive the following hypothesis:

Hypothesis 3: The utilization of one's professional experience/knowledge is negatively associated with the progress of academic entrepreneurship.

3.2.3.2 Economic motivations

Aside from transfer motivations, monetary incentives have been widely discussed as an important entrepreneurial motivational factor in the entrepreneurship research literature. Interestingly, in the academic entrepreneurship context, monetary factors seem to be less influential compared with nonmonetary incentives (Hayter, 2011; Lam, 2011; Goethner et al., 2012). That is, the expected financial income only shows to have an indirect influence on the entrepreneurial intentions of scientists, and no direct impact on entrepreneurial behavior has been found (Goethner et al., 2012). The reason why the influence of financial rewards is limited may depend on the age and position of academics as well as other personal concerns. For example, considering the nature of academic careers, scientists tend to gather sufficient capital stock for setting up a company at a relatively late stage; therefore, it may be difficult for them to establish a new firm in their younger years (Antonioli et al., 2016; Rizzo, 2015; Lévesque and Minniti, 2006).

Furthermore, most scientists do not consider financial reward as the primary goal when deciding to engage in entrepreneurial activities because they consider such financial rewards more as a form of collateral compensation for the time and effort they have devoted (Morales-Gualdrón et al., 2009; Hayter, 2011; Lam, 2011; Goethner et al., 2012). Moreover, scientists are considered highly skilled employees. Due to their professional career, scientists usually possess a very broad spectrum of theoretical expertise and strong abstraction capabilities. Academics are aware of their capabilities and skills, and they know that they can also achieve a high net income in the private industry. In other words, scientists who are strongly triggered by the income motive will prefer a position in paid employment relative to becoming an entrepreneur. Along these lines, we therefore propose that financial income motives will have a negative influence in motivating academics to advance their entrepreneurial activities. Accordingly, we posit the following hypothesis:

Hypothesis 4: Increasing financial income as a motivation is negatively associated with the progress of academic entrepreneurship.

As mentioned above, in entrepreneurship research, the distinction between opportunity and necessity entrepreneurs is much debated (Block and Sandner, 2009; Block and Wagner, 2010). Opportunity-driven individuals decide to engage in entrepreneurial activities voluntarily, while necessity-driven individuals are more likely to engage in entrepreneurial activities because of external factors such as job dissatisfaction or

unemployment (Block and Wagner, 2010). In the academic context, necessity motivations are strongly related to working conditions within universities. Essentially, these working conditions are often seen as push factors, such as stability and lifelong employment (i.e., limited work contracts and nontenure positions), the pressure to "publish or perish", bureaucratic routines and procedures and governance issues (Balven et al., 2017; Neves and Franco, 2016). Entrepreneurship as the preferred mode of entry of academics can therefore be traced to the fact that their current working conditions are not truly satisfying (Kirkwood 2009). Moreover, individuals who choose to undertake entrepreneurial activities due to necessity reasons are generally more motivated and willing to take more steps to prove that they can do better than with their previous employers (Kirkwood, 2009). Especially for skilled individuals, the fear of unemployment is an important motivational factor resulting in more progress along the path of self-employment (Horta et al., 2016). Based on these arguments, we therefore propose that academics are no exception, meaning that this group is also exposed to a high risk of having to leave their prior employer (i.e., the university), which makes them think about taking steps to start a new business. Thus, we formulate the following hypothesis:

Hypothesis 5: Necessity as an entrepreneurial motivation is positively associated with the progress of academic entrepreneurship.

3.2.3.3 Lifestyle motivations

Work-life and role balance in the academic context refers to whether an academic believes that he or she has an appropriate workload compared with the responsibilities that come from other work or personal duties (Balven et al., 2017). This balance is dependent on the coordination of organizational and other personal factors. Although many universities have implemented policies that favour personal balance, such as leaves of absence programs and on-site childcare, academics still struggle to balance their work and personal lives (Kirkwood, 2009). The reason for this struggle is that an academic usually has to fill multiple roles simultaneously, such as being a lecturer, an inventor, a mother/father or an entrepreneur, and managing many different roles is difficult (Balven et al., 2017). When work-life balance becomes an issue, academics are most likely to postpone or abandon commercial or entrepreneurial activities and tend to spend more time on other activities (Balven et al., 2017). Based on this, we argue that it is especially difficult for academics to be fully engaged in both research and entrepreneurial activities.

That is, if such work-life balance issues are considered important for academics, they may connect entrepreneurial activities with being lower priority and prefer to allocate their time and effort to research or other personal activities. Hence, the following hypothesis can be derived:

Hypothesis 6: Work-life balance as an entrepreneurial motivation is negatively associated with the progress of academic entrepreneurship.

3.3 Method and data

3.3.1 Sample

Our study is based on a two-wave cross-sectional dataset collected in 2013 and 2016 at 73 German universities. In the initial survey in 2013, 36,918 scientists from different types of universities, faculties and positions were surveyed regarding the actions they undertook to start a new business. The responses from 7,342 scientists were initially received and thoroughly evaluated. The scientists who were surveyed in 2013 were then invited to participate in a follow-up survey in 2016. A total of 1,252 completed the questionnaire in 2016, which corresponded to a response rate of approximately 17%. After excluding all those cases with missing values in the variables of interest, the information from 611 scientists could be fully evaluated for the following empirical analysis.

3.3.2 Dependent and explanatory variables

Table 3.1 shows the descriptive statistics and illustrates our dependent, independent and control variables. Our dependent variable is venture progress, which is measured by the extent to which a start-up project has been advanced; i.e., the scientists in the follow-up survey in 2016 were asked to provide information about the steps they have taken to advance a start-up project. The corresponding items were developed on the basis of the GUESS survey (Global University Entrepreneurial Spirit Students' Survey, http://www.guesssurvey.org/) that was conducted in 2013 and 2016. On a dichotomous scale (1=yes; 0=no), seventeen different self-reported items were examined, which comprehensively described the venture progress of the scientists (see Table 3.A1).

Given that there is a spectrum of activities associated with a different degree of exploration or exploitation of start-up project steps, the following seventeen spin-off-related activities were been categorized and aggregated into eight different stages: *Stage 1) if the scientists have a specific founding idea. Stage 2) if the scientists have reserved money for the implementation of his/her founding idea, have negotiated with outside creditors and/or inside investors, or have invested their own money in the implementation of the founding idea. Stage 3) if the scientists have started the product or service development or built a prototype. Stage 4) if the scientists have recruited a co-founder/funding team, developed a business plan, collected information about the market and competitors, or have purchased/leased equipment/materials/rooms. Stage 5) if the scientists have a set date for establishment. Stage 6) if the scientists have taken care of the exploitation rights or registered at the tax office. Stage 7) if the scientists have started advertising campaigns and marketing, have met potential customers, or have acquired important business partners. Stage 8) if the scientists have accepted first orders.*

Our explanatory variable covers the scientists' individual motivations towards entrepreneurship. More specifically, in the initial 2013 survey, the scientists were asked to provide information about the reasons why they wanted to become self-employed. Specifically, a total of six different motivation items were included in the questionnaire, which we classified into three major dimensions: 1) transfer motives, 2) economic motives and 3) lifestyle motives. Each dimension includes several specific motivation items. Transfer motives consist of a) *applying research ideas*, b) *self-realization* and c) *knowledge and skill utilization*; economic motives consist of a) *monetary motives* and b) *necessity motives*; and lifestyle motives consist of *work-life balance motives*. All items were self-reported and measured on a five-point Likert scale (1=strongly disagree to 5=strongly agree) (see Table 3.A1).

Table 3.1: Descriptive statistics.

Variable	Mean	Std. Dev.	Min	Max	Year	VIF
Dependent variable:						
Venturing progress	1.115	1.755	0	8	2016	.
University characteristics:						
Invention at university (1=Yes, 0=No)	.273	.446	0	1	2013	1.34
University type (1= university, 0= university of applied science)	.802	.399	0	1	2013	1.67
Faculties:						
STEM	.653	.476	0	1	2013	2.24
Economics/ Social science	.164	.370	0	1	2013	2.04
Architecture	.011	.107	0	1	2013	1.13
Medical technology	.026	.160	0	1	2013	1.21
Arts	.010	.099	0	1	2013	1.14
Positions:						
Professor	.223	.416	0	1	2013	3.74
Assistant professor	.185	.389	0	1	2013	3.18
Research assistant	.516	.500	0	1	2013	4.54
Research types:						
Basic research	3.124	1.425	1	5	2013	1.61
Applied research	4.038	1.160	1	5	2013	1.63
Interdisciplinary research	3.576	1.214	1	5	2013	1.17
Individual characteristics:						
Age	38.674	10.688	24	67	2013	2.27
Gender (1=Male, 0=Female)	.245	.431	0	1	2013	1.29
Migration background (1=Yes, 0=No)	.085	.279	0	1	2013	1.06
Married (1=married, 0=unmarried)	.722	.448	0	1	2013	1.31
Children (1=Yes, 0=No)	.473	.500	0	1	2013	1.69
Risk taking willingness	2.876	.920	1	5	2013	1.18
Self-employed colleagues	.448	.498	0	1	2013	1.15
Self-employed parents	.313	.464	0	1	2013	1.05
Entrepreneurial Contacts	.491	.500	0	1	2013	1.28
Motivations:						
Apply research idea (H1)	3.489	1.273	1	5	2013	1.40
Self-realization (H2)	3.830	.986	1	5	2013	1.51
Knowledge & skill utilization (H3)	3.534	1.074	1	5	2013	1.56
Monetary (H4)	3.187	1.248	1	5	2013	1.19
Necessity (H5)	2.183	1.111	1	5	2013	1.26
Work-life-balance (H6)	2.540	1.317	1	5	2013	1.40

Note: N= 611

As depicted in Table 3.1, approximately 80% of the scientists work in research-based universities, while 20% work for universities of applied science. Almost 27% of the respondents have made inventions based on their research activities at their research institutes. Field-wise, 65% of our sample are researchers within STEM faculties (e.g., mathematics, informatics and information technology scientists, natural scientists and technics), 16% are economic or social scientists, 3% are in medicine and health management, and 1% are architects. With regard to their current position at the research institutes, nearly 39% percent of the researchers in the sample are professors (20% are full professors, and 18.5% are assistant professors), and approximately 52% are research assistants (Ph.D. students, post-doctoral students).

Regarding our first research question, the descriptive statistics suggest that the most important motivating factors are self-realization (mean= 3.8), followed by knowledge and skill exploitation (mean= 3.5) and applying research ideas (mean= 3.4). Taken together, the findings suggest that transfer motives play the most important role in the academic entrepreneurship context. In addition, monetary motives (mean 3.1) and work-life balance (mean= 2.5) are more relevant for academics than necessity motives (mean= 2.2).

The correlations between the variables are shown in Table 3.2. Please note that there are only weak correlations between the independent variables. The variance inflation factors (VIF) range from 1.05 (lowest value) to 4.54 (highest value). We analysed all the variable histograms and found that the errors are identically and independently distributed with constant variance. Overall, these results only suggest the presence of moderate multicollinearity.

3.3.3 Control variables

By following the contextualized research approach (Welter, 2011), we control for several variables that might simultaneously affect venture progress, both from the individual and the organizational level. Starting from the individual level, we control for characteristics such as gender, age, migration background, risk-taking propensity and social capital. Previous studies have indicated that male and female researchers are driven by different types of motives (Maes et al., 2014). Abreu and Grinevich, 2017, for example, suggest that female researchers perceive entrepreneurial obstacles in the spin-out formation process more strongly than their male counterparts. Therefore, the venture progress might be less for female researchers than for male researchers. Furthermore, it can be assumed that scientists

can only amass the sufficient capital stock for setting up a company at a relatively late stage considering their professional nature. In addition, as age increases, the period in which profits can be made through entrepreneurial activities declines (Bijedić et al., 2017; Lévesque and Minniti, 2006; Hossinger et al., 2020). As a result, the venture progress might become less as age increases.

Regarding migration background, Constant and Zimmermann (2006) find that people with a migration background are more likely to be self-employed than their counterparts without a migration background. Moreover, academics with work experience in different cultures possess a greater diversity of ideas, perspectives and creative techniques than do academics who have only worked in few different cultures (Krabel and Mueller, 2009; McEvily and Zaheer, 1999). As a proxy for cultural diversity, we therefore control for migration background. Moreover, risk-taking propensity is also one of the key factors in the early stages of academic entrepreneurship, and academics who are willing to take more risks are more likely to start their own businesses (Singh Sandhu et al., 2011; Hayter, 2015a; Huynh, 2016; Rasmussen et al., 2011; Rasmussen et al., 2015; Scholten et al., 2015; Walter et al., 2011). Thus, we control for risk-taking propensity, in addition to children and marital status.

Furthermore, we control for the social capital of scientists because previous studies have indicated that entrepreneurial contacts that facilitate foundation are of fundamental importance for the implementation of an entrepreneurial project (Prodan and Drnovsek, 2010; Hayter, 2015b; Huynh, 2016; Rasmussen et al., 2011; Rasmussen et al., 2015; Scholten et al., 2015; Walter et al., 2011; Hossinger et al., 2020; Rothaermel et al., 2007). Hence, it is to be expected that founders who have already established networks also have made more venture progress. Additionally, role models and peers also affect the likelihood of academics engaging in entrepreneurial activities (Haeussler and Colyvas, 2011; Johnson et al., 2017; Moog et al., 2015). Hence, we control for both parents and colleagues with prior entrepreneurial experience.

Table 3.2: Correlation table.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
venture progress	1																												
Invention at university	.104	1																											
University type	.004	.065	1																										
STEM	.059	.177	.164	1																									
Economics/ social science	-.006	-.222	-.113	-.607	1																								
Architecture	.002	.003	-.062	-.148	-.048	1																							
Medical technology	-.046	.014	-.021	-.225	-.073	-.018	1																						
Arts	-.025	.051	.008	-.137	-.044	-.011	-.016	1																					
Professor	.019	.131	-.465	-.073	.125	.016	.011	-.013	1																				
Assistant professor	.048	.048	.226	.073	-.040	-.051	-.025	-.047	-.255	1																			
Research assistant	-.034	-.170	.241	.050	-.023	.043	-.046	.030	-.552	-.491	1																		
Basic research	.051	.024	.378	.187	-.135	-.053	-.014	-.032	-.124	.222	-.017	1																	
Applied research	.041	.180	-.253	-.068	.035	.036	-.005	-.075	.200	-.176	-.022	-.495	1																
Interdisciplinary research	.116	.108	.067	-.034	-.057	.025	.057	.076	.054	.097	-.117	.049	.180	1															
Age	-.039	.185	-.343	-.035	-.035	.002	.100	-.025	.584	-.035	-.540	-.135	.144	.028	1														
Gender	-.048	-.239	-.003	-.207	.056	.117	.121	.136	-.141	-.037	.112	.060	-.140	.005	-.140	1													
Migration background	.087	-.042	.049	.087	-.056	.022	-.050	.029	-.050	.021	.026	-.027	-.025	-.005	-.041	.003	1												
Married	-.030	.127	-.144	-.023	-.002	.033	-.013	.025	.227	-.015	-.207	-.074	.052	-.057	.329	-.002	.032	1											
Children	.004	.213	-.187	.057	-.082	.052	.009	-.028	.344	.072	-.361	-.046	.105	.009	.532	-.091	-.077	.449	1										
Risk taking willingness	.045	.123	-.014	-.024	.065	.065	-.011	-.005	.149	.000	-.153	-.036	.117	.085	.120	-.076	.054	.039	.100	1									
Entrepreneurial Contacts	.208	.169	-.161	-.089	.052	.048	.003	.035	.214	-.029	-.175	-.120	.208	.125	.178	-.149	.041	.091	.119	.218	1								
Self-employed colleagues	.061	.134	.002	-.041	.073	.058	-.004	.010	.174	.011	-.173	-.035	.141	.193	.177	-.017	.020	.090	.134	.129	.174	1							
Self-employed parents	.014	-.097	.016	.017	-.012	.027	-.022	-.031	-.072	.024	.046	-.012	-.001	-.032	-.076	.042	.009	.009	-.024	.091	.044	-.069	1						
Apply research idea (H1)	.156	.212	-.025	.189	-.118	-.029	-.087	-.077	.051	-.021	-.026	.030	.115	.099	-.035	-.118	.044	-.005	.040	.137	.222	.046	-.021	1					
Self-realization (H2)	.125	-.026	.002	-.030	.043	.003	-.050	-.067	-.131	-.057	.115	-.036	-.032	.053	-.138	.014	.023	-.037	-.099	.135	.088	-.021	.095	.296	1				
Knowledge & skill utilization (H3)	.028	.095	-.206	-.100	.079	.090	-.048	-.026	.045	-.082	-.015	-.140	.160	.089	.068	.008	-.045	.054	.077	.129	.287	.086	.039	.358	.403	1			
Monetary (H4)	.051	.011	-.156	-.023	.037	-.016	-.016	.012	.084	-.088	-.020	-.071	.115	.030	.032	-.091	.077	-.015	.019	.107	.121	.058	.015	.157	.244	.278	1		
Necessity (H5)	.059	-.119	.102	-.019	-.045	-.018	.107	.043	-.232	.235	-.048	.091	-.182	-.011	-.023	.185	-.008	.014	-.009	-.171	-.057	-.015	.014	-.129	.035	.027	-.037	1	
Work-life-balance (H6)	-.008	-.168	.079	-.043	-.030	-.009	.034	.035	-.247	.019	.149	.051	-.140	-.003	-.210	.240	.004	-.062	-.077	.031	-.032	-.057	.077	.019	.375	.189	.174	.204	1

Note: N= 611

From the organizational level, we control for inventions due to the university, the university type, faculties, positions and the research disciplines. Scientists with inventions based on their research at the university could consider their inventions as potential entrepreneurial opportunities to pursue. We therefore assume that scientists with an invention are more likely to engage in entrepreneurial activities than are their counterparts without an invention. Walter et al. (2013) point out that scientists' entrepreneurial intentions are determined by their ties to industry and research disciplines. Since research projects with the private sector are more common at universities of applied sciences than at research-based universities, academics at universities of applied sciences will also benefit more from these industry ties, which might eventually lead to more venture progress.

Additionally, the scientist's faculty or research field could also affect the venture progress (Perkmann et al., 2011; Huyghe and Knockaert, 2015; Moog et al., 2015; Fini and Toschi, 2016; Hossinger et al., 2020). Start-up projects from the STEM, medical and biotechnology fields are usually technology-oriented and capital intensive. Hence, the initial kick-off of a project requires ample financial resources, which could impede further venture progress. Furthermore, scientists from the aforementioned research fields usually do not have sufficient business management and legal knowledge, which makes the implementation of their own entrepreneurial project even more difficult (Zhou et al., 2011; Davey et al., 2016; Neves and Franco, 2016). Regarding position at the university, Haeussler and Colyvas (2011) indicate that scientists with tenure positions at the university are more likely to engage in entrepreneurial activities due to social and financial securities. Hence, we control for university position. Last but not least, Arvanitis et al. (2008) and Fischer et al. (2017) point out that universities with a focus on applied research have a higher propensity to engage in technology transfer activities than do universities with a focus on basic research.

3.3.4 Analytical procedure

In the empirical models discussed below, we test our hypotheses by using hierarchical multiple linear regression. Specifically, we develop two regression models. In the first model, we regress the effects of the control variables on the venture progress. To test hypotheses H1 to H6, the second model additionally includes the scientists' individual motivations. To analyse the validity of our research hypotheses more deeply, we first apply OLS regression. However, please note that we additionally estimate Tobit models (Greene, 2003; Wooldridge, 2002) to check the robustness of the OLS results, given that some

scientists reported that zero activities were undertaken to advance their start-up projects between 2013 and 2016 (see Table 3.A2). Because the results only change marginally, the OLS estimation results are reported in the following.

3.4 Results

In Model 1, we regress the controls on the degree of start-up project advancement. As shown in Table 3.3, it is worth mentioning that the degree of start-up project advancement is significantly higher for scientists who made an invention based on their research activities compared with their counterparts without such invention. These results are in line with the findings of Stuart and Ding (2006) as well as Krabel and Mueller (2009). Moreover, and in line with prior research (Arvanitis et al., 2008; Fischer et al., 2017), our results indicate that academics who are more involved in interdisciplinary research are also more likely to commercialize their knowledge and implement their founding plans. Moreover, the founder's age is negatively associated with the venture progress, which is consistent with the findings of Bijedić et al. (2017) and Lévesque and Minniti (2006). Interestingly, our results indicate that more venture progress has been made among scientists with a migration background. Regarding founders' social capital, our results show a highly significant effect, which indicates that possessing entrepreneurial contacts will accelerate venture progress. Despite this, we did not find significant effects for the other control variables.

In Model 2, we regress both the controls and the different motivating factors on our dependent variable of venture progress. In sum, we find supporting evidence for hypotheses H1, H2, H3 and H5. However, we have to reject hypotheses H4 and H6. That is, the regression results do not show a significant effect for the independent variable *monetary motives* (β=.019; p= 0.741). Therefore, we have to reject hypothesis 4. Thus, being motivated by financial rewards such as higher and improved earning opportunities is not significantly associated with venture progress. Moreover, the results do not support hypothesis 6. An improved work-life balance (β=-.057; p= .327) as a start-up motive is not significantly related to venture progress. Our regression results do demonstrate a significant positive effect on the variable *applying research ideas* (β=.116; $p<0.10$), which indicates that the extent to which scientists strive for the practical application of their research ideas is positively associated with venture progress. Thus, hypothesis 1 is fully supported by the data.

Table 3.3: Regression results.

DV: Venture progress	**Model 1**			**Model 2**		
	Coef.	Std.	P>|t|	Coef.	Std.	P>|t|
University characteristics						
Invention at university	.323	(.188)	*	.330	(.188)	*
University type	-.177	(.231)		-.216	(.231)	
Faculties						
STEM	.263	(.206)		.201	(.207)	
Economics/ Social science	.247	(.249)		.260	(.244)	
Architecture	.016	(.799)		.178	(.850)	
Medical technology	-.214	(.364)		-.280	(.349)	
Arts	-.543	(.639)		-.386	(.633)	
Others (=reference category)						
Positions						
Professor	.104	(.301)		.232	(.299)	
Assistant professor	.172	(.313)		.183	(.308)	
Research assistant	.040	(.274)		.126	(.263)	
Others (=reference category)						
Research types						
Basic research	.079	(.064)		.077	(.063)	
Applied research	.015	(.071)		.041	(.072)	
Interdisciplinary research	.122	(.053)	**	.111	(.053)	**
Individual characteristics						
Age	-.016	(.010)	*	-.014	(.010)	
Gender	.031	(.162)		.034	(.169)	
Migration background	.521	(.261)	**	.468	(.265)	**
Married	-.151	(.180)		-.167	(.177)	
Children	.082	(.183)		.110	(.182)	
Risk taking willingness	-.029	(.081)		-.028	(.082)	
Entrepreneurial Contacts	.707	(.147)	***	.696	(.147)	***
Self-employed colleagues	.052	(.149)		.060	(.147)	
Self-employed parents	.041	(.152)		.033	(.147)	
Motivations						
Apply research idea (H1)				.116	(.066)	*
Self-realization (H2)				.237	(.084)	***
Knowledge & skill utilization (H3)				-.201	(.075)	***
Monetary (H4)				.019	(.056)	
Necessity (H5)				.178	(.068)	***
Work-life balance (H6)				-.057	(.058)	
Constant	.478	(.699)		-.562	(.808)	
N	611			611		
F	2.66	***		3.07	***	
R^2	0.0836			0.115		

Note: Robust standard errors in parentheses;
* p ≤.10, ** p ≤ .05, *** p ≤ .01

Furthermore, the results show that our independent variable *knowledge & skill exploitation* (β=-.201; p<0.01) demonstrates a highly significant negative effect on venture progress. This outcome indicates that stronger transfer motives are related to less venture progress. This finding supports hypothesis 3. Additionally, we also find support for hypothesis 2. The regression results show a positive correlation between the independent variable *self-realization* and the dependent variable of venture progress (β=-.237; p<0.01). Thus, our results indicate that academics who are driven by an intrinsic pursuit of self-realization undertake more venture progress than those who are not. With a beta value of β=.133, this variable demonstrates the highest explanatory power. Last but not least, our results demonstrate a highly significant positive effect on our variable *necessity motives* and venture progress (β=.178; p<0.01). This finding suggests that academics who are driven by necessity motives are more likely to engage in entrepreneurship than those who are not. This finding also supports hypothesis 5. A possible explanation for this finding could be found in the working conditions at the universities.

3.5 Discussion and conclusion

In this study, we investigate which motivating factors play a more important role in academic entrepreneurship and how these motivating factors affect the venture progress of academic entrepreneurship. Our study shows that academics are driven by a diverse set of individual motives that induce them to start a company. We find that the most important motivating factors are self-realization, the need for better knowledge and skill utilization and the desire to apply one's own research ideas. Furthermore, economic motives, such as monetary and necessity motives, are also important motivational drivers for academics to start a company. Surprisingly, we also find that striving for a better work-life balance as a founding motive plays a minor role in academic entrepreneurship. Last but not least, we find that the need for better knowledge and skill utilization impedes the venture progress, while self-realization, the need for application and necessity motives positively affect the venture progress of academic entrepreneurship.

Several implications can be drawn from our results. First, our findings indicate that, compared with entrepreneurs in general, the identity of academics plays a dominant role in their participation in entrepreneurial activities. Academic entrepreneurs are driven by a strong inner self-realization motive as well as a need for utilization. In other words, they

strongly devote themselves to improving society by transferring and disseminating technology (Morales-Gualdrón et al., 2009; Berggren, 2017; Iorio et al., 2017).

Second, it is worth noting the negative effect between the need for better knowledge and skill utilization and the venture progress. A possible explanation for this finding could be that scientists might consider a start-up as a platform to further advance their research activities. Hence, scientists may invest their knowledge and skills in their research rather than in concentrating on the commercial exploitation of their research via entrepreneurship. Moreover, an alternative explanation for this finding might be grounded in the scientific system. Scientific acceptance and recognition within academia is mostly achieved by publishing research results in international journals. Thus, the success and reputation of a scientist is primarily measured within the community by the number and ranking of his or her publications (O'Gorman et al., 2008; Wright et al., 2009). During the start-up process, scientists might therefore concentrate more on their publication activities rather than on their commercialization activities. Hence, academics who are driven by this specific motive may either postpone or quit their new venture plans in favour of using this time for publication. Consequently, some start-up projects either proceed very slowly or are abandoned altogether.

Third, and in line with the previous empirical evidence, we find no significant effect of monetary motives, which partly confirms that compared with nonmonetary incentives, the influence of monetary factors among academic entrepreneurs is rather limited (Hayter, 2011; Lam, 2011). In other words, scientists may consider such financial reward as a primary goal when engaging in entrepreneurial activities only as a form of collateral compensation for the time and effort they have devoted (Morales-Gualdrón et al., 2009; Goethner et al., 2012).

Fourth, our findings highlight that the group of necessity founders tends to make more venture progress than opportunity founders. This is also in line with prior findings (Kirkwood, 2009). We believe that the reason for this effect in our study may be attributed to the working conditions at German universities. Due to the mostly limited and part-time working contracts among scientists, many have to constantly search for new jobs to avoid being unemployed.

Finally, starting a business requires a high degree of personal time and effort. Founders often have to work hard and have only a limited free time. Especially in the start-up phase, company founders have less time for personal matters, such as leisure time, family,

or hobbies, as they invest the majority of their time and effort in the founding project. This negatively affects their work-life balance. Surprisingly, however, we did not find a significant effect of work-life balance on venture progress. A possible explanation for this finding could be that the work-life balance as an employed scientist at a university is comparatively well pronounced. Scientists have relatively flexible working schedules and therefore are able to manage their time themselves. Therefore, the issue of work-life balance might be less important for scientists.

This study provides several theoretical and practical implications. From a theoretical perspective, our findings indicate that the intention-action gap in academic entrepreneurship can be bridged by encouraging and enhancing motives that are positively related to academic entrepreneurship. Specifically, our study provides empirical evidence that research-related motives are the most important motives in the context of academic entrepreneurship. Moreover, scientists who are driven by necessity motives are more likely to achieve more progress than are those driven by opportunity. This finding contributes to the literature related to push and pull theory, which also suggests that scholars should focus more on this interesting group of founders. Hence, the potential causes and consequences deserve further analysis. More specifically, future research should analyse how to bridge the gap by encouraging and enhancing the motives that are positively related to academic entrepreneurship and how to readjust or reduce the influence of the motivating factors that show negative effects. Moreover, other issues deserve further study as well, for example, to what extent the different motivation categories vary between the different types of founders and how the effects of the aforementioned motives can be moderated or mediated by the types of founders and their research, faculties and positions within the university.

In terms of policy implications, our study shows that research-related motives are the most relevant motives in driving venture progress. Therefore, university administrators and their technology transfer programs should specifically focus on meeting these needs of academics. Regarding the group of necessity founders, universities should readjust their coaching and mentoring programs to provide necessary help.

Our study is also not without limitations. First, our research design is based on self-reported surveys, in which academics participated voluntarily. Therefore, a potential selection bias could exist. Second, our data are from only one country (Germany), which means our findings may not be generalizable to other countries with different cultural and regulatory backgrounds.

Table3.A1: Variable description.

Variable	Description
Dependent variable:	
Venture progress	Dependent variable: Number of activities undertaken to advance a start-up project by university scientists (from 0 to 8 - all of above described in section model)
University characteristics:	
Invention at university	Binary variable=1 if founder has made an invention based on a research project at the university, zero otherwise
Applied science university	Binary variable=1 if founder works at university of applied science, zero otherwise
Faculties:	
STEM	Binary variable =1 if founder works at the faculty of mathematics, natural science, technique or physics, zero otherwise
Economics/ social science	Binary variable =1 if founder works at the faculty of economics/ social science, zero otherwise
Architecture	Binary variable =1 if founder works at the faculty of architecture, zero otherwise
Medical technology	Binary variable =1 if founder works at the faculty of medicine/ health management, zero otherwise
Arts	Binary variable =1 if founder works at the faculty of music, design, art, zero otherwise
Positions:	
Professor	Binary variable =1 if founder is a full professor, zero otherwise
Assistant professor	Binary variable =1 if founder is an assistant professor, zero otherwise
Research assistant	Binary variable =1 if founder is a research assistant, zero otherwise
Research types:	
Basic research	How would you characterize your research activities at the university? Basic research (from 1 to 5): 1= strongly disagree; 5= strongly agree
Applied research	How would you characterize your research activities at the university? Applied research (from 1 to 5): 1= strongly disagree; 5= strongly agree
Interdisciplinary research	How would you characterize your research activities at the university? Interdisciplinary research (from 1 to 5): 1= strongly disagree; 5= strongly agree

(Table continues on the next page)

Table3.A1: Variable description. (continued)

Individual characteristics:	
Age	Metric variable. Please state your age
Gender	Binary variable =1 if founder male and zero if the founder is female
Migration background	Binary variable =1 if founder has a migration background; zero otherwise
Married	Binary variable =1 if founder is married; zero otherwise
Children	Binary variable =1 if the founder has at least one child; zero otherwise
Risk taking willingness	Are you generally a risk-averse person or do you try to avoid risks? (from 1 to 5): 1= low risk-taking propensity; 5= high risk-taking propensity
Entrepreneurial Contacts	Binary variable =1 if the founder has contacts which are helpful for the implementation of the founding project; zero otherwise
Self-employed colleagues	Binary variable =1 if the founder has self-employed colleagues; zero otherwise
Self-employed parents	Binary variable =1 if the founder has self-employed parents; zero otherwise
Motivations:	
Apply research idea	Why do you (would you) want to become self-employed? Practical application of own research ideas (from 1 to 5): 1= strongly disagree; 5= strongly agree
Self-realization	Why do you want to become self-employed? Self-realization and independence (from 1 to 5): 1= strongly disagree; 5= strongly agree
Knowledge & skill utilization	Why do you want to become self-employed? Improved utilization of professional experience/knowledge (from 1 to 5): 1= strongly disagree; 5= strongly agree
Monetary	Why do you want to become self-employed? Higher and better earning opportunities (from 1 to 5): 1= strongly disagree; 5= strongly agree
Necessity	Why do you want to become self-employed? Dissatisfaction with the current work situation and/ or afraid of unemployment (from 1 to 5): 1= strongly disagree; 5= strongly agree
Work-life-balance	Why do you want to become self-employed? Improved work-life balance (from 1 to 5): 1= strongly disagree; 5= strongly agree

Table3.A2: OLS and Tobit regression results.

DV: Venture progress	**Model 1** (OLS regression)				**Model 2** (OLS regression)				**Model 3** (Tobit estimation)			**Model 4** (Tobit estimation)		
University characteristics														
Invention at university	.323	(.188)	1.720	*	.330	(.188)	1.760	*	.349	(.399)	.870	.361	(.398)	.910
Applied science university	-.177	(.231)	-.770		-.216	(.231)	-.940		-.374	(.508)	-.740	-.454	(.508)	-.890
Faculties														
STEM	.263	(.206)	1.270		.201	(.207)	.970		.577	(.499)	1.160	.493	(.493)	
Economics/ Social science	.247	(.249)	.990		.260	(.244)	1.070		.328	(.613)	.530	.376	(.604)	
Architecture	.016	(.799)	.020		.178	(.850)	.210		-.400	(1.617)	-.250	.049	(1.577)	
Medical technology	-.214	(.364)	-.590		-.280	(.349)	-.800		-1.335	(1.272)	-1.050	-1.552	(1.270)	
Arts	-.543	(.639)	-.850		-.386	(.633)	-.610		-2.197	(2.021)	-1.090	-1.804	(1.979)	
Others (Reference category)														
Positions														1.310
Professor	.104	(.301)	.340		.232	(.299)	.780		.626	(.760)	.820	1.012	(.771)	1.090
Assistant professor	.172	(.313)	.550		.183	(.308)	.590		.717	(.751)	.950	.813	(.745)	.850
Research assistant	.040	(.274)	.150		.126	(.263)	.480		.340	(.710)	.480	.596	(.704)	
Others (Reference category)														
Research types														
Basic research	.079	(.064)	1.230		.077	(.063)	1.230		.087	(.139)	.630	.079	(.137)	.580
Applied research	.015	(.071)	.210		.041	(.072)	.570		-.020	(.170)	-.120	.039	(.168)	.230
Interdisciplinary research	.122	(.053)	2.270	**	.111	(.053)	2.080	**	.201	(.139)	1.440	.191	(.137)	1.390

(*Table continues on the next page*)

Table3.A2: OLS and Tobit regression results. (continued)

Individual characteristics																
Age	-.016	(.010)	-1.650	*	-.014	(.010)	-1.480			-.060	(.023)	-2.600	***	-.058	(.023)	-2.500	**
Gender	.031	(.162)	.190		.034	(.169)	.200			-.056	(.405)	-.140		-.047	(.408)	-.120	
Migration background	.521	(.261)	1.990	**	.468	(.265)	1.770	**		1.148	(.545)	2.110	**	1.018	(.536)	1.900	*
Married	-.151	(.180)	-.840		-.167	(.177)	-.940			-.329	(.398)	-.830		-.345	(.390)	-.880	
Children	.082	(.183)	.450		.110	(.182)	.610			.317	(.407)	.780		.368	(.402)	.920	
Risk-taking willingness	-.029	(.081)	-.360		-.028	(.082)	-.340			-.136	(.182)	-.750		-.115	(.182)	-.630	
Entrepreneurial Contacts	.707	(.147)	4.810	***	.696	(.147)	4.750	***		1.559	(.345)	4.510	***	1.570	(.351)	4.470	***
Self-employed colleagues	.052	(.149)	.350		.060	(.147)	.410			.145	(.336)	.430		.152	(.329)	.460	
Self-employed parents	.041	(.152)	.270		.033	(.147)	.220			-.014	(.347)	-.040		-.056	(.341)	-.160	
Motivations																
Apply research idea					.116	(.066)	1.770	*						.248	(.144)	1.720	*
Self-realization					.237	(.084)	2.820	***						.501	(.192)	2.610	***
Knowledge & skill utilization					-.201	(.075)	-2.680	***						-.450	(.181)	-2.490	**
Monetary					.019	(.056)	.330							.063	(.136)	.460	
Necessity					.178	(.068)	2.630	***						.424	(.156)	2.720	***
Work-life-balance					-.057	(.058)	-.980							-.124	(.137)	-.900	
Constant	.478	(.699)	.680		-.562	(.808)	-.690			-.365	(1.629)	-.220		-2.807	(1.847)	-1.520	
N	611				611				N	611				611			
F	2.66	***			3.07	***			LR chi2	49.15	***			68.56	***		
R^2	0.0836				0.115				Pseudo R2	0.0276				0.0385			

Note: Robust standard errors in parentheses.

* p ≤.10, ** p ≤ .05, *** p ≤ .01

4 Psychological factors and the perception of obstacles in academic entrepreneurship

Abstract

The question why so many academic entrepreneurs postpone or stop their new venture creation plans has not been answered in detail by previous entrepreneurship literature. Our study helps to close this gap in research by focusing on psychological factors. We argue that specific responsive psychological factors have important impacts on the perception of entrepreneurial obstacles especially for academic entrepreneurs. Drawing on a comprehensive dataset of 711 German university scientists, we find that the perception of entrepreneurial obstacles depends (a) positively on the degree of individual decision paralysis and the attitude towards science and (b) negatively on entrepreneurial self-efficacy and individual risk-taking propensity. In sum, our results help to understand if and how strong these psychological factors affect a scientist's perception of start-up obstacles and, thus, can assist university administrators and policy makers to make their entrepreneurship support programs more effective.

Keywords Academic entrepreneurship · Entrepreneurial obstacles · Decision paralysis · Avoidance reaction · Venturing progress

4.1 Introduction

The phenomenon of why scientists start their own new venture has drawn considerable attention in entrepreneurship literature (e.g., Fritsch and Krabel, 2012; Van Gelderen et al., 2015). Nonetheless, the question of why many academic entrepreneurs stop or postpone pursuing their business ideas has not yet been answered convincingly by previous research. While existing studies have advanced our understanding which factors drive academics to start their own businesses (Hayter, 2015a; Iorio et al., 2017; Lam, 2011), only a paucity of research explored the reasons what prevent so many researchers from bringing their founding plans into action (Kollmann et al., 2017; Hossinger et al., 2020). Our study helps to close this gap in research literature in parts by focusing on the psychological mechanisms behind such researcher's avoidance reactions. Specifically, we argue that certain responsive psychological factors which are more common at universities have important effects on the obstacles perceived. This in turn leads to different subsequent entrepreneurial decisions of opportunity evaluation and exploitation.

Using a comprehensive two wave dataset of 711 academic entrepreneurs from 73 German universities, we therefore investigate the following research question: How do the psychological factors of university scientists affect the extent to which they perceive entrepreneurial obstacles? By doing so, our analysis is focused on individual decision paralysis, self-efficacy, individual's attitude towards science and his or her risk-taking propensity and how these specific factors affect the extent of perceived entrepreneurial obstacles. Accordingly, our hypotheses are built on three well-known psychological theories, namely the decision conflict theory from Janis and Mann (1977), the theory of planned behaviour from Ajzen (1991) and institutional theory drawn from Meyer and Rowan (1977).

In line with our hypotheses, our findings show that the extent of entrepreneurial obstacles perceived by scientists depend strongly on the degree of individual decision paralysis, self-efficacy, attitude towards science and risk-taking propensity. Whereas decision paralysis and attitude towards science are positively associated with the extent of obstacles perceived, self-efficacy and risk-taking propensity show a negative relationship.

From the theoretical and practical perspective, our study sheds more light on the avoidance phenomenon of academic entrepreneurship and, thus, helps to understand the psychological mechanisms that are responsible for the avoidance decisions of academic

entrepreneurs when facing start-up obstacles. Moreover, we contribute to research in this stream of literature by showing that the extent of obstacles perceived can be explained to some extent by multiple psychological factors of academic scientists. In particular, this is the first study to focus on the concept of decision paralysis to explain entrepreneurial avoidance decisions by university scientists and thus provides future research with a new perspective to assess the reaction of individuals to obstacles encountered during the entrepreneurial process. From a practical perspective, our study contributes to literature by providing university administrators, technology transfer offices and potential investors with information how to develop targeted knowledge commercialization strategies based on the psychological mechanisms to help scientists leverage their perception of obstacles as objectively and accurately as possible.

The remainder of the paper is structured as follows: in the second section, the empirical findings of related prior research are summarized, and our theoretical framework and hypotheses are introduced. Subsequently, our empirical design is presented. The final section discusses our findings and presents limitations and suggestions for future research.

4.2 Theoretical background and hypotheses

The path of academic entrepreneurship is iterative as well as non-linear so that challenges from both internal and external dimensions have to be faced (Druilhe and Garnsey, 2004; Rasmussen et al., 2014; Rothaermel et al., 2007; Miranda et al., 2017; 2018; Djokovic and Souitaris, 2008). According to Vohora et al. (2004), for example, the development of ASOs generally experience five successive development phases. Due to the deficiency of social capital, weaknesses of resources and inadequacy of internal capabilities, the transition between each phase is separated by "critical junctures" (thresholds) that need to be overcome in order to move forward to the next phase (Vohora et al., 2004). In this context, Van Geenhuizen and Soetanto (2009) emphasize that these obstacles that are faced by ASOs in different development phases could be either market- (e.g. marketing knowledge, sales skills and customer base), management- (e.g. management capacity), finance- (e.g. cash flow and capital investment) or physically related (e.g. accommodation and infrastructure). Previous studies also identify the factors that impede the creation of ASOs from multiple dimensions. For example, conservative attitudes and perceptions of academics such as fear of failure, risk and stress aversion will trigger their avoidance reactions which, in turn, will have a detrimental effect on the way academics evaluate and

exploit entrepreneurial opportunities (Abreu and Grinevich, 2017; Hayter et al., 2017; Kollmann et al., 2017; Maes et al., 2014; Singh Sandhu et al., 2011). Additionally, insufficient resources for technology transfer, the costs associated with innovation and a lack of applicability of knowledge impede the emergence of ASOs as well (O'Gorman et al., 2008; Davey et al., 2016; Neves and Franco, 2016). Weak entrepreneurial culture, lack of support within the organization, combined with the bureaucratic procedures were also found to be the key hurdles of ASO creation (Davey et al., 2016; Botelho and Almeida, 2010; Neves and Franco, 2016). To sum up previous research results: Though the role of obstacles in the entrepreneurial context has been examined before, too little is known about how and how strong specific factors affect the way individuals perceive entrepreneurial obstacles. Especially the psychological mechanisms underlying such avoidance decisions in the venturing process have been neglected so far by research literature. We therefore aim to fill this gap in this stream of research literature by applying three well-known psychological theories, namely the decision conflict theory from Janis and Mann (1977), the theory of planned behaviour from Ajzen (1991) and the institutional theory drawn from Meyer and Rowan (1977).

4.2.1 Decision paralysis

Decision conflicts occur when decision makers have to choose between multiple alternatives (Huber et al., 2012; Luce et al., 2000). Based on the individual objectives, the decision maker evaluates the "pros and cons" of each alternative subjectively (Anderson, 2003). Preference uncertainty appears when the individuals are unable to choose between the alternatives with sufficient certainty (Huber et al., 2012; Anderson, 2003). This can lead to an appetence-aversion or approach-avoidance conflict (Dhar, 1996; O'Neil et al., 2015; Berelson and Steiner, 1964). Simultaneously, the consequences of each decision have to be considered as well. Hence, individuals need to weigh this in advance. As a result, ambivalence may arise due to the advantages and disadvantages of each alternative (O'Neil et al, 2015). Finally, such ambivalence may either be resolved or trigger avoidance reactions (Berelson and Steiner, 1964; O'Neil et al., 2015).

Based on the decision conflict theory from Janis and Mann (1977), psychological stress can be triggered by such an appetence-aversion conflict, which then can result in the failure of high-quality decision-making (Janis and Mann, 1977; Mann et al., 1998; Dhar, 1996). Furthermore, decision-makers usually attempt to explain a decision both to

themselves and to third parties (Redelmeier and Shafir, 1995; Huber et al., 2012). Therefore, psychological stress can be explained by factors originating from two different sources: (a) either the fear of heavy personal, material or social losses due to the decision making and (b) or by the loss of individual reputation and self-esteem if the decision goes wrong (Mann et al., 1998). There are two main reaction patterns when dealing with psychological stress under complex and difficult decision-making circumstances, namely vigilance and procrastination (Janis and Mann, 1977). Vigilance describes the state of increased alertness of a decision maker. The decision maker meticulously searches for more relevant information at high analytical expense and repeatedly compares the advantages and disadvantages of the relevant alternatives based on his personal objectives. (Janis and Mann, 1977; Mann et al., 1998). Procrastination describes the attempt made by the decision maker to deliberately escape the decision conflict by delaying or avoiding a decision making (Anderson, 2003). Due to incomplete and distorted information, the decision maker searches for an optimal alternative and hesitates to take responsibility for the decision or to develop wish rationalizations (Luce, 1998; Mann et al., 1998). In other word, the decision maker fears the negative consequences of his decision so that it can become more attractive to him to avoid making decisions instead of making a wrong decision which could lead to failure (Ferrari, 1991; Janis and Mann, 1977; Mann et al., 1998). Moreover, existing literature indicates that the more complicated and extensive a decision conflict is perceived by a decision maker, the more pronounced both vigilance and procrastination tendencies will be (Tversky and Shafir, 1992; Redelmeier and Shafir, 1995). In addition, the degree of vigilance also has a positive effect on the degree of procrastination (Mann et al., 1998). Thus, by combining both vigilance and procrastination, a new holistic construct can be implemented to explain the difficulty to make such decisions. While previous studies focused on the choice procrastination or avoidance in decision making, the degree of vigilance associated with it has systematically been overlooked. The degree of vigilance which causes procrastination effect can be defined as decision paralysis (Luce, 1998; Janis and Mann, 1977; Mann et al., 1998).

How does this body of research now relate to entrepreneurial decisions in the academic context? The act of entrepreneurship puts academic founders under a series of complex decisions, such as selection of suitable cooperation partners, determination of distribution channels, arrangement of patents and copyrights or searching for optimal financing sources and other. All these decisions require a high level of commitment,

concentration and rational behaviour from the founder-side. Moreover, another factor that has decisive influence on decision making is the fear of a founder to make suboptimal decision and the possible negative consequences of such decision. Due to the professional characteristics and backgrounds, especially academic entrepreneurs are expected to be particularly analytical, considerate and tend to behave more rationally than other types of entrepreneurs. Therefore, academic entrepreneurs will attempt to collect as much information as possible during the decision-making process. That is, they will search intensively for the best solutions with a high analytical effort. However, due to the special innovative nature of academic entrepreneurship, the decision situation will change constantly, and perfect decision solutions will often not exist. This, eventually, will lead to confusion, helplessness and procrastination and result in a higher perception of entrepreneurial obstacles. Based on these arguments, we therefore propose the following hypothesis:

Hypothesis 1: An increase in decision paralysis by academic entrepreneurs is positively related to the extent of perceived entrepreneurial obstacles

4.2.2 Entrepreneurial self-efficacy

Based on the theory of planned behaviour, the concept self-efficacy describes the extent of one's self-confidence to successfully complete specific tasks based on her/his capabilities and skills (Ajzen, 1991; Bandura, 1977; Gist and Mitchell, 1992; Wilson et al., 2007; Obschonka et al., 2015). An important feature of self-efficacy is that it is task- and domain-specific (Zimmerman et al., 1992) Individuals may have a low self-efficacy in one area but a high self-efficacy in another (Bandura, 1977; 1982). The extent of self-efficacy is determined by two factors: the psychological belief if an individual has the necessary skills and capabilities to solve a specific task (Gist and Mitchell, 1992; Bandura, 1989), and the individual's belief that these skills and capabilities can be converted into an effective outcome (Bandura 1977; 1990). Current studies show that individuals with a strong self-efficacy are more likely to pursue and successfully complete specific tasks than those with relatively lower degrees of self-efficacy (Bandura, 1997; 1982; Wood and Bandura, 1989). Furthermore, Bandura (1977) argues that self-efficacy determines, on the one hand, how much effort an individual will invest in order to solve a specific task, and on the other, how long this effort will last due to the perceived obstacles. Thus, with a strong self-efficacy tendency, even the most difficult obstacles can be overcome by an entrepreneur through a

persistent effort. Entrepreneurs with higher self-efficacy are those who are more aware of their skills and capabilities and will therefore also have a stronger conviction that fulfilment of a specific task strongly depends on these capabilities (Bandura, 1997; Fernández-Pérez et al., 2015).

In the context of academic entrepreneurship, previous studies indicate that scientists with a higher entrepreneurial self-efficacy are more likely to found their own firms (Díaz-García and Jiménez-Moreno, 2010; Fernández-Pérez et al., 2015). In the context of academic spin-offs, it can therefore also be expected that the degree of ESE of scientists will influence the extent of the entrepreneurial obstacles perceived. Due to their professional characteristics, scientists usually possess a diverse set of theoretical expertise and abstraction capabilities (Zimmerman et al., 1992). Regarding their strong abstraction capabilities, scientists are more likely to successfully apply their specialist knowledge than other types of founders when establishing a company. Scientists with a higher level of entrepreneurial self-efficacy are therefore more confident and believe that they have the capabilities to achieve the entrepreneurial objective on their own. As a result, we expect entrepreneurial obstacles to be less strongly perceived. Thus, we hypothesize:

Hypothesis 2: An increase in entrepreneurial self-efficacy by academic entrepreneurs is negatively related to the extent of perceived entrepreneurial obstacles

4.2.3 Risk-taking propensity

Entrepreneurial decision and risk are inextricably connected (Brindley, 2005; Caliendo et al., 2014). Previous studies show that the ability to bear risks is often seen as one of the main characteristics of an entrepreneur, which has a decisive influence on the success of the foundation of new ventures as well (Haeussler and Colyvas, 2011; Hoye and Pries, 2009; Singh Sandhu et al., 2011). Risk-taking propensity is defined as an individual's current tendency to take or avoid risks (Sitkin and Weingart, 1995). Thus, risk-taking propensity is based on an internal subjective interpretation of expected losses compared to the expected rewards under uncertainty (Brockhaus, 1980). According to social learning theory, risk-taking propensity can be considered as a learned behaviour that can change over time (Brindley, 2005). Therefore, risk-taking propensity is an emergent property of the decision maker which depends decisively on both personal traits and the socio-cultural environment (Sitkin and Weingart, 1995; Brindley, 2005).

Macko and Tyszka (2009) indicate that it is also necessary to distinguish the types of risks, namely purely chance-related and skill-related risks. People are willing to take more risks only if the outcome of their decision depends on skills instead of chance (Macko and Tyszka, 2009). The risks associated with starting a venture are mainly skill-related, which are perceived subjectively by individuals' personal experiences and abilities. People without prior entrepreneurial experience will evaluate the risks and obstacles higher, which would prevent them from pursuing it eventually (Sitkin and Weingart, 1995). This applies to academics as well. Academic founders have to constantly make decisions under uncertainty in the venturing process. However, the consequences of the decisions cannot be foreseen and may results in losses. Most of academics lack market knowledge or entrepreneurial expertise in terms of founding a firm (Agarwal and Shah, 2014; Van Geenhuizen and Soetanto, 2009). In this situation, they have no control of the outcomes and will perceive the difficulty of the decision much higher. Consequently, they are less likely to take the risks that come along. Thus, we expect that the risk-taking propensity of academics is negatively associated with the entrepreneurial obstacles perceived. We therefore hypothesize:

Hypothesis 3: Risk-taking propensity of academic entrepreneurs are negatively related with the extent of entrepreneurial obstacles perceived

4.2.4 Attitude towards science

According to the institution theory (Meyer and Rowan, 1977), individuals adjust themselves according to the expectations and norms of the institutions they belong to. Thus, an important factor that affect the extent of perceived entrepreneurial obstacles may derive from the socialization process in a scientific context. For example, at the beginning of their careers, young scientists may still quite open to the topic of entrepreneurship. However, this openness is will gradually be lost as their career continues. The explanation for this phenomenon is that junior researchers at universities will realize quickly and clearly that the future of their academic careers depend primarily on their publication quantity and quality (Wright et al., 2009; Lacetera, 2009). With the increasing emergence of the "publish or perish culture" in academia, both junior and established researchers perceive their future opportunities and recognition to be closely associated with the number and the quality rank of their academic publications (O'Gorman et al., 2008; Wright et al., 2009; Lacetera, 2009). Viewed negatively, there is still a lack of appreciation for the knowledge commercialization within the science community in the university context (Bijedić et al., 2017). Furthermore,

for scientists who believe that academia and industry should be distinguished and perceive research findings as public goods will focus more on publishing their studies rather than commercializing them or applying for patents (Guerrero et al., 2015; Kruss and Visser, 2017). Put differently, scientists are locked in publishing their studies instead of searching for potential commercialization opportunities (Johnson et al., 2017). Consequently, some start-up projects are not further specified by scientists or proceed very slowly (O'Gorman et al., 2008; Wright et al., 2009; Bijedić et al., 2017). Moreover, once a scientist has achieved a certain recognition within the academic community, the lock-in effect persists. In a related vein, previous studies also argue that there is a trade-off effect between knowledge transfer and scientific activity; that is, getting engaged in knowledge transfer activities at the expense of scientific productivity (Czarnitzki et al., 2014; Shane, 2004a; 2004b). Since establishing a new company requires extra time and personal resources, scientists have to balance their resources and time between these activities (i.e. opportunity costs) (Neves and Franco, 2016), which could undermine their scientific careers due to lack of scientific outcomes (Aldridge and Audretsch, 2011). The balance and the potential opportunity cost will make it for scientists more difficult to switch from research to entrepreneurship. Hence, entrepreneurial obstacles will be perceived more strongly. We therefore hypothesize:

Hypothesis 4: An increase in attitude towards science by academic entrepreneurs is negatively related to the perception of entrepreneurial obstacles.

4.3 Methodology

4.3.1 Sample and data

Our empirical study is based on a dataset that was conducted in cooperation with the IfM Bonn (Institut für Mittelstandsforschung Bonn) in 2013 and 2016 covering 73 German universities. In the initial survey in 2013, 36,918 scientists from different types of universities of higher education (research and teaching / universities of applied sciences), from a variety of faculties (including information and computer science, medicine, engineering and biology) and holding different positions (i.e. from a researcher to a full professor positions) were surveyed with a focus on their entrepreneurial propensities and actions they have undertook to start a new business (gestation activities) and obstacles they have perceived. Responses from 7,342 scientists were received. The scientists who have been surveyed in 2013 were then invited to participate a follow-up survey in 2016. Out of

the questionnaires that have been sent out, a total of 1,252 completed the questionnaire, which correspondents to a response rate of approx. 17%. After excluding those with missing values on start-up activities (e.g. for example those who abandoned their plans on commercialization), information is available from 771 scientists. We use this sample to estimate the empirical models and test our four hypotheses.

Our sample of 771 scientists are at different start-up stages: 73% were in the pre-market entry stage, 11% in the market entry stage and around 15% were in the post market entry stage. Our sample covers scientists from different types of universities. 84% of them work for research-based universities, while 16% work in universities of applied science. Almost 18% of the sample had prior start-up experience and approximately 20% of the sample have made inventions based on their research activities at their research institutes. Field-wise around 72% of the scientists in our sample are members of the STEM faculties (science, technology, engineering, and mathematics), 13% of our sample are economics or social scientists, 0.5% are architects, 1.8% are in medicine and health management, less than 1% are artists and 11% of the scientists in our sample are members of other faculties.

4.3.2 Dependent and explanatory variables

Table 4.A1 provides the complete variable description in detail. Table 4.1 describes the variables at the individual and organizational level that we use in our regression models with their summary statistics. The third column of Table 4.1 also includes the year in which the scientist's characteristics were observed (2013 or 2016).

Our dependent variable is the extent of perceived entrepreneurial obstacles. In order to measure this, scientists from both the initial and the follow-up surveys were asked to provide information about what impedes them from further advancing their start-up project. The items used to measure these obstacles were taken from the ISCE survey 2006 (International Survey on Collegiate Entrepreneurship). A total of nine different items (entrepreneurial obstacles) were examined (self-report), which range from the business model, the work time load and the deficiency of foundation knowledge or financial resources. All items were measured in a 5-point Likert scale (1=strongly disagree; 5=strongly agree). The reliability coefficient of Cronbach's alpha across all nine items was α=0.8040. All items were aggregated to an average index and included in our regression models.

Table 4.1: Descriptive statistics.

Variable	Mean	Std. Dev.	Min	Max	VIF
Dependent variable					
Entrepreneurial obstacles	3.358	.867	1	5	.
Start-Up progression					
Pre-market entry stage	.735	.442	0	1	.
Market entry stage	.113	.316	0	1	1.12
Post market entry stage	.153	.360	0	1	1.31
University characteristics					
Invention at university	.204	.404	0	1	1.23
University type	.843	.364	0	1	1.47
Faculties					
STEM	.718	.450	0	1	2.28
Economics/ Social science	.133	.340	0	1	2.04
Architecture	.005	.072	0	1	1.07
Medical technology	.018	.133	0	1	1.17
Arts	.009	.095	0	1	1.12
Other faculty	.116	.321	0	1	.
Positions					
Professor	.146	.354	0	1	2.96
Assistant professor	.210	.407	0	1	3.28
Research assistant	.565	.496	0	1	4.21
Other position	.079	.270	0	1	.
Research types					
Basic research	3.405	1.407	1	5	1.67
Applied research	3.765	1.258	1	5	1.73
Interdisciplinary research	3.408	1.287	1	5	1.23
Individual characteristics					
Age	36.492	10.130	23	65	2.15
Gender	.322	.468	0	1	1.14
Migration background	.088	.283	0	1	1.03
Married	.671	.470	0	1	1.32
Children	.396	.489	0	1	1.68
Entrepreneurial Contacts	.264	.441	0	1	1.35
Start-Up promotion offer	.299	.458	0	1	1.11
Start-Up experience	.182	.386	0	1	1.20
Self-employed colleagues	.338	.473	0	1	1.15
Self-employed parents	.300	.459	0	1	1.05
Individual psychological factors					
Decision paralysis (H1)	3.431	.532	1	5	1.09
Self-efficacy (H2)	2.955	1.032	1	5	1.54
Risk-taking propensity (H3)	2.745	.974	1	5	1.30
Attitude towards science (H4)	3.097	.817	1	5	1.07

Note: N= 771

The following four variables are our main explanatory variables to test our hypotheses: decision paralysis, entrepreneurial self-efficacy, risk-taking propensity and attitude towards science. The measurement of decision paralysis was based on the Melbourne decision making questionnaire from 1997 that was developed by Mann et al. (1998). Two sub-variables, namely vigilance and procrastination were also examined in the original study based on six different items (Mann et al., 1998). The results showed that the reliability coefficient Cronbach's alpha achieved in this study deviates only slightly from that of the original study. Looking at both variables separately, the Cronbach alpha of the sub-variable vigilance is $\alpha=0.780$ and Cronbach alpha of the procrastination is $\alpha=0.780$. If both sub-constructs were to be combined for decision paralysis, Cronbach's alpha for all 12 items is $\alpha=0.7469$.

Another important variable is the risk-taking propensity. According to the measurement method from Caliendo et al (2014), scientists interviewed were asked if they were rather a risk seeking or a risk averse person. To measure the entrepreneurial self-efficacy, scientists surveyed were asked to evaluate their success expectations to the entrepreneurial project on the basis of their personal capabilities. More specifically, the measurement was based on the construct developed by Zellweger et al. (2011) for measuring the ESE. This construct was based on four different items. The reliability coefficient Cronbach's alpha for these items was $\alpha=0.9039$.

The measurement of attitudes towards science was based on the construct from Ding et al. (2006) and Haeussler and Colyvas (2011). Scientists interviewed were asked to evaluate various statements with regard to the scientific publication system and the balance between research and entrepreneurship (self-report). All items from these measures (decision paralysis, ESE, risk taking propensity, attitude towards science) were measured in a 5-point Likert scale (1=strongly disagree; 5=strongly agree). To develop the regression model, the items were subsequently condensed by using an average index and included as our main independent variables. Since the underlying survey was conducted in German, all items were translated into English in advance with the help of three different translators.

4.3.3 Control variables

By following the contextualized research approach (Welter, 2011), we control for several variables from multiple dimensions that may affect our dependent variables as well as the extent of perceived entrepreneurial obstacles. Starting from the organizational level, we controll for the degree of start-up progression. To identify the potential phase-specific barriers, we control for three different progress stages. We measure a stage by the extent to which a spin-off project has been progressed. Given the fact that there is a spectrum of activities, associated with different degrees of exploration or exploitation of spin-off project steps, we control for the following three progress stages, namely the pre-market entry stage, the market entry stage and the post-entry stage. Moreover, we control for invention at the university. Scientists with inventions based on their research at the university could consider the inventions as a potential entrepreneurial opportunity to pursue. We therefore assume that scientists with an invention will perceive the entrepreneurial obstacles much less compared to their peers without an invention.

In terms of the university-specific influencing factors, we control for the types of university. Former studies show that having contacts with private sectors in research projects would increase the propensities of scientists involved to found new companies and to establish more networks (Arvanitis et al., 2008). Since research projects with the private sector are more common at universities of applied sciences than at universities, academics at universities of applied sciences will also benefit more from these networks. As a consequence, this could lead to a lower level of perceived entrepreneurial obstacles. Additionally, previous studies show that the type of research (basic or applied research), the position within the university as well as the research disciplines affect academics' entrepreneurial behaviours. Perkmann et al (2011) indicate that the entrepreneurial commitment of scientists from the medical technology field is far more pronounced than scientists from the economic-/ social sciences. While scientists from the medical technology field and STEM are active in all entrepreneurial areas, scientists from the economic-/ social sciences tend to concentrate on consulting services and/or contract research for industry (Abreu and Grinevich, 2013; Fini and Toschi, 2016; Moog et al., 2015; Prodan and Drnovsek, 2010). Start-up projects from the STEM, bio- and medical technological faculties are usually technology-oriented and capital intensive.

Furthermore, scientists from the aforementioned research fields usually do not have sufficient business management and legal knowledge (Zhou et al., 2011; Davey et al., 2016; Neves and Franco, 2016). This makes the implementation of their own entrepreneurial project even more difficult. Therefore, scientists from the STEM, bio- and medical technology fields are expected to perceive entrepreneurial obstacles much more strongly than their colleagues from other fields. To control this effect, the faculties STEM, economics/ social science, architecture, medical technology as well as arts were compared with the other faculties.

Moreover, we control for the positions of scientists within the university. Due to the social and financial securities, scientist with tenure positions are expected to perceive entrepreneurial obstacles much less. With regard to the research types, Arvanitis et al. (2008) and Fischer et al. (2017) indicate that universities with a focus on applied research have a higher propensity to engage in technology transfer activities than universities with a focus on basic research, which in turn could reduce the extent of perceived entrepreneurial obstacles. As for the demographic characteristics of scientists, previous studies show that female scientists are less likely to commercialize their research results compared to their male colleagues and consequently they have lower entrepreneurial propensities (Ding et al., 2006; Díaz-García and Jiménez-Moreno, 2010). Abreu and Grinevich, 2017) indicates that female researchers perceive entrepreneurial obstacles in the spin-out formation process much more acutely than their male counterparts. Due to this reason, we control for a potential gender-specific effect. In addition, age has a decisive influence on the extent of perceived entrepreneurial obstacles as well. Considering the nature of academic career, scientists could only gather sufficient capital stock for setting up a company at a relatively late stage. Moreover, as age increases, the period in which profits can be achieved through entrepreneurial activities decreases as well (Bijedić et al., 2017; Lévesque and Minniti, 2006; Lévesque and Minniti, 2006). As a result, the entrepreneurial obstacles could be perceived much more strongly with increasing age. Therefore, we control for a scientists age.

Another control variable is the original background of the founder. Previous research results suggest that people with a migration background are more likely to be self-employed than those without (Constant and Zimmermann, 2006; Siegel and Waldman, 2019). In addition, Krabel and Mueller (2009) found that academics with work experience in different cultural environments possess a greater diversity of ideas, perspectives and creative techniques than those with few culture backgrounds (Krabel and Mueller, 2009; McEvily

and Zaheer, 1999). Hence, we control for migration backgrounds of scientists. Given the fact that stress aversion is a key barrier in the early stages of academic entrepreneurship, academics with conservative attitudes toward entrepreneurship, such as being stress averse or fearful of failure, are less likely to start their own businesses (Hossinger et al., 2020; Singh Sandhu et al., 2011; Huynh, 2016; Rasmussen et al., 2015; Walter et al., 2011). Consequently, the extent of perceived entrepreneurial obstacles could be higher as well. To proxy the effect of stress and fear we additionally control for, children and marital status.

Regarding the entrepreneurial networks, a number of studies argue that the variety and intensity of entrepreneurial networks change entrepreneurial skills of the founders, but also the sustainable development of the company (Rasmussen et al., 2011; Walter et al., 2011; Rasmussen et al., 2015; Scholten et al., 2015). Hence, it is to be expected that founders who have already established networks or contacts would perceive entrepreneurial obstacles much less. Therefore, we control for the entrepreneurial contacts of scientists.

We also control if a scientist attended a start-up promotion offer. Start-up promotion offers provided by such as technology transfer offices, patent agencies or incubators significantly improve the performance of ASOs due to a set of valuable services such as complementary technical and management supports (Fernández-Alles et al., 2015; Rodríguez-Gulías et al., 2016; Slavtchev and Göktepe-Hultén, 2016), contacts to external funding sources (Berbegal-Mirabent et al., 2015), and training and mentoring programs (Gras et al., 2008). Hence, it is to be expected that scientists who attended the start-up promotion offers would perceive entrepreneurial obstacles much less.

Furthermore, entrepreneurial skills and experiences also enhance the capabilities of scientists in identifying and exploiting entrepreneurial opportunities (Abreu and Grinevich, 2013; Acs et al., 2013; Erikson et al., 2015; Fini and Toschi, 2016; Fini et al., 2011; Krabel and Mueller, 2009; Shane, 2004a; 2004b). Mosey and Wright (2007) argued that founders who failed to establish a company in the past would repeatedly benefit from the experience they have gained, and the networks established when they decide to found a new company again. Based on their previous experience, scientists who have already founded a company would perceive the entrepreneurial obstacles much less. Thus, we control for the prior entrepreneurial experience of scientists.

Previous research also suggests that the entrepreneurial behaviour of scientists is closely influenced by the local entrepreneurial culture. The existence of a favourable entrepreneurial atmosphere within a local environment and the availability of people with open minds would significantly encourage academics to be self-employed (Davey et al., 2016; Fini et al., 2011; Ghio et al., 2016). In this regard, Stuart and Ding (2006) and Moog et al. (2015) indicate that role models and peers affect the likelihood of academics to engage in entrepreneurial activities. A supportive entrepreneurship environment would help scientists perceive the entrepreneurial obstacles less. Hence, we control for both self-employed colleagues and parents.

4.3.4 Analytical procedure

In the empirical models, which will be discussed in detail in the next section, the hypotheses derived from the theories were tested by using multiple linear regression. As shown in Table 4.2, two regression models were developed. In the first regression model (model 1), the influence of the control variables regarding the extent of perceived entrepreneurial obstacles has been examined firstly. A further regression model (model 2) has been developed to test the hypotheses H1, H2, H3 and H4, which included both the independent variables and the control variables. The underlying correlations between the variables used are shown in Table 4.3. We find only weak correlations between the independent variables. The variance inflation factors (VIF) range from 1.03 (lowest value) to 4.21 (highest value). We analysed all variables histograms and found that the errors are identically and independently distributed with constant variance. Overall, these results only suggest the presence of moderate multi-collinearity.

Table 4.2: Regression results.

DV: Entrepreneurial obstacles	Model 1			Model 2		
	Coef.	St. Err.	P>|t|	Coef.	St. Err.	P>|t|
Start-Up progression						
Pre-market entry stage	.	.		.	.	
Market entry stage	-.275	(.088)	***	-.155	(.081)	*
Post market entry stage	-.317	(.094)	***	-.151	(.082)	*
University characteristics						
Invention at university	.020	(.082)		.082	(.072)	
University type	-.022	(.105)		-.032	(.090)	
Faculties						
STEM	-.115	(.092)		-.190	(.086)	**
Economics/ Social science	-.649	(.118)	***	-.455	(.105)	***
Architecture	-.236	(.313)		-.156	(.347)	
Medical technology	-.583	(.282)	**	-.836	(.266)	***
Arts	-.446	(.451)		-.566	(.310)	*
Other faculty	.	.		.	.	
Positions						
Professor	-.365	(.151)	**	-.161	(.133)	
Assistant professor	-.162	(.121)		-.060	(.105)	
Research assistant	-.142	(.112)		-.002	(.101)	
Other position	.	.		.	.	
Research types						
Basic research	.045	(.026)	*	.031	(.023)	
Applied research	.019	(.030)		.028	(.028)	
Interdisciplinary research	-.031	(.025)		-.020	(.021)	
Individual characteristics						
Age	-.004	(.004)		-.006	(.004)	
Gender	.113	(.064)	*	.064	(.060)	
Migration background	-.065	(.108)		.019	(.094)	
Married	-.031	(.067)		.004	(.060)	
Children	.139	(.081)	*	.105	(.069)	
Entrepreneurial Contacts	-.226	(.078)	***	-.045	(.068)	
Start-Up promotion offer	.010	(.063)		-.013	(.056)	
Start-Up experience	-.204	(.086)	**	-.120	(.077)	
Self-employed colleagues	.067	(.064)		.092	(.055)	*
Self-employed parents	-.200	(.063)	***	-.121	(.057)	**
Individual psychological factors						
Decision paralysis (H1)				.220	(.052)	***
Self-efficacy (H2)				-.301	(.033)	***
Risk-taking propensity (H3)				-.117	(.032)	***
Attitude towards science (H4)				.107	(.035)	***
Constant	3.894	(.265)	***	3.830	(.355)	***
N	771			771		
F-test	7.767	***		16.408	***	
R-squared	.196			.377		

Note: Robust standard errors in parentheses;
* p ≤.10, ** p ≤ .05, *** p ≤ .01

Table 4.3: Correlation matrix.

	Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)
(1)	Entrepreneuial obstacles (DV)	1																																
(2)	Pre market entry stage	.24	1																															
(3)	Market entry stage	-.10	-.59	1																														
(4)	Post market entry stage	-.21	-.71	-.15	1																													
(5)	Invention at university	-.01	-.16	.01	.19	1																												
(6)	University type	.07	.05	-.02	-.04	.02	1																											
(7)	STEM	.18	.04	.00	-.05	.16	.20	1																										
(8)	Economics/ Social science	-.26	-.03	-.01	.05	-.16	-.06	-.63	1																									
(9)	Architecture	-.02	-.08	.09	.02	-.04	-.07	-.12	-.03	1																								
(10)	Medical technology	-.06	.02	-.05	.02	.00	-.05	-.22	-.05	-.01	1																							
(11)	Arts	-.03	.00	-.03	.04	-.02	.00	-.15	-.04	-.01	-.01	1																						
(12)	Other faculty	.07	-.01	.02	-.01	-.04	-.18	-.58	-.14	-.03	-.05	-.04	1																					
(13)	Professor	-.16	-.10	-.02	.14	.11	-.39	-.08	.10	-.03	.00	.00	.01	1																				
(14)	Assistant professor	.03	.01	-.02	.01	.08	.20	.11	-.06	-.04	-.05	-.02	-.05	-.21	1																			
(15)	Research assistant	.06	.06	.05	-.11	-.14	.17	.01	.02	.06	-.02	.00	-.05	-.47	-.59	1																		
(16)	Other position	.06	.01	-.03	.01	-.01	-.10	-.08	-.07	-.02	.10	.02	.15	-.12	-.15	-.33	1																	
(17)	Basicresearch	.12	.05	-.02	-.04	.03	.34	.21	-.17	.02	-.01	-.07	-.10	-.09	.19	-.01	-.15	1																
(18)	Applied research	-.09	-.10	.00	.13	.15	-.26	-.10	.09	-.04	-.03	-.09	.10	.17	-.15	.02	-.01	-.53	1															
(19)	Interdisciplinary research	-.10	-.15	.02	.17	.17	.01	-.07	.00	.02	.05	-.03	.09	.07	.11	-.10	-.08	-.05	.30	1														
(20)	Age	-.08	-.04	-.06	.10	.21	-.30	-.01	-.06	-.05	.08	.05	.04	.54	.09	-.53	.13	-.06	.09	.06	1													
(21)	Gender	.10	.11	-.03	-.12	-.19	-.02	-.15	.03	.07	.09	.02	.12	-.12	-.03	.06	.09	.06	-.10	-.04	-.14	1												
(22)	Migration background	-.02	-.05	.02	.05	.06	.06	.03	-.04	-.02	.03	-.03	.00	-.05	.03	.01	.01	.01	.03	.04	-.04	-.01	1											
(23)	Married	-.04	-.05	.01	.06	.10	-.12	-.04	-.02	.01	.05	.01	.04	.18	.04	-.18	.03	-.07	.06	.05	.30	.02	.01	1										
(24)	Children	.00	-.05	-.03	.09	.15	-.18	.04	-.07	-.02	.01	.03	.00	.30	.14	-.35	.04	-.05	.08	.07	.53	-.08	-.05	.47	1								
(25)	Entrepreneurial Contacts	-.24	-.38	.14	.34	.13	-.07	-.11	.11	.04	-.02	-.03	.05	.17	-.04	-.09	.00	-.12	.20	.14	.13	-.13	.05	.06	.08	1							
(26)	Start-Up promotion offer	.06	.12	-.02	-.14	-.14	.04	-.04	-.06	.03	.02	.06	.08	-.10	-.01	.07	.03	.05	-.08	-.14	-.14	.10	.05	-.07	-.10	-.10	1						
(27)	Start-Up experience	-.19	-.15	.05	.15	.00	-.16	-.17	.13	.11	.01	.06	.05	.17	.02	-.16	.05	-.15	.11	.08	.23	-.01	-.03	.14	.15	.17	-.05	1					
(28)	Self-employed colleagues	-.03	-.10	.00	.12	.18	.04	-.01	.03	-.01	-.04	-.01	.00	.12	.02	-.09	-.01	-.09	.15	.13	.15	-.02	.01	.07	.14	.20	-.19	.12	1				
(29)	Self-employed parents	-.12	-.06	.03	.04	-.07	.06	-.04	.03	-.01	.02	-.06	.03	-.09	.04	.03	.02	.04	-.01	.05	-.08	.02	.00	-.01	-.04	.08	.04	.02	-.02	1			
(30)	Decission paralysis (H1)	.21	-.01	.04	-.02	.01	-.01	.01	-.05	-.05	.04	.03	.03	-.10	-.04	.08	.05	.01	-.02	-.03	-.04	-.04	.04	-.07	-.01	-.07	.05	-.01	-.09	-.05	1		
(31)	Self-efficacy (H2)	-.51	-.32	.15	.25	.06	-.09	-.24	.29	.03	-.07	-.01	.06	.10	-.09	.06	-.09	-.16	.19	.12	-.02	-.12	.07	.03	-.02	.34	-.08	.22	.09	.08	-.09	1	
(32)	Risk taking propensity (H3)	-.35	-.17	.05	.17	.12	-.01	-.06	.10	-.02	-.03	-.05	.00	.15	.01	-.11	-.02	-.02	.07	.08	.11	-.10	.07	.07	.06	.23	-.05	.11	.11	.11	-.21	.40	1	
(33)	Attitude towards science (H4)	.18	.07	.00	-.09	-.09	.06	.03	-.08	-.03	.06	.03	.02	-.05	.04	-.05	.10	.11	-.09	-.06	.01	.02	-.03	.00	-.01	-.05	.06	.05	-.04	-.03	.05	-.16	-.08	1

Note: N= 771

4.4 Results

The results in model 1indicate that the extent of perceived entrepreneurial obstacles is lower in the market entry stage (β=-.275; p> p<0.01) and the post-market entry stage (β=-.317; p<0.01) compared with the pre-market entry stage.

With regard to the university-related characteristics such as university types, faculties, positions, and research types, we could not find a significant effect for the types of university. Similarly, the invention at the university also has no influence on the extent of perceived of entrepreneurial obstacles. However, the regression results show that scientists from the economics/social science (β=-.649; p<0.01) and medical technology faculties (β=-.583; p<0.05) perceive entrepreneurial obstacles much less than their colleagues from other faculties. Regarding the position at the university, our results indicates that professors (β=-.365; p<0.05) perceive entrepreneurial obstacles much less than their colleagues in other positions. In terms of research types, our results show a significant positive correlation between the extent of basic research (β=-0.04; p<0.10) and the extent of perceived entrepreneurial obstacles.

With regard to the individual characteristics of the founders, the results indicate that female scientists perceive entrepreneurial obstacles more strongly than their male colleagues (β=.113; p<0.10). These results are consistent with the findings of Ding et al (2006) and Bijedić et al. (2017). However, the age-specific effect proposed by Bijedić et al. (2017) and Lévesque and Minniti (2006) could not be proven in our study. We also could not find supporting evidence for the cultural diversity effect that suggested by Krabel and Mueller (2009). Regarding the previous entrepreneurial experience and social capitals of scientists, the regression results show a highly significant negative effect for the founders' social capitals (β=-.226; p<0.01) and a significant positive effect for prior entrepreneurial experience (β=-.204; p<0.05). Thus, our results are in line with the findings of Hayter (2015a), Huynh (2016), Caliendo et al. (2014) and Fritsch and Krabel (2012). Additionally, our results show that the extent of perceived entrepreneurial obstacles is significantly lower for founders with self-employed parents (β=-.200; p<.01), which indicate that an entrepreneurial-friendly environment could reduce the extent of perceived entrepreneurial obstacles.

In model 2, we included our explanatory variables next to the control variables. The result shows that the extent of decision paralysis has a highly significant positive effect on the perceived entrepreneurial obstacles (β=.220; p<0.01), which indicate that as the decision paralysis enhanced, entrepreneurial obstacles would be perceived much more strongly. This finding supports our first hypothesis. In addition, the regression results also suggest that both the ESE (β=-.301; p<0.01) and the individual risk-taking propensity (β=-.117; p<0.01) demonstrates a significantly positive effect on the perceived entrepreneurial obstacles. This finding confirms our second and third hypothesis and supports the theoretical assumption that scientists with a higher ESE and risk-taking propensity perceive entrepreneurial obstacles much less. Furthermore, the results suggest that there is a positive correlation between attitude towards science and the perceived entrepreneurial obstacles. The estimated results show that academics who are more interested in research activities instead of commercialisations perceive entrepreneurial obstacles more strongly (β=.107; p<0.01). This finally supports our fourth hypothesis. Table 4.4 provides an overview of the accepted and rejected hypothesis.

Regarding the beta values of all variables, the independent variables demonstrate relatively high explanatory power. Comparing the results with those from model 1, it can be observed that by taking into account behavioural scientific constructs, the effects of the established controls decreased. However, the effective direction and significance remain unchanged. This supports both the theoretical foundation and the robustness of the established regression models.

Table 4.4: Accepted and rejected hypothesis.

Assumed hypotheses		
H1:	*The stronger the decision paralysis, the higher the perceived entrepreneurial obstacles.*	✓
H2:	*The higher the entrepreneurial self-efficacy, the lower the perceived entrepreneurial obstacles.*	✓
H3:	*The more positive the attitude towards science, the stronger the perceived entrepreneurial obstacles.*	✓
H4:	*The higher the risk-taking propensity, the lower the perceived entrepreneurial obstacles.*	✓

4.5 Discussion

In this study, we investigated how individual psychological factors affect the extent of perceived entrepreneurial obstacles of university scientists. Based on the representative dataset, this paper shows that the perception of entrepreneurial obstacles in the venturing process of ASOs is significantly determined by four major psychological variables, namely decision paralysis, entrepreneurial self-efficacy, risk-taking propensity and attitude towards science.

Our study shows that the perception of obstacles in academic entrepreneurship is determined less by entrepreneurial and/or university-specific factors, but rather by the individual factors of the founders. The empirical findings suggest that the extent of perceived entrepreneurial obstacles is strongly related to the degree of decision paralysis. As decision paralysis increases, entrepreneurial obstacles are perceived more strongly by the scientists. We argue that this is due to the fact that scientists tend to make more rational and analytical decisions than other types of founders. They attempt to avoid personal, material and social losses as much as possible. As a result, scientists constantly seek for more optimal and safer solutions when planning their founding project. However, such perfect conditions do not exist in reality, and scientist reconsider their decisions or solutions continually, which in turn leads to confusion, helplessness and eventually paralysis. Consequently, this dilemma makes scientists perceive the entrepreneurial obstacles more strongly.

Furthermore, the empirical results also suggest that the extent of perceived entrepreneurial obstacles depends strongly on entrepreneurial self-efficacy. Scientists who have a higher level of entrepreneurial self-efficacy perceive the obstacles less strongly. The explanation we present in this paper is that scientists generally possess a very broad spectrum of knowledge and a high level of abstraction capability. In the course of their professional careers, scientists are constantly being introduced to new subjects and circumstances, which require them to learn new knowledge and skills continually. In addition, since scientists are specialists in their research field, they are aware of their expertise and they can exploit their expertise when they decide to be self-employed. Consequently, scientists with a high ESE will found a company with an open mind and full self-confidence. Furthermore, these scientists are also in a better position to overcome serious entrepreneurial obstacles.

With regard to the individual risk-taking propensity, our findings show that the risk-taking propensity of academics is negatively associated with the extent of perceived entrepreneurial obstacles, which also means that academic entrepreneurs are moderate risk takers. A possible explanation for this finding could be that the individual risk-taking propensity might come along with lower perception of the anticipated losses resulting from complex decision situations. Academic founders have to constantly make decisions under uncertainty in the venturing process. However, the consequences of the decisions could not be foreseen and could results in losses. Individuals with a higher risk-taking propensity would be less afraid of the negative consequences of their decisions as they have taken them into account. Accordingly, the obstacles would be perceived less.

Regarding the effect of attitudes towards science, our findings suggest that scientists who are strongly socialized to the scientific community perceive entrepreneurial obstacles more strongly. This finding could be explained by the role identity of scientists and the pressure from scientific publishing system. Academics are constantly under a strong publication pressure due to the fact that promotion and recognition depend on it (O'Gorman et al., 2008; Wright et al., 2009; Bijedić et al., 2017). Hence, scientists will perceive the entrepreneurial obstacles more strongly and tend to concentrate more on publishing their research results rather than seeking for potential commercialisation opportunities.

From a theoretical perspective, our study sheds more lights on the avoidance phenomenon of academic entrepreneurship and helps to understand the psychological mechanisms that are responsible for the avoidance decisions of academic entrepreneurs when facing these obstacles. In this regard, our study provides evidence that the perception of obstacles in academic entrepreneurship is determined less by entrepreneurial and/or university-specific factors, but rather by the individual attitudes of the researchers and potential founders. As mentioned above, we believe that focussing on decision paralysis in the academic context provides a very interesting and new perspective to explain why many academic entrepreneurs stop or postpone pursuing their start-up plans. Hence, the potential causes and consequences deserve further analysis in the future. For example, to what extent do paralysis tendencies vary between different types of founders or to what extent may the effect of decision paralysis on start-up progress be mediated and/or moderated by perceived entrepreneurial obstacles and/or attitude towards science. In addition, if decision paralysis persists, an interesting research question would be if and how it continues to affect entrepreneurial venture at later stages. Last but not least our study also provides evidence

that several of the well-established influencing factors of academic entrepreneurship play a less important role when individual psychological factors are taken into account, such as the gender effect and the effect of human and social capital that have been often mentioned in the entrepreneurship literature diminishes once the individual psychological factors were included.

From a practical perspective, our results can be valuable for university administrators when reconsidering their coaching and mentoring programmes. The empirical findings suggest that coaching programmes should be customized and focused more on the analysis of the decision behaviour of the founders. For example, the extent of decision paralysis may be reduced if targeted as a training principle. Moreover, universities can provide necessary financial supports for establishing and expanding networks and training start-up coaches. These coaches could support scientists within the university to implement their founding projects and decrease the uncertainty of scientists by providing professional advices and compensating possible knowledge shortages.

In order to further increase the number of university start-ups, a stronger entrepreneurial culture should be implemented within the universities. To achieve this goal, university administrators can reconsider their promotion systems and knowledge transfer should also be considered as an indicator alongside research and teaching missions at universities. As for the policy makers, they may reconsider the process and conditions for applying funding programmes. The application process could be simplified, and the restrictions should be eased so that the spectrum of eligible start-up projects can be expanded. This would relieve scientists from the heavy financial burdens and promote their start-up projects forward, which would, in turn, increase the number of ASOs eventually.

Our study is also not without limitations. Firstly, our research design is based on self-reported surveys, in which academics participate voluntarily. Therefore, a potential selection bias could exist. Secondly, our data is from only one country (Germany), which means our findings may not be generalizable to other countries with different cultural and regulatory backgrounds.

Table 4.A1: Complete variable description.

Variable	Variable description	Year	Mean	Std.Dev.	Min	Max	VIF
Entrepreneurial obstacles	What prevent you from further advancing your start-up project? (1= strongly disagree; 5= strongly agree): 1) I don't consider myself as an entrepreneur. 2) The risk of failing as an entrepreneur is too high. 3) The time load is too high for me. 4) I do not have enough financial resources. 5) I do not have enough support from the private environment. 6) For the implementation I need a partner as co-founder. 7) I do not (yet) have a clear business model. 8) For the implementation I need (more) market knowledge. 9) For the implementation I need (more) managerial/legal knowledge.	2016	3.358	.867	1	5	.
Pre-market entry stage	Binary variable=1 if the founding project is in the pre-market entry stage, zero otherwise	2016	.735	.442	0	1	.
Market entry stage	Binary variable=1 if the founding project is in the market entry stage, zero otherwise	2016	.113	.316	0	1	1.12
Post-market entry stage	Binary variable=1 if the founding project is in the post market entry stage, zero otherwise	2016	.153	.360	0	1	1.31
Invention at university	Binary variable=1 if founder has made an invention based on a research project at the university, zero otherwise	2013	.204	.404	0	1	1.23
University type	Binary variable=1 if founder works at university of applied science, zero otherwise	2013	.843	.364	0	1	1.47
STEM	Binary variable =1 if founder works at the faculty of mathematics, natural science, technique, or physics, zero otherwise	2013	.718	.450	0	1	2.28
Economics/ Social science	Binary variable =1 if founder works at the faculty of economics/ social science, zero otherwise	2013	.133	.340	0	1	2.04
Architecture	Binary variable =1 if founder works at the faculty of architecture, zero otherwise	2013	.005	.072	0	1	1.07
Medical technology	Binary variable =1 if founder works at the faculty of medicine/ health management, zero otherwise	2013	.018	.133	0	1	1.17
Arts	Binary variable =1 if founder works at the faculty of Music, design, art, zero otherwise	2013	.009	.095	0	1	1.12
Other faculty	Binary variable =1 if founder works in another as aforementioned faculty, zero otherwise	2013	.116	.321	0	1	.
Professor	Binary variable =1 if founder is a full professor, zero otherwise	2013	.146	.354	0	1	2.96
Assistant professor	Binary variable =1 if founder is an assistant professor, zero otherwise	2013	.210	.407	0	1	3.28
Research assistant	Binary variable =1 if founder is a research assistant, zero otherwise	2013	.565	.496	0	1	4.21
Other position	Binary variable =1 if founder works in another as aforementioned position, zero otherwise	2013	.079	.270	0	1	.
Basic research	How would you characterize your research activities at the university? (1= strongly disagree; 5= strongly agree)	2013	3.405	1.407	1	5	1.67

(Table continues on the next page)

Table 4.A1: Complete variable description. (continued)

Applied research	How would you characterize your research activities at the university? (1= strongly disagree; 5= strongly agree)	2013	3.765	1.258	1	5	1.73
Interdisciplinary research	How would you characterize your research activities at the university? (1= strongly disagree; 5= strongly agree):	2013	3.408	1.287	1	5	1.23
Age	Metric variable. Please state your age	2013	36.492	10.130	23	65	2.15
Gender	Binary variable =1 if founder male and zero if the founder is female	2013	.322	.468	0	1	1.14
Migration background	Binary variable =1 if founder has a migration background; zero otherwise	2013	.088	.283	0	1	1.03
Married	Binary variable =1 if founder is married; zero otherwise	2013	.671	.470	0	1	1.32
Children	Binary variable =1 if the founder has at least one child; zero otherwise	2013	.396	.489	0	1	1.68
Entrepreneurial Contacts	Binary variable =1 if the founder has contacts which are helpful for the implementation of the founding project; zero otherwise	2013	.264	.441	0	1	1.35
Start-Up promotion offer	Binary variable =1 if the founder attended a start-up promotion offers; zero otherwise	2013	.299	.458	0	1	1.11
Start-Up experience	Binary variable =1 if the founder has prior start-up experience offer; zero otherwise	2013	.182	.386	0	1	1.20
Self-employed colleagues	Binary variable =1 if the founder has self-employed colleagues; zero otherwise	2013	.338	.473	0	1	1.15
Self-employed parents	Binary variable =1 if the founder has self-employed parents; zero otherwise	2013	.300	.459	0	1	1.05
Decision paralysis	Please indicate to what extent you agree with the following statements (1= strongly disagree; 5= strongly agree): 1) I try to be clear about my objectives before making decisions. 2) I spend a lot of time to think before making decisions. 3) I attempt to collect as much information as possible before making decisions 4) I try to compare all alternatives with each other 5) I attempt to find the advantages of all alternatives. 6) I try to find the best way to make a decision 7) I wasted a lot of time on trivial matters before getting to the final decision. 8) I tend to put off making decisions 9) Even after I have made a decision, I delay acting upon it. 10) When I have to make a decision, I wait a long time before starting to think about it. 11) I delay making decisions until it is too late.	2016	3.431	.532	1	5	1.09
Self-efficacy	Please indicate to what extent you agree with the following statements (1= strongly disagree; 5= strongly agree): 1) I have the capability to establish my own firm. 2) I have faith that the launching of my own firm will be a success. 3) I have all the necessary knowledge to start my own firm. 4) I have the entrepreneurial skills to start my own firm.	2016	2.955	1.032	1	5	1.54

(Table continues on the next page)

Table 4.A1: Complete variable description. (continued)

Risk-taking propensity	Are you generally a risk-averse person or do you try to avoid risks? (from 1 to 5): 1= low risk-taking propensity; 5= high risk-taking propensity	2016	2.745	.974	1	5	1.30
Attitude towards science	Please indicate to what extent you agree with the following statements (1= strongly disagree; 5= strongly agree): 1) Science and entrepreneurship are not compatible. 2) Knowledge should not be commercialized. 3) Knowledge transfer between science and industry leads to social prosperity. 4) In my faculty, entrepreneurial self-employment is not welcomed. 5) In academia, Publication has a higher recognition than the commercialization ofknowledge.	2016	3.097	.817	1	5	1.07

Note: N= 771

5 Individual and structural influences on the entrepreneurial activities of academics[4]

Abstract

In this paper we study how and the extent to which (i) individual working conditions (e.g. peers, working atmosphere, work contract incentives, wage satisfaction), (ii) institutions (e.g. technology transfer offices, patent exploitation agencies, chair in entrepreneurship or awards for academic entrepreneurship) and (iii) network relationships simultaneously affect the likelihood of engaging in entrepreneurial activities (nascent entrepreneurship) in academia. Using unique data collected from 5.992 academic scientists in 73 German Universities, we find that entrepreneurial peers and performance-based monetary incentives have a strong positive effect on the entrepreneurial intentions. We show that, although there is a comprehensive support infrastructure for start-ups in German academic institutions, these services are little known amongst their staff. Moreover, we find that market-related networks show a high correspondence with high entrepreneurial intentions, whereas networks within the own university do not have any impact. Several mentioned aspects were analysed before, but mostly on a limited sample (e.g. only in STEM field), isolated personal variables (e.g. gender) or isolated environmental aspects (e.g. peer groups). Our study provides a holistic view on the impact of several university-specific structural factors on entrepreneurial intentions among academic scientists in Germany by simultaneously focusing on personal and occupational characteristics for different faculties.

Keywords Academic entrepreneurship · Nascent entrepreneurship · German universities · Institutions ·Working conditions ·Knowledge transfer

JEL Classification O32 · M13 · J24

[4] This chapter is under preparation for submission to a "B" ranked journal.

5.1 Introduction

The functions of universities have been extended since the second academic revolution, a “third mission”, which stands for transferring knowledge from different research fields to private industry, has been integrated (Visintin and Pittino, 2014). Meanwhile, this function has been proven to be one of the most important sources for generating innovation and economic growth, the importance and contributions of various academic entrepreneurial activities have been recognized globally as well (Block et al., 2017; Berbegal-Mirabent et al., 2015; Guerrero et al., 2008). Accordingly, governments around the world encourage their universities to become more active in transferring their knowledge from academia into private industry. Certainly, starting a new firm is one of the most striking ways for transferring knowledge from academia into the market and consequently foster technology development on a macro level (Miranda et al., 2017; Shane, 2004a). Thus, recent shifts in university and government policies aim at establishing a stronger entrepreneurial spirit among the scientific staff of universities However, the founding process is complex and the entrepreneurial propensities of academics are influenced not only by individual factors, but also factors from parent organizations and diverse external participants (Rasmussen et al., 2014).

Up to date and to our best knowledge, empirical evidence taking into account individual as well as institution-specific structural and environmental factors that affect scientists’ entrepreneurial intentions remains scarce. According to Fritsch and Krabel (2012), there are a relatively large number of start-up-interested scientists compared to a significantly small number of actual company founders, this phenomenon suggests that a high discrepancy between the propensity to found a company and actual implementation in the academic context still exists. Moreover, the joint impact, the interplay between different predictors across various levels as well as within a certain level are still under-researched. little is known, for example, about whether and how specific incentive schemes provided by universities efficiently raise the start-up inclination of the scientific staff, despite the perceived importance of knowledge transfer from universities. But in order to enhance the effectiveness of commercial exploitation of research-based innovation, it is important to understand the specific factors influencing the entrepreneurial intentions of academic scientists comprehensively.

Our study fills this research gap by analysing, how do (a) individual working conditions, e.g. work place endowments, work contracts and income, peers, (b) institutions, e.g. technology transfer offices, patent exploitation agencies, chairs in entrepreneurship or start-up awards, and (c) networks affect the likelihood of the scientific staff to get engaged in entrepreneurial activities.

Using unique data collected from 5.992 academic scientists in 73 institutions of higher education in Germany from a wide range of faculties, we find that specific working conditions and institutional offers as well as most of our network relationship dimensions affect the propensity of academic scientists to start a new venture.

The paper is organized as follows: In the next section, we discuss some theoretical perspectives which may help explain the propensity of scientists to become entrepreneurs and derive the hypotheses. Section three explains the operationalization of our dependent and independent variables and provides the regression results. Finally, in section four, we discuss our results, indicate the limitations of our study and make some concluding remarks.

5.2 Theoretical background and hypotheses

Recent changes and developments in university and government policies aimed to foster an entrepreneurial climate in universities to facilitate the technology transfer to private industry and thus to foster technological development, also known as the ‘third mission’ of universities (Van Looy et al., 2011; Visintin and Pittino, 2014). The main goal of these enactments is to motivate scientists and universities to generate more research output that can be commercialized. However, literature shows that most scientists still seem to have low entrepreneurial intentions and many universities are still far away from being “entrepreneurial” (Cuntz et al., 2012). Fritsch and Krabel (2012) indicate that around 28% of all scientists at universities or research institutions consider start-ups as an attractive employment alternative. However, only 3.2% of all scientists found their own companies ultimately. Moreover, the results of these studies indicate that the motivating factors for university scientists to transition into entrepreneurship may be very specific and just related directly to the transition process but are situated in earlier stages of the entrepreneurial decision process. For this reason, the following chapters focus on workplace conditions, networks and institutional factors which might influence the personal propensity of academic staff for entrepreneurship.

5.2.1 Working conditions

Entrepreneurial intentions are determined by several personal and environmental factors (Rasmussen et al., 2014; Walter et al., 2013). The immediate working conditions in which academics are embedded are directly affect the decisions of academics who are planning to engage in entrepreneurial activities (Muscio et al., 2016). Within the entrepreneurship research, environmental determinants, which foster entrepreneurial intentions and start-up propensity, are subdivided into pull-factors and push-factors. Pull-factors constitute positive causes and expected incentives of an entrepreneurial career, e.g. self-fulfilment, gaining a broader range of competencies or commercialization of one's human capital (Lam, 2011; Antonioli et al., 2016), whereas push-factors are reactions to insufficient conditions and lead to a desire to escape or avoid dissatisfactory working conditions, e.g. (impending) unemployment or a dissatisfying workplace culture (Sass, 2011). While pull-factors are linked to opportunity entrepreneurship and are seen as factors that affect entrepreneurial intentions directly in a positive manner, push-factors are rather linked to necessity entrepreneurship and foster entrepreneurial intentions allusively, as one possible "way out" of a (potentially) precarious situation.

Within this distinction, the individual working conditions of academic staff at institutions of higher education can be subdivided into monetary incentives, peer-effects that can stimulate or inhibit entrepreneurial propensity. In the study at hand we analyse whether and to what extent specific working conditions affect the entrepreneurial propensity of academicians at German institutions of higher education.

5.2.1.1 Monetary incentives

Monetary incentives are often used to regulate staff's behaviour by defining objective agreements and providing performance-linked compensation, bonuses or other monetary incentives (Lazear, 1992). Objective agreements require objective and observable criteria in order to provide a feedback directly linked to the employee's performance (Kräkel, 1996). Especially individuals with a high need for achievement strive for a performance-based feedback and incentives directly linked to the output, therefore monetary incentives based on objective agreements are effective for this group. At the same time, the need for achievement is one of the personality traits most linked to entrepreneurial behaviour and entrepreneurial propensity as well as generally to high performers in the workforce. There is

empirical indication that entrepreneurs have a significantly higher degree of need for achievement than other respective groups (Stewart and Roth, 2007).

Within the entrepreneurship research, performance-based monetary incentives are discussed and empirically proven as one of the key motives for entrepreneurial activity of academics. However, the influence of monetary incentives is always context-specific, its importance often depends on the personal concerns and situations of academics (Rizzo, 2015; Antonioli et al., 2016; Hossinger et al., 2020). D'Este and Perkmann (2011) identified that the monetary incentives are particularly relevant when academics decide to patent or to start their own businesses. In other word, these academics are mostly motivated by the monetary rewards. Depending on the arrangement, they can be seen as a pull-factor, for example to achieve higher earnings and to commercialize human capital, as well as a push-factor, e.g. as a reaction to the dissatisfaction with current compensation (Corolleur et al., 2004; Isfan et al., 2005; Sass, 2011). Based on the theoretical and empirical review of the literature following hypotheses can be derived:

Hypothesis 1: Performance-based monetary incentives as bonuses to the agreed upon salary increase the entrepreneurial propensity.

Hypothesis 2: High satisfaction with the current compensation diminishes the entrepreneurial propensity of academics.

5.2.1.2 Peer effects

Throughout the process of socialization, role models have a high impact on the development of motives and future career decisions (Bercovitz and Feldman, 2008; Nelson, 2014; Alonso-Galicia et al., 2015; Nicolaou and Souitaris, 2016; Johnson et al., 2017). Several studies demonstrate that entrepreneurs' children show a higher entrepreneurial propensity than children of employees (Caliendo et al., 2011; Wins, 2004). However, not only family members and peers within the socialization affect the entrepreneurial propensity, but also professional peers (Stuart and Ding, 2006; Moog et al., 2015).

Peers can affect the entrepreneurial propensity either directly or indirectly, through institutional norms and culture, e.g. in school, university or the supervisor (Antonioli et al., 2016; Bercovitz and Feldman, 2008; Frank et al., 2003; Huyghe and Knockaert, 2015; Sass, 2011). Therefore, it can be assumed that the entrepreneurial culture at the institution on higher education or at the particular department can affect the entrepreneurial propensity.

This also applies for entrepreneurial activities and attitudes of co-workers or supervisors. The effect is stronger the closer the individual is to the entrepreneurial role model. There is severe empirical evidence for these assumptions (Moog et al., 2015; Stuart and Ding, 2006).

Several studies indicate that institutional attitude towards entrepreneurship affects the entrepreneurial activity of the academic staff (Grimm and Jaenicke, 2012; Huyghe and Knockaert, 2015; Feola et al., 2019). Bercovitz and Feldman (2008) addressed that the individual behaviours of academics are strongly affected by the social norms within departments. The entrepreneurial orientation of department leaders ('role model') and peers ('peer effect') significantly influence the individual entrepreneurial behaviours of academics (Nelson, 2014; Johnson et al., 2017). In a similar vein, Kenney and Goe (2004) found out that an entrepreneurial culture within the faculty can foster entrepreneurial propensity of the staff, whereas Rasmussen et al. (2014) showed that a negative attitude towards entrepreneurial activities of scientists within the faculty inhibits entrepreneurial propensity of the employed academicians.

Individual role models affect the entrepreneurial propensity even more than institutional values. The better the reputation of the role model within the scientific community and the more visible the role model is, the bigger his/her impact on the entrepreneurial propensity of the academicians (Berggren, 2011; Stuart and Ding, 2006). Especially successful role models within the faculty that are involved in entrepreneurial activities are crucial for fostering entrepreneurial propensity among young academicians (Geißler et al., 2010; Isfan et al., 2005). Based on the presented theoretical and empirical work, we derived following hypothesis:

Hypothesis 3: Professional peers engaged in entrepreneurial activities foster entrepreneurial intentions of academics.

5.2.2 Networks

The individual choice of an employee to pursue self-employment is not only attributed to the level of skills and to the conditions in the current workplace. Previous studies on this topic also support the assumption that external relations can have a strong impact on the creation of academic spin-offs (Krabel and Mueller, 2009; Karlsson and Wigren, 2012; Fernández-Pérez et al., 2014; 2015; Elfring and Hulsink, 2003; Grandi and Grimaldi, 2003). However, up to date, it is still unclear how the quality of specific network

relationships affects the scientist's willingness to launch a new business. In the following, we address this question and get a deeper insight into the role of networks and their impact on entrepreneurial intentions among academic staff at institutions of higher education.

According to knowledge spill-over theory, the context of decision-making has an impact on one's determination to launch an own business (Acs et al., 2013). The theory is based on the assumption that profitable opportunities arise from knowledge spill-overs. Innovation and new knowledge are regarded to be the key driving force for entrepreneurial investments. The processes of knowledge creation can thereby be stimulated by intensive forms of personal interchange (Ahmad and Ingle, 2011). Cope et al. (2007) as well as De Carolis and Saparito (2006) argue that social capital, which is incorporated in networks, combined with personal factors foster entrepreneurial behaviour. Social capital is regarded as a productive resource built in form of relations among agents, facilitating social and also economic transactions (Parker, 2009) as well as accumulating market specific knowledge. Based on common knowledge created over time, social capital leads to network externalities (Herrmann-Pillath, 2000). The productivity of social capital stems from shared understandings, norms and expectations among network members (Ostrom, 2000). Thus, social capital helps transferring information and other resources with comparatively small costs (Westlund and Bolton, 2003). Social interaction is of high economic value, if its use provides access to scarce and valuable knowledge.

Taking advantage of social capital by social interaction can furthermore help individuals to improve their entrepreneurial ability of decision making and increase their entrepreneurial intentions, calculated risk propensity and also to detect market opportunities (Acs et al., 2013; Hayter, 2013; Fernández-Pérez et al., 2014). Therefore, networks can be perceived as a productive factor, since scientists employed at university rarely holds all the required resources. Thus, being embedded in a respective network can become a precondition for planning and preparing a start-up venture.

Leyden and Link (2013), for example, go into greater detail and discuss the specific role of networks for scientists employed at universities in the context of entrepreneurship. The authors point out that collaborations with stakeholders from the private sector can facilitate the knowledge transfer. According to this assumption, scientists who have ties to potential clients and suppliers, can profit from the access to strategic resources and more attractive conditions. The knowledge gained from these network relations might strengthen

the ability of these academic employees to start their own business. These considerations lead to our next hypotheses:

Hypothesis 4: Market related networks foster entrepreneurial intentions among academics.

Martinez and Aldrich (2011) furthermore assume that diverse networks somehow are positively related to higher entrepreneurial activity. Therefore, the knowledge transfer is reinforced by an increasing number of different network partners. This is also a reason why diverse network relations can have a positive impact on the research productivity of scientists. This latter effect might encourage those individuals embedded in networks to use them in order to commercialize their research output. This assumed seed function of a network will be explored by the following hypothesis:

Hypothesis 5: A high variety of networks has a positive impact on the entrepreneurial intentions of academics.

5.2.3 Institutions

Institutions of higher education can be described as incubators, i.e. as a support system for researchers willing to launch a new business. This became a strategic goal of institutions of higher education and is realized by incentivizing academic entrepreneurship for students as well as for the academic staff. The respective university concepts aim for raising awareness among the academic staff and fostering entrepreneurial spirit. Moreover, they can also improve the visibility and reputation of start-up enterprises for potential customers (Avnimelech and Feldman, 2015; Gras et al., 2008).

Developing a well-structured and well-functioning supporting mechanism for entrepreneurship within university would also significantly promote the entrepreneurial activities of academics (Landry et al., 2006). The typical entrepreneurial support services usually consist of chairs for entrepreneurship offering lectures and courses about entrepreneurship, consulting and support programs offered by technology transfer offices, or start-up and idea workshops, contests and awards. Moreover, as information on property rights becomes relevant, university offers provide information on these issues, as well.

The respective offers incentivizing academic entrepreneurship differ greatly in scope and diversity between German institutions of higher education. The following core activities, however, are predominantly found at universities and cover the different stages of the start-

up founding process: (a) entrepreneurial education, (b) consulting and supporting offers, (c) start up workshops and contests (d) patent exploitation agencies.

5.2.3.1 Entrepreneurship education

The theory of planned behaviour by Ajzen and Fishbein (1980) explains human behaviour and the development of individual intents for action. Ajzen (1991) finds that actions will be performed particularly after persons develop intent to act. This intent arises from the attitude towards an action as well as from subjectively perceived social standards. If intent to act has developed, individuals will perform the action if they are able to control it and have knowledge of whether they will be able to go through with it. Shapero's model (1984) is based on similar assumptions, but directly targeted at entrepreneurial action. Shapero (1984) views the components of "desirability" and "feasibility" to be triggers for becoming a nascent entrepreneur. Accordingly, an enterprise will be founded if it appears desirable and feasible (Wagner, 2006). Furthermore, increasing knowledge about entrepreneurship will also increase the willingness to switch into self-employment (Isfan et al., 2005; Wagner, 2006).

Previous empirical studies suggest that entrepreneurial education at universities mostly has a positive influence on the willingness of students to found enterprises (Isfan et al., 2005; Lüthje and Franke, 2003; Mayhew et al., 2012; Peterman and Kennedy, 2003; Schwarz et al., 2009; Souitaris et al., 2007; Turker and Selcuk., 2009; Walter et al., 2013), especially on improving the entrepreneurial self-efficacy (ESE) and entrepreneurial intention (EI) of academics (Prodan and Drnovsek, 2010; Shinnar et al., 2014; Alonso-Galicia et al., 2015). Thus, we develop the following hypothesis:

Hypothesis 6: Entrepreneurship education programs foster entrepreneurial intentions of academics by increasing the desirability and feasibility of entrepreneurship.

5.2.3.2 Consulting and supporting offers

Nearly all German institutions of higher education maintain technology transfer offices to stimulate technology transfer activities as a statutory premise. They facilitate the transfer process either directly by initiating co-operations between the university and businesses, or indirectly by raising awareness for entrepreneurship among their academic staff. However, the entrepreneurial performance of universities also depends to a great extent on the size, experience as well as the quality of TTOs (O'Shea et al., 2005; Gras et al., 2008; Caldera and Debande, 2010; Ramaciotti and Rizzo, 2015). the financial resources of technology transfer facilities vary strongly, which also affects their performance. Technology transfer offices can consist of one single person or a large team with individual project managers and specialists as consultants, e.g. for legal matters. This influences their performance, as shown by Hülsbeck (2010). According to the study by Kratzer et al. (2010), strong division of labour in the transfer organizations has a positive effect on the number of published university inventions.

In addition to direct consulting and support offers, founders' or idea awards are applied as a qualification strategy. They are at times organized by technology transfer offices or their network partners. Even though the respective details of such awards can vary a lot, they are usually targeted at improving the business plan and facilitating the pre-seed phase by evaluating and offering specialized advice related to marketing, sales and industry-specific aspects, management, accounting or financial and investment plans (Waldmann et al., 2010). Since the awards are often organized regionally, networking with regional partners is facilitated and regional media coverage increases visibility of the future businesses (Knyphausen-Aufseß and Goodwin, 2009; Waldmann et al., 2010). Thus, we generate the following hypothesis:

Hypothesis 7: Technology transfer offices foster the entrepreneurial intentions of scientists by reducing information costs.

5.2.3.3 Start-up camps

Transferring new research results into market-ready products or services is a special challenge in the process of founding an enterprise (Acatech, 2012). Particularly basic research common in universities is often unpredictable regarding its relevance for the

industry. Founders' workshops can therefore be helpful by giving potential founders the chance to test their product ideas with prototypes or a product for the market.

Founders' start-up camps at institutions of higher education provide a start-up infrastructure for the pre-seed phase, such as equipped office rooms, special devices and lab facilities. The latter often require high investments that founders cannot provide by themselves. Particularly capital-intensive start-ups can therefore be greatly supported by start-up camps, while new enterprises with low capital intensity will consider these rather less important. The access to this infrastructure will reduce the capital bottleneck (Stahlecker and Lo, 2004; Fini et al., 2017). Thus, we state the following hypothesis:

Hypothesis 8: Start-up camps foster entrepreneurial intentions of academics by reducing investment costs.

5.2.3.4 Patent exploitation agency

The role of universities in the patent utilization process in Germany has changed substantially with amendment of "§ 42 ArbnErfG", a statute originally providing university professors with unrestricted right to use and commercialize inventions they made as part of their research duties. With the mentioned amendment, the property rights of university research results swapped from the individuals to the institutions. From there on, the legally protected (e.g. as patents) and commercially exploited research outputs belong to the institution and the inventor receives 30 % of the gross income. In exchange, the institution will bear all costs for applying for the patent and commercialization.

At least one patent exploitation agency per Federal state was founded for this purpose. The patent exploitation agencies evaluate the inventions and decide whether they should be patented. The agencies also offer, among other things, consulting services for founding projects establish and administrate contacts and co-operations with market partners, negotiate and supervise contracts as well as offer courses and training events for inventors (Hoeren, 2005). Therefore, we hypothesize:

Hypothesis 9: Patent exploitation agencies foster the entrepreneurial intentions of scientists by reducing investment costs.

5.3 Data and variables

To shed more light on whether and how individual and structural factors affect the scientists' intention to start a new venture, we collected data on German university scientists. In November and December 2013, we sent a questionnaire to 36,918 scientists in 73 random sampled universities in Germany. The sample includes academics from a variety of disciplines (mathematics, information sciences, sciences and technology, social science, economics, humanities and health care as well as art and design). We included all hierarchical levels of academic staff and academic degrees: research associates (Ph.D. students and postdocs), assistant professors, associate professors and professors in tenure positions.

The standardized online survey consists of a bulk of questions about the employment history of the academics in general, their current occupational situation and occupational aspirations in the near future, with a focus on their perception of entrepreneurial activities and entrepreneurial intentions as well as their individual networks. Furthermore, we ask them about the institutional infrastructure facilitating entrepreneurship and the entrepreneurial culture within their institution of higher education. In total 10,199 scientists responded to the survey and 5,998 completed the questionnaire, so they build our sample base for the further data analysis.

5.3.1 Dependent variable

Entrepreneurial activity. Our dependent variable has three parameter values. At first, the academicians were asked, whether they have a basic business idea, regardless if its level of elaboration. This is an indication of entrepreneurial intentions. If the answer was "no", we operationalize it as "no entrepreneurial intentions". If they affirmed, we considered this to be a basic or low-level form of entrepreneurial intentions. Finally, following the understanding by Reynolds et al. (2000), nascent entrepreneurs are individuals who start investing time and resources into business foundation. Therefore, we consider academics as nascent entrepreneurs if they have business ideas and have undertaken at least one of the typical activities for further elaboration of the business ideas, e.g. having developed a business plan, made the idea known to potential customers or business partners, or talked to financiers. We consider these activities as gestation activities.

The distribution of the entrepreneurial activity variable shows that about one third of all the academicians within our sample have a business idea. Within the group of 2,033 (33.9 %) scientists with a business idea, 1,060 (17.7 %) scientists show no gestation activities. However, 973 (16.2 %) scientists have a business idea and have started to initiate at least one gestation activity. Following Reynolds et al. (2000), we consider these 973 scientists to be nascent entrepreneurs.

5.3.2 Independent variables

Working conditions. Our sample includes information on a variety of specific working conditions for the academic staff at German institutions of higher education. Following the theoretical explanations in the last chapter, these experiences should be either conducive to switching into entrepreneurship or keeping the paid employment position in university. In particular, we collected data on (1) performance-based monetary incentives in five different quality dimensions (i.e. vocational and tenure-track negotiations; research, teaching, art; funding; further training and promotion of young talent; administration); (2) satisfaction with current compensation in one dimension (i.e. Likert scale ranging from "1" very unsatisfied to "5" very satisfied) and (3) peer effects measured in three dimensions (i.e. entrepreneurial activity among colleagues and co-workers exists; conversation among colleagues about entrepreneurial activity of other colleagues within the faculty; conversation among colleagues about entrepreneurial activity of other employees and/or students within the institution).

Networks. With regard to the network ties, we included in our regression model contacts (1) to investors; (2) to potential clients; (3) to potential other business partners; (4) to (trade) associations; (5) in a private sphere; (6) to scientists at the workplace (university); (7) to scientists at the other research entities and (8) a network variable capturing the variety of the different network partners.

Institutions. With regard to institutional influences, we included the following offers: (1) start-up camp; (2) founders' or idea award; (3) consulting; (4) coaching; (5) entrepreneurship education; (6) technology transfer office; (7) patent exploitation agency; (8) and a variable capturing the number of different offers used.

5.3.3 Control variables

Finally, we included the following control variables in our regression models: (1) gender (1=scientist is female); age (in years); nationality (1=foreign); parent(s) employment (1=parent(s) are self-employed); partner's employment(1=partner is self-employed); type of university (1=university of applied sciences); subject field (1= Math/Engineering/Natural Science/Technology); position (1=professor); working hours (1=full time); side job/business (1=yes); type of research (basic, applied and multidisciplinary research) and invention (1=scientist has made an invention).

5.3.4 Analytical approach

In the empirical models discussed below, we regress scientists' propensity to leave paid employment for self-employment on different working conditions, network relationships, institutional factors and the control variables discussed above. Overall, twelve different specifications of the empirical model are estimated. Firstly, we calculated a basic model with the set of control variables discussed above. Based on this model, we then included the variables representing a broad range of working conditions (Table 5.1 and Table 5.2). Thirdly, we replace the working condition variables with our network relationship variables (Table 5.3). Finally, we replace the network variables with the institutional variables (Table 5.4). As our dependent variable is a three-item ordinal scale variable, the appropriate econometric model is a regression model for ordinal outcome variables. In the cases, where we comment on our results, we refer to the predictive probability that the scientist has a business idea and has already initiated at least one gestation activity (Likert scale value=3) compared to the situation where the scientist has no business idea (Likert scale value=1). Moreover, the empirical models presented here have robust standard errors with correction for heteroscedasticity. Corresponding correlations for the variables are presented in Table 5.5. Both measures indicate that our results are not greatly biased by multicollinearity.

5.4 Results

Regarding the effects of the individual working conditions on the entrepreneurial activity of academics, three hypotheses were tested by using multivariate regression analysis.

The multivariate data analysis shows that, at a first glance, there is no statistically significant impact of perform-based monetary incentives within the working contract (c.f. Table 5.1). On the second glance, the analysis shows that the quality of the agreed incentivized performance can have either positive or negative effect on the entrepreneurial activity of academicians, so the effects level each other out: Monetary incentives based on performances in research, lecturing or art foster the entrepreneurial activity by 4.5 percentage points, whereas incentives based on administrative tasks inhibit the entrepreneurial activity by 5.4 percentage points. Both single effects are statistically significant and show opposing effects on the entrepreneurial activity.

Table 5.2 (model 3) shows that the satisfaction with current salary has a statistically significant negative effect on the entrepreneurial activity. The more satisfied with the current compensation at the institution of higher education, the less entrepreneurial activity can be observed. Therefore, the satisfaction with the current salary can also be considered as a push factor. Table 5.2 (model 4) shows furthermore statistically significant positive peer effects on the entrepreneurial propensity of the responding scientists. According to the findings of other empirical studies, role models have in general positive impact on the entrepreneurial activity of academics. The closer the scientist to a role model, the stronger the fostering effect on entrepreneurial activity: visible and approachable role models, like colleagues within the faculty, have a stronger positive impact on the entrepreneurial activity than distant role models, which also still a positive, but weaker impact on the entrepreneurial activity.

Table 5.1: Ordered logit estimation results: Monetary incentives.

	Model 1 Probability of nascent entrepreneurship			**Model 2** Probability of nascent entrepreneurship		
	dy/dx	Std.	P>|z|	dy/dx	Std.	P>|z|
Gender (female)	-.055	(.007)	***	-.055	(.007)	***
Age	.002	(.001)	***	.002	(.001)	***
Migration background	.037	(.013)	***	.034	(.013)	**
Self-employed parents (yes)	.019	(.008)	**	.019	(.008)	**
Self-employed partner (yes)	.023	(.012)	**	.024	(.012)	**
University	-.026	(.012)	**	-.028	(.012)	**
STEM	-.014	(.009)		-.014	(.009)	
Professor	-.043	(.012)	***	-.041	(.013)	***
Full time job (yes)	-.001	(.008)		-.001	(.008)	
Side job/business (yes)	.066	(.012)	***	.065	(.012)	***
Basic research	-.032	(.008)	***	-.033	(.008)	***
Applied research	.017	(.008)	**	.017	(.008)	**
Interdisciplinary research	.042	(.008)	***	.042	(.008)	***
Invention at university (yes)	.061	(.011)	***	.061	(.011)	***
Working condition	-.044	(.009)	***	-.044	(.009)	***
Infrastructure awareness	.013	(.007)	*	.012	(.007)	
Network availability	.185	(.008)	***	.185	(.008)	***
Performance-based monetary incentives	-.004	(.015)				
...vocational and tenure-track negotiations				-.030	(.023)	
...research, teaching, art (yes)				.045	(.027)	*
...funding (yes)				.005	(.027)	
...further training and promotion of young talent (yes)				.019	(.033)	
...administration (yes)				-.054	(.022)	**
N	5992			5992		
-2 Log-Likelihood	4613.87			4608.97		
McFadden R^2	.120			.121		

Significance level: *(p < 0.1); **(p < 0.05); ***(p < 0.01)
Note: dy/dx for factor levels is the discrete change from the base level

Table 5.2: Ordered logit estimation results: Compensation and peer effects.

	Model 3 Probability of nascent entrepreneurship			**Model 4** Probability of nascent entrepreneurship		
	dy/dx	Std.	P>|z|	dy/dx	Std.	P>|z|
Gender (female)	-.053	(.007)	***	-.052	(.007)	***
Age	.002	(.001)	***	.002	(.001)	***
Migration background	.036	(.013)	***	.036	(.013)	***
Self-employed parents (yes)	.020	(.008)	**	.020	(.008)	***
Self-employed partner (yes)	.025	(.012)	**	.019	(.011)	*
University	-.023	(.012)	*	-.030	(.012)	**
STEM	-.016	(.009)	*	-.010	(.009)	
Professor (yes)	-.045	(.011)	***	-.043	(.011)	***
Full time job (yes)	.010	(.008)		-.004	(.008)	
Side job/business (yes)	.065	(.012)	***	.058	(.012)	***
Basic research	-.033	(.008)	***	-.029	(.008)	***
Applied research	.019	(.008)	**	.015	(.008)	*
Interdisciplinary research	.040	(.008)	***	.038	(.008)	***
Invention at university (yes)	.058	(.011)	***	.058	(.010)	***
Working condition	-.028	(.009)	***	-.045	(.008)	***
Infrastructure awareness	.014	(.007)	**	.005	(.007)	
Network availability	.182	(.008)	***	.172	(.008)	***
Compensation						
very satisfied	.088	(.023)	***			
unsatisfied	.067	(.016)	***			
medium	.038	(.014)	***			
satisfied	.012	(.013)				
Peer effects						
Entrepreneurial activity among colleagues exists (yes)				.030	(.008)	***
Conversation among colleagues about entrepreneurial activity of other colleagues within the faculty (yes)				.088	.018	***
Conversation among colleagues about entrepreneurial activity of other employees and/or students within the institution (yes)				.029	.015	*
N	5992			5992		
-2 Log-Likelihood	4594.97			4574.48		
McFadden R^2	.124			.128		

Significance level: *(p < 0.1); **(p < 0.05); ***(p < 0.01)
Note: dy/dx for factor levels is the discrete change from the base level
Reference category: “very dissatisfied” with the compensation at the university

Table 5.3: Ordered logit estimation results: Network relationships.

	Model 5 Probability of nascent entrepreneurship			**Model 6** Probability of nascent entrepreneurship			**Model 7** Probability of nascent entrepreneurship		
	dy/dx	Std.	P>|z|	dy/dx	Std.	P>|z|	dy/dx	Std.	P>|z|
Gender (female)	-.054	(.007)	***	-.059	(.007)	***	-.052	(.007)	***
Age	.001	(.001)	**	.002	(.001)	***	.002	(.001)	***
Migration background	.043	(.013)	***	.036	(.013)	***	.037	(.013)	***
Self-employed parents (yes)	.027	(.007)	***	.017	(.008)	**	.021	(.008)	***
Self-employed partner (yes)	.023	(.011)	**	.025	(.012)	**	.025	(.012)	***
University	-.020	(.011)	*	-.029	(.012)	**	-.023	(.012)	***
STEM	-.016	(.008)	*	-.011	(.009)		-.011	(.009)	
Professor (yes)	-.045	(.010)	***	-.035	(.011)	***	-.045	(.011)	***
Full time job (yes)	-.003	(.007)		.003	(.008)		.000	(.008)	
Side job/business (yes)	.047	(.011)	***	.076	(.012)	***	.057	(.012)	***
Basic research	-.019	(.007)	***	-.033	(.008)	***	-.029	(.008)	***
Applied research	.014	(.007)		.024	(.008)	***	.012	(.008)	
Interdisciplinary research	.036	(.007)		.044	(.008)	***	.034	(.008)	***
Invention at university (yes)	.045	(.010)	***	.070	(.011)	***	.053	(.011)	***
Working condition	-.042	(.008)	***	-.041	(.008)	***	-.045	(.008)	***
Networks…									
availability	.022	(.007)	***						
to Investors	.077	(.022)	***						
to potential clients	.207	(.018)	***						
to other potential business partners	.132	(.015)	***						
to (trade) associations	.001	(.013)							
Networks…									
availability				.028	(.007)				
in a private sphere				.166	(.010)	***			
to scientists at the workplace (university)				.004	(.011)				
to scientists from other research institutions				.046	(.012)	***			
Infrastructure awareness							.008	(.007)	
Variety of network partners							.059	(.002)	***
N	5992			5992			5992		
-2 Log-Likelihood	4580.39			4715.90			4591.64		
McFadden R^2	.127			.101			.125		

Significance level: *(p < 0.1); **(p < 0.05); ***(p < 0.01)
Note: dy/dx for factor levels is the discrete change from the base level

With respect to the network effects on the entrepreneurial activity of academicians, two hypotheses were tested using multivariate regression analysis

Referring to the Hypothesis 4, the probability of starting an own business increases by 21 percentage points, if a scientist is able to make use of contacts to potential customers in beforehand (Table 5.3, model 5). Furthermore, the likelihood of a scientist commercializing her/his know-how into entrepreneurship is 13 percentage points higher, when contacts to potential other market partners e.g. suppliers) are maintained. Additionally, contacts with investors such as banks, public and private investors improve the probability of starting an own business by eight percentage points. These findings support Audretsch and Acs (1990) notion, that the gathering of market-oriented expertise enables entrepreneurs to discover market chances and to start an own business. No statistically significant impact is detected in the case of contacts to (trade) associations. The positive network effects are not restricted to external business relations: Further analyses lead to the conclusion that nascent entrepreneurs depend even more on private contacts (Table 5.3, model 6). This result underlines the importance of the supports that founders receive from family members and friends. In addition, the findings indicate that contacts to other scientists outside the own research institute are of great importance as well.

Model 7 in Table 5.3 provides an insight into the effects of network size on the propensity of scientists to start an own business (see also Hypothesis 5). The entrepreneurial activity increases on average by six percentage points when network relations are gradually expanded. However, with the amount of different contacts, the effect is levelling off. The findings confirm the research results of Semrau and Werner (2014), who noted that the relation between the size of a nascent entrepreneur´s network and the access to start-up relevant resources is showing a positive, but concave correlation. The findings are also in line with the results of Reynolds (1997), who concluded that spin-offs mostly occur in networks of smaller size.

With respect to the impact of the institutional factors on the entrepreneurial activity of academic scientists, four hypotheses were tested using multivariate regression analysis (see Hypotheses 6-9).

Table 5.4: Ordered logit estimation results: Institutional factors.

	Model 8			Model 9			Model 10		
	Probability of nascent entrepreneurship			Probability of nascent entrepreneurship			Probability of nascent entrepreneurship		
	dy/dx	Std.	P>|z|	dy/dx	Std.	P>|z|	dy/dx	Std.	P>|z|
Gender (female)	-.052	(.007)	***	-.051	(.007)	***	-.051	(.007)	***
Age	.002	(.001)	***	.002	(.001)	***	.002	(.001)	***
Migration background	.038	(.013)	***	.037	(.013)	***	.039	(.013)	***
Self-employed parents (yes)	.019	(.008)	**	.019	(.008)	***	.020	(.008)	**
Self-employed partner (yes)	.025	(.012)	**	.026	(.011)	***	.025	(.012)	**
University	-.029	(.012)	**	-.032	(.012)	***	-.032	(.012)	***
STEM	-.017	(.009)	*	-.014	(.009)		-.016	(.009)	**
Professor (yes)	-.051	(.011)	***	-.046	(.011)	***	-.050	(.011)	***
Full time job (yes)	-.001	(.008)		-.003	(.008)		-.003	(.008)	
Side job/business (yes)	.061	(.012)	***	.056	(.012)	***	.056	(.012)	***
Basic research	-.030	(.008)	***	-.028	(.008)	***	-.028	(.008)	***
Applied research	.015	(.008)	**	.016	(.008)	**	.015	(.008)	**
Interdisciplinary research	.040	(.008)	***	.039	(.008)	***	.039	(.008)	***
Invention at university (yes)	.044	(.010)	***	.046	(.010)	***	.043	(.010)	***
Working condition	-.046	(.008)	***	-.045	(.008)	***	-.045	(.008)	***
Network availability	.175	(.008)	***	.172	(.008)	***	.173	(.008)	***
Offers provided by institutions									
have been used	.110	(.014)	***						
start-up camp				.093	(.027)	***			
founders' or idea award				.058	(.030)	*			
consulting				.101	(.034)	***			
coaching				.038	(.038)				
entrepreneurial education				.020	(.020)				
technology transfer office (TTO)				-.012	(.020)				
patent exploitation agency				.038	(.023)	*			
Number of different offers							.042	(.005)	***
N	5992			5992			5992		
-2 Log-Likelihood	4569.54			4544.01			4557.61		
McFadden R^2	.129			.133			.131		

Significance level: *(p < 0.1); **(p < 0.05); ***(p < 0.01)
Note: dy/dx for factor levels is the discrete change from the base level

In contradiction to some other studies, we found no evidence that the attendance of an entrepreneurship lecture enhances the likelihood to develop an entrepreneurial spirit (Hypothesis 6). However, our results indicate that consulting offers, start-up camps, awards and patent exploitation agencies go along with a higher entrepreneurial activity (Hypotheses 8 and 9). In contrast, this effect does not hold for technology transfer offices, which do not offer any individual services for potential business founders (Hypothesis 7, Table 5.4, Model 9). This finding is consistent with the results of the studies made by Hülsbeck (2010) and Kratzer et al. (2010), who found out that a strong division of labour in the transfer organizations increases the service efficiency and enhances the entrepreneurial spirit at the university. In other words, a broader number of different services provided by different specialists foster the entrepreneurial activity among academic members of the institutions of higher education. This is consistent with our results which show a statistically significant positive impact of the variety of used services on the entrepreneurial activity of academics (Table 5.4, Model 10).

5.5 Discussion and outlook

In this paper, we applied economic reasoning and multivariate modelling to analyse, which specific factors influence the entrepreneurial activities of academics. We used ordered logit models to analyse different aspects of institutional impact (working conditions, networks and infrastructure) on the entrepreneurial activity of academicians with respect to personal and vocational circumstances for the academics as well as their attitudes and aspirations towards entrepreneurship.

Several important findings have attracted our attention and should be considered by university administrators in Germany. First, we do not find that TTOs facilitate the entrepreneurial propensity of scientists, which is line with several other empirical evidence. TTOs face the problems of awareness and receptiveness by academics (Huyghe et al., 2016b; Muscio, 2010). Tedious and complicated application procedures and bureaucracy make a lot of scholars, especially highly productive scientists choose a “back-door route” to bypass TTOs and contract directly with external industrial partners or investors to commercialize their research results (Aldridge and Audretsch, 2010; Fini et al., 2009). The role of commercialization unit such as university TTO in linking scientists to external stakeholders needs to be reconsidered and the cooperation mechanisms must be redesigned.

Second, findings from several prior research indicate that scientists from biological sciences and STEM disciplines are more likely to engage in licensing activity than their colleagues from other research fields. It is also known that areas where inventions are more of applied nature such as engineering have better market opportunities and orientation toward markets in bio-engineering and medical sciences (Aldridge and Audretsch, 2011). However, our STEM variable does not particularly show statistically significant, which means that scientists from all research fields in German universities are equally likely to start a business at university. This is an interesting finding which deserve to be further investigated. In fact, this demonstrates that German university system enables knowledge development and successful commercialization across different fields, from economics, arts to physics and health technology.

With regard to the working conditions, we find that performance-based monetary incentives and peers show clear pull effects regarding the entrepreneurial propensity of scientists in German academic institutions. Monetary incentives can have a conflictive impact on the entrepreneurial propensity in dependence of their particular quality. Offering incentives for research, lecturing and art is beneficial for entrepreneurial activity, whereas incentivized administrative activities have an inhibitory effect on it. This result is consistent with the findings of previous empirical evidence, which confirm that the influence of monetary incentives is always context specific (Antonioli et al., 2016; Hayter, 2011; Lam, 2011; Rizzo, 2015). Professional peers have also a strong positive effect on the entrepreneurial personality. Especially close and visible role models engaged in entrepreneurial activities foster the propensity to also become an entrepreneur within the academic staff. Furthermore, the satisfaction with the current salary has an inhibitory effect on the propensity to become an entrepreneur, which is considered as a push factor.

Regarding the network effects, the regression results largely confirm our hypotheses. Network relations turn out to be a key feature in explaining the entrepreneurial activity and intention to generate academic spin-offs in Germany. Potential start-ups are clearly influenced in the first place by private relations, but also by market-related business contacts. Founders strongly rely on these relations. There is some evidence suggesting that, from a certain size of the network on, the positive effect on the entrepreneurial activity diminishes. Therefore, the results indicate that too broad networks are not used effectively for putting the knowledge spill-over to use, which also suggest that academics should find the balance between diversity and quality when they implement their social capitals.

The extent to which institutions of higher education provide specific institutional support in the pre-founding process reflects in the degree of entrepreneurial activity of the academic staff. To assure a broad and professional set of entrepreneurships facilitating infrastructure, smaller institutions of higher education should collaborate, e.g. by building clusters for entrepreneurial support, and extend their networks to supportive institutions, such as chambers of industry and commerce in the region. The fact that entrepreneurship chairs do not show a significant effect on the entrepreneurial activity does not mean that such lectures have no impact in reality. Fostering entrepreneurial mind-sets among academics is equally important as providing infrastructures and policies. To achieve this goal, entrepreneurship education is seen as an effective mean. On one hand, the goal of an entrepreneurship education especially for groups with hardly or any knowledge about entrepreneurship is awareness training and qualifying the attendants to make an elaborate decision about this occupational choice rather than blindly pushing them into self-employment. An attendant who based on the entrepreneurship education program recognizes through the training, that being an entrepreneur does not suit his personal characteristics and needs, can be seen as a successful result of entrepreneurship education (Bijedić, 2013; Walter and Block, 2016). On the other hand, the effects of entrepreneurship education as basic awareness trainings cannot be measured immediately and show their impact often delayed (Bijedić, 2013).

Finally, there are some restrictions to our results: we included a rather small range of entrepreneurship education programs into our analyses, like entrepreneurship lectures. Especially these offers are required courses for university members which have studied economics and therefore provoke a bias in the data. Furthermore, due to the cross-sectional design of the study, the causality of the results remains ambiguous. Since longitudinal perspective is needed to distinctively prove the causal effects of the analysed determinants, we plan to conduct a second wave of the study.

To sum up the main results: Our analysis shows that individual and structural working conditions as well as network relationships influence the entrepreneurial activity of academicians. Moreover, and to the best of our knowledge, this study is the first to use representative data to directly test how the entrepreneurial propensities of academics are related to specific individual and institutional working conditions at once.

Table 5.5: Correlation matrix.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Gender (female)	1																			
2	Age	-.107	1																		
3	Migration background	.006	-.076	1																	
4	Self-employed parents	.048	-.063	.062	1																
5	Self-employed partner	.049	.214	.032	.046	1															
6	University	.006	-.344	.097	.031	-.091	1														
7	STEM	-.171	-.049	.051	-.026	-.069	.130	1													
8	Professor	-.109	.512	-.069	-.032	.131	-.319	-.058	1												
9	Full time job	-.196	.167	.040	-.037	-.003	.041	.117	.161	1											
10	Side job/business	-.001	.161	.091	.045	.098	-.156	-.124	.042	-.119	1										
11	Basic research	-.004	-.109	.067	.017	-.043	.286	.171	-.041	-.033	-.105	1									
12	Applied research	-.069	-.110	.036	.009	-.023	.028	-.039	.025	.108	.022	-.249	1								
13	Interdisciplinary research	-.021	-.068	.063	.031	.004	.133	-.046	.021	.075	.002	.028	.338	1							
14	Invention at university	-.146	.119	.080	.005	.042	.042	.153	.099	.119	.051	.027	.139	.108	1						
15	Working condition	-.049	-.003	-.009	.001	.024	-.044	.006	.045	.052	.002	-.011	.061	-.003	-.009	1					
16	Network availability	-.126	.021	.000	.068	.068	-.041	-.064	.085	.045	.108	-.092	.150	.130	.121	.011	1				
17	Infrastructure awareness	-.096	.079	-.122	-.004	.028	-.010	.022	.107	.105	-.005	-.047	.094	.080	.112	.067	.215	1			
18	Performance-based monetary incentives	-.063	.227	.042	.008	.093	-.188	-.041	.509	.112	.045	-.032	.041	.024	.066	.029	.084	.074	1		
19	…Vocational and tenure-track negotiations	-.047	.171	-.010	-.018	.082	-.143	-.020	.463	.084	.009	-.007	.026	.024	.064	.047	.049	.045	.650	1	
20	…Research, teaching, art	-.056	.201	.033	.012	.079	-.189	-.030	.458	.104	.029	-.036	.046	.016	.045	.032	.065	.076	.876	.580	1
21	…Funding	-.047	.186	.009	-.008	.071	-.137	-.017	.461	.103	.035	-.019	.048	.025	.053	.019	.077	.074	.739	.591	.711
22	…Further training and promotion of young talents	-.003	.157	-.006	.002	.051	-.176	-.024	.350	.069	.006	-.050	.020	-.009	.005	.010	.047	.053	.539	.459	.572
23	…Administration	-.045	.198	-.040	-.007	.084	-.247	-.030	.433	.070	.019	-.077	.031	.014	.022	.029	.065	.074	.630	.538	.627
24	Compensation	-.013	-.039	-.004	.008	.011	.056	-.003	.000	.220	-.051	-.022	.067	-.002	-.042	.312	-.028	.064	-.009	-.006	-.010
25	Entrepreneurial activity among colleagues	-.081	.135	-.011	.001	.076	.016	-.032	.074	.108	.086	-.068	.076	.077	.107	.016	.203	.163	.041	.032	.026
26	Conversation about entrepreneurial activity of other colleagues	-.045	-.049	.024	.008	.018	.029	-.030	-.030	.043	.054	-.038	.084	.082	.048	.021	.174	.089	-.007	-.002	.002
27	Conversation about entrepreneurial activity of other employees	-.036	.121	.004	.028	.066	-.086	-.087	.130	.042	.072	-.078	.077	.071	.046	.041	.186	.138	.085	.073	.077
28	Contacts to investors	-.064	.019	.014	.027	.014	-.001	-.024	.063	.029	.069	-.023	.053	.069	.073	-.004	.236	.081	.062	.045	.046
29	Contacts to potential clients	-.080	.126	-.028	.003	.080	-.098	-.069	.116	.037	.148	-.129	.120	.091	.127	.009	.433	.135	.083	.063	.074
30	Contacts to potential business partner	-.105	.061	-.016	.032	.063	-.073	-.040	.106	.057	.138	-.120	.140	.106	.146	-.003	.488	.134	.079	.050	.069
31	Contacts to (trade) associations	-.046	.157	.014	.003	.067	-.122	-.103	.152	.016	.123	-.087	.099	.071	.080	.008	.346	.121	.134	.086	.122
32	Variety of network partners	-.134	.080	-.005	.049	.075	-.064	-.077	.128	.056	.145	-.112	.174	.163	.167	.017	.798	.227	.116	.081	.101
33	Offers have been used	-.112	.081	-.026	.005	.015	-.008	.046	.123	.083	.065	-.050	.106	.085	.241	.038	.232	.313	.069	.050	.063
34	Start-up camp	-.067	.020	.007	-.004	-.010	.012	-.002	.040	.059	.057	-.038	.066	.062	.099	.022	.141	.167	.016	-.003	.007
35	Founders' or idea award	-.051	.024	-.003	.003	.023	.011	-.006	.038	.050	.063	-.039	.054	.042	.101	.020	.130	.140	.023	.016	.023
36	Consulting	-.071	.036	-.011	-.002	-.002	.026	.030	.045	.053	.062	-.042	.050	.043	.123	.007	.150	.151	.031	.005	.033
37	Coaching	-.031	.008	-.017	.018	.004	.008	-.015	.006	.038	.082	-.041	.031	.024	.090	.007	.098	.107	.019	-.007	.015
38	Entrepreneurial education	-.048	-.021	-.035	.010	.016	.013	-.031	-.015	.020	.043	-.048	.057	.047	.045	.009	.145	.181	-.011	-.017	-.011
39	Technology Transfer Office	-.090	.173	-.036	-.022	.042	-.060	.058	.201	.091	.064	-.050	.073	.054	.215	.030	.158	.186	.121	.096	.119
40	Patent exploitation agency	-.094	.120	-.015	-.006	.018	.020	.086	.146	.085	.056	.010	.085	.075	.313	.018	.141	.181	.086	.077	.082
41	Number of the offers	-.103	.086	-.025	-.003	.021	.005	.031	.110	.089	.091	-.053	.094	.079	.224	.026	.214	.249	.067	.042	.063

(Table continued on next page)

Table 5.5: Correlation matrix. (continued)

		(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)	(41)
21	…Funding	1																				
22	…Further training and promotion of young talents	.601	1																			
23	…Administration	.603	.607	1																		
24	Compensation	-.008	-.015	-.031	1																	
25	Entrepreneurial activity among colleagues	.032	.021	.019	.021	1																
26	Conversation about entrepreneurial activity of other colleagues	-.009	-.010	-.033	.000	.224	1															
27	Conversation about entrepreneurial activity of other employees	.079	.069	.075	-.002	.176	.346	1														
28	Contacts to investors	.050	.006	.044	-.022	.104	.099	.144	1													
29	Contacts to potential clients	.078	.040	.055	-.041	.144	.111	.137	.215	1												
30	Contacts to potential business partner	.090	.050	.066	-.026	.174	.143	.168	.284	.504	1											
31	Contacts to (trade) associations	.118	.102	.117	-.035	.115	.072	.137	.175	.327	.277	1										
32	Variety of network partners	.113	.074	.094	-.038	.237	.191	.228	.416	.647	.677	.555	1									
33	Offers have been used	.089	.036	.059	.015	.124	.117	.162	.157	.192	.217	.177	.287	1								
34	Start-up camp	.026	.007	.009	.024	.071	.104	.133	.152	.117	.140	.117	.183	.534	1							
35	Founders' or idea award	.029	-.011	-.002	.010	.081	.085	.087	.117	.112	.121	.125	.173	.449	.418	1						
36	Consulting	.051	.003	.003	.004	.068	.080	.135	.157	.146	.162	.115	.212	.483	.544	.466	1					
37	Coaching	.029	.002	-.005	-.003	.088	.074	.089	.141	.130	.123	.116	.161	.341	.329	.388	.425	1				
38	Entrepreneurial education	-.008	-.028	-.006	-.001	.066	.088	.121	.104	.108	.128	.110	.188	.577	.351	.346	.358	.296	1			
39	Technology Transfer Office	.141	.075	.118	.014	.108	.062	.127	.159	.155	.196	.168	.229	.594	.304	.289	.338	.263	.217	1		
40	Patent exploitation agency	.100	.030	.057	.001	.097	.060	.103	.139	.173	.183	.127	.219	.577	.237	.226	.268	.221	.187	.513	1	
41	Number of the offers	.085	.020	.044	.011	.127	.120	.176	.212	.207	.234	.194	.303	.797	.696	.661	.729	.584	.615	.669	.610	1

6 Academic Entrepreneurship in German Universities: Who can help?[5]

Abstract

This study focuses on the knowledge spill-over of academic entrepreneurship in Germany between 2013 and 2016. Building on the endogenous economic growth and the knowledge spill-over of entrepreneurship theory, we develop a model which explains the interplay between the individual characteristics of scientists, the organizational (university) context and the collaboration between scientists and external stakeholders. Using a sample of 826 scientists, our results find the following combinations of knowledge collaborations which facilitate academic entrepreneurship: technology transfer offices (TTOs) enable collaboration with private industry; patent agencies facilitate collaboration with other scientists and potential customers; university incubators facilitate collaboration with capital investors and develop new business contacts; support programs at universities facilitate collaboration with customers. The study has implications for scholars, scientists, university managers and investors aiming to support start-up activities and invest in research commercialization in developed economies such as Germany.

Keywords Academic entrepreneurship · Technology transfer · University · Commercialization · Germany

JEL Classification M130 · L260 · O310 · O320

[5] This chapter has been submitted to *Research Policy* in January 2020. An initial decision of the chief editor is pending.

6.1 Introduction

Universities around the world are currently implementing far-reaching changes to become more entrepreneurial (Audretsch, 2014; Guerrero and Urbano, 2012; 2014; Block et al., 2017; Urbano and Guerrero, 2013). This has led them to accept more contract-based research, patenting, licencing and spin-off activities to promote the commercialisation of their academic research (Etzkowitz et al., 2000; O'Shea et al., 2005; Grimaldi et al., 2011; Perkmann et al., 2013; Meoli and Vismara, 2016). In particular, these changes have attracted the attention of researchers willing to commercialize their inventions, as well as policy-makers wishing to foster social and economic development and exploit university innovation (Guerrero et al., 2016; Link et al., 2005; Link and Scott, 2005; 2019; Hossinger et al., 2020). As a result, it is apparent that universities and industries aim to develop stronger linkages between scientists and external stakeholders through academic entrepreneurship activity (Siegel et al., 2003; Siegel and Wright, 2015) and other forms of knowledge transfer (Algieri et al., 2013; Cunningham and Link, 2015; Miller et al., 2014). This includes new stakeholders such as incubators, private industry, other business partners [6], venture capitalists, the stock market and professional associations (Mansfield and Lee, 1996; Hague and Oakley, 2000; Rasmussen et al., 2011; Bradley et al., 2013).

In this paper, we define academic entrepreneurship as the creation of new businesses by scientists (spin-offs, start-ups) based on university-developed knowledge. This definition is grounded in the context of specific legislative and organizational interventions enacted to foster academic entrepreneurship (Fini et al., 2016). While academic entrepreneurship represents an efficient response to a multifaceted university function (Etzkowitz, 2002; D'Este and Perkmann, 2011; Audretsch, 2014; Guerrero et al., 2015) there is a limited understanding of the mechanisms and channels of knowledge transfer. For instance, the knowledge spill-over of academic entrepreneurship often lack clarity (Bradley et al., 2013), when researched within an organizational context (Steffensen et al., 2000; Audretsch, 2014) and environmental -ecosystem context (Siegel et al., 2004; Link and Siegel, 2005; Shu et al., 2014; Audretsch and Belitski, 2017; Heaton et al., 2019).

[6] In this study we define other business partners as contractors who are directly involved in companies' business, which can be supplies and potential customers for a scientist.

This study addresses a call to bridge the micro, organizational and environmental divide in university knowledge transfer (Di Gregorio and Shane, 2003; Djokovic and Souitaris, 2008; Lockett et al., 2003; Lockett and Wright, 2005; Rothaermel et al., 2007) with the purpose to examine a range of combinations that connect environmental and organizational contexts (Aldridge and Audretsch, 2010) for knowledge creation and commercialization (Mustar et al., 2006; Guerrero et al., 2015) across 73 German universities between 2013 and 2016. We depart by arguing, that researchers have only recently begun to recognize the role different organizational mechanisms (Bercovitz et al., 2001; Schmitz et al., 2017) play in facilitating collaborations between different types of external stakeholders (Muscio, 2010; Kenney and Patton, 2009; Abreu et al., 2016).

This study fills the gap in the extent literature by adopting the endogenous growth and knowledge spill-over theory of entrepreneurship (Aldridge and Audretsch, 2010; Acs et al., 2013; Audretsch and Belitski, 2013a; 2013b; Braunerhjelm et al., 2010). In doing so, we propose and test a multi-level model of university research commercialization via the academic entrepreneurship of 826 scientist-business founders observed between 2013 and 2016 in 73 German universities. Our study makes three contributions to the academic entrepreneurship and knowledge transfer literature. Firstly, it advances our understanding of the interplay between micro, organizational and environmental factors that can facilitate knowledge transfer from the university to the markets (Lockett et al., 2003; O'Kane et al., 2015; Link and Scott, 2019; Walter and Block, 2016). Secondly, it expands the empirical evidence that complementarity between organizational structures and external stakeholders leads to knowledge commercialization (Kenney and Patton, 2009; Markman et al., 2009; Siegel and Wright, 2015). Thirdly, it extends the scope of analysis from the efficiency of knowledge commercialization (Min et al., 2019; Phan and Siegel, 2006) to the variety of external stakeholders and knowledge commercialization channels available for university scientists in Germany.

Our empirical findings confirm that scientists who attend events at university TTOs are more likely to engage in a number of start-up development activities, while the same events organized by patent agencies and university incubators via different support programs do not affect the scientists' entrepreneurship activities (Kolympiris and Klein, 2017). This finding supports prior research on the role of TTOs, emphasising their important role as facilitators of knowledge transfer from a university to industry (Algieri et al., 2013; Grimaldi

et al., 2011). Moreover, we provide empirical evidence that private industry partnerships and contacts with capital investors will increase the start-up development activities of scientists in Germany, as was shown for university start-ups in other developed economies (Rasmussen et al., 2011). We also find that: (a) collaborations with external scientists and customers along with activities at patenting agencies, (b) collaborations with business partners and investors along with incubator activities, (c) collaborations with customers within the support programs as well as (d) collaborations with the private industry and TTOs all have a positive and significant effect on academic entrepreneurship. By focussing on specific combinations of organizational stakeholders (TTOs, patent agencies, support programs and university incubators) on the one side and external stakeholders on the other, several important managerial and policy implications can be derived directly from our hypotheses and model design.

The remainder of this study is structured as follows. The next section introduces the knowledge spill-over of academic entrepreneurship and formulates a number of research hypotheses. Section three summarises the data and methodology used in the study. Section four outlines the major findings, while section five discusses the results relevant for policy. Section six concludes.

6.2 Theoretical framework

6.2.1 The knowledge spill-over of academic entrepreneurship

Building on the endogenous growth theory and the knowledge spill-over literature (Acs et al., 2013; Audretsch and Belitski, 2013a; 2013b), we distinguish between the multiple layers of the entrepreneurial university (Guerrero and Urbano, 2014; Guerrero et al., 2016) which are associated with three groups of factors known to impact knowledge commercialization by scientists. Several scholars have shown that innovation and knowledge commercialization at university is driven by specific characteristics such as university size, ownership, research quality, technical orientation (or nature of research) and RandD funding level (Gras et al., 2008; Kirby et al., 2011; Abreu et al., 2016; Huyghe et al., 2014; 2016b; Markman et al., 2005; Hossinger et al., 2020). For example, some empirical studies have found that university size is positively related to the rate of spin-off creation (Caldera and Debande, 2010). Besides this, previous researchers have also found that private

universities improve their performance in terms of technology transfer activity (Siegel et al., 2003), while research-led universities are more conducive for knowledge spill-over than teaching-led universities (Abreu et al., 2016).

In line with our conceptual framework, we understand knowledge spill-over from universities as a multilevel phenomenon. The first level of analysis concentrates on the individual characteristics of the scientists promoting knowledge spill-over (e.g. age, training, faculty background, entrepreneurship cognition, risk perceptions etc.). Intuitively, we draw here on entrepreneurial theories within the resource-based view of entrepreneurship (Powers and McDougall, 2005).

The second level focuses on universities and its organisational structures, such as TTOs, knowledge transfer partnerships and incubators as well as the partners they collaborate with, such as patent agencies (Carayol and Matt 2004; Guerrero et al., 2016). Accordingly, the organisational level is represented by specific university characteristics and the resource-based view of entrepreneurship - most importantly internal stakeholders such as TTOs, special programs and training at university, university incubators and patenting offices which universities liaise with (Link et al., 2007).

Finally, the system level pays attention to environmental factors and external stakeholders, such as technological and industry associations, industry, venture capitalists (VCs), angel investors and banks, customers and suppliers (Bradley et al., 2013). This level emphasizes the role of the external environment on academic entrepreneurship (Aidis et al., 2008; O'Shea et al., 2005; Florida and Kenney, 1988; Perkmann et al., 2013; Guerrero and Urbano, 2012; 2014).

6.2.2 Knowledge spill-over theory and the role of stakeholders

Creating a supportive environment to facilitate knowledge transfer can result in higher levels of academic entrepreneurial activity (Clarysse et al., 2011a; Hossinger et al., 2020). Over the years, several scholars have studied the process of transferring technology from the university to the marketplace by drawing on the knowledge spill-over of entrepreneurship perspective (Guerrero et al., 2015; Audretsch, 2014; Belitski et al., 2017). Their results reveal that knowledge spill-over often fails because the bureaucratic procedures within university structures slow down or even block knowledge transfer activities by increasing the uncertainty about available external stakeholders interested in university

research (McAdam et al., 2016). This caveat is known as the *knowledge filter and* can be viewed as a barrier or impediment between investments in knowledge and its commercialization in the marketplace.

However, organizational structures such as incubators, university TTO, patenting offices and specific university support programs are known to play important roles in shaping the development of the local innovation ecosystem for academic entrepreneurship (Korosteleva and Belitski, 2017; Siegel and Wessner, 2012). Accordingly, combinations of these specific university structures should penetrate the knowledge filter by functioning as an endogenous response to entrepreneurial opportunities (Romer, 1986; Acs et al., 2013). Penetrating the knowledge filter is important as the accumulation of large amounts of knowledge which is not commercialized in the market can drive up costs, intensify uncertainty and reinforce sustainability risks.

Along these lines, Audretsch (2014) therefore suggests that investments in research and teaching alone will only facilitate knowledge commercialization if the knowledge spill-over of entrepreneurship can be appropriated to the university scientists; i.e. to those who actually create the knowledge base and are best able to understand the potential of their innovation and promote the knowledge spill-over. However, scientists who aim to commercialize knowledge require legal, financial and mentoring support from patent agencies, TTOs, support programs, science parks and incubators in enabling the knowledge to reach the customers. Consequently, greater engagement with a variety of stakeholders (Miller et al., 2014) along with efficient organizational knowledge transfer conduits will bridge information asymmetries between inventors and private sector (Heinzl et al., 2013; Hellmann, 2007) and will enable access to markets (Huyghe et al., 2016b). In this setting, scientists can rely on organizational structure support (Civera et al., 2019) and are able to efficiently search for partners to facilitate the knowledge spill-over from university to the market – i.e. by minimizing their operational, transaction and time costs.

Studies seeking to explain the knowledge spill-over theory of entrepreneurship in universities have identified a number of internal (organizational) and external (environmental) factors (e.g. tax credits that support technology commercialization) as well as stakeholder activities (Guerrero et al., 2015; 2016) that facilitate the knowledge transfer process (Kirby et al., 2011). These include the establishment of a TTO at the university or research institutes, and collaborations with patent agencies, technological associations or

accelerator programmes (Carayol and Matt, 2004; Guerrero et al., 2016). Although university stakeholders will support academic entrepreneurs (Siegel et al., 2007; Abreu et al., 2016), there may be different returns to knowledge collaboration with different stakeholders (Miller et al., 2014).

Since universities have integrated far-reaching changes to become more entrepreneurial (Audretsch, 2014), a generalizable model of knowledge transfers no longer exists (Bradley et al., 2013; Litan et al., 2007). Consequently, researchers attempted to draw a multilevel entrepreneurial university model with multiple combinations of stakeholders that are continually shaping the knowledge transfer process. In line with this, academic entrepreneurship emerges as a conduit of knowledge between university organizational structures and external stakeholders (Miller et al., 2014; Link et al., 2015). In other words, each stakeholder brings their own unique set of skills, networks, market knowledge and competences which simultaneously affects and enables knowledge spill-overs by academic entrepreneurs.

Multiple stakeholders - internal and external to the university - who all attempt to exert influence on the knowledge commercialization have to be considered in this specific knowledge transfer process (Alsos et al., 2011). On the one side, we have client firms, government institutions, venture capitalists and other investors, business partners, other scientists as well as internal institutions (TTOs, patenting offices) which ask for a disclosure of inventions. TTOs, for example, engage in various support services such as partner searches, management of intellectual property rights (Siegel et al., 2003) which increases the chances for an inventor to expose his or her invention to a broader audience including potential investors. TTOs will thus create networks, bringing researchers into contact with experts from industry and VCs (Clarysse et al., 2011a; 2011b) to expand the pool of inventions with potentially high commercial value and increase the opportunities for cross-fertilization of academic output (Zucker et al., 2002). On the other side, we have science parks, incubators and support programmes (mentoring, accelerators) for cases where the technology is cutting edge but has yet to be tested in the market. The incubation process and venture investment usually take a long time because all assumptions are tested before a valuable IP is given to a separate company. In addition, the incubator program also exposes an academic to formal and highly specialized venture capital funds.

Prior research also suggests that the quality of the university environment and its ability to generate and transfer knowledge is measured by the number of disclosures, knowledge transfer staff, patents and incubation processes. Also crucial are the effectiveness of knowledge transfer support programmes with incubators, TTOs and patenting agencies which altogether have a positive effect on academic entrepreneurship (Kolympiris and Klein, 2017). It is thus a combination of organizational factors with other external facilitators which enables university knowledge transfer (Link et al., 2015). For example, collaborations between researchers and university TTOs as well as patent agencies and incubation programs can multiply commercialization channels. Taken together we hypothesize:

Hypothesis 1: Collaboration with organizational stakeholders (TTOs, patent agencies, support programs, incubators) increases academic entrepreneurship (bridging the micro-organizational divide).

6.2.3 External collaboration and academic entrepreneurship

Prior research has identified the role of the entrepreneurial university in knowledge transfer in which knowledge per se is embodied into scientists while relevant business-related information is held by the private sector (Agrawal, 2006). The resulting knowledge asymmetry triggers scientists and the private sector to rearrange their knowledge transfer activities (Link and Scott, 2005). Based on this, we argue that the knowledge transfer is the result of collaborations between scientists and external partners and is therefore an important strategy to obtain access university knowledge.

In addition, knowledge asymmetry will intensify collaborations between scientists, leading them to co-create new products and services (Heinzl et al., 2013). It is thus rational to assume that knowledge collaboration has multiple roles in knowledge transfers. First, it enables scientists to recognise market opportunities by sourcing information from different partners. Second, it eases the learning process and makes it easier to access resources, including specialized programs. Third, by easing the market through testing for ideas, information from external stakeholders will further enhance knowledge exploration efforts. Moreover, in cases where knowledge is to be commercialized, knowledge will be further adapted and adopted by external users (Von Stamm, 2004). First, this enables the integration of new ideas and the creation of marketable and commercializable goods and services (Belitski and Desai, 2016; Grandi and Grimaldi, 2005) which otherwise would have never

been commercialized (Audretsch and Keilbach, 2005). In fact, previous research has demonstrated that industry-related entrepreneurs are better able to identify valuable market opportunities than academic entrepreneurs, although their degree of technological novelty may be lower (Czarnitzki et al., 2014).

Second, such collaborations reduce the cost of market entry by easing the market discovery and appropriation mechanisms (Cassiman and Veugelers, 2002). Third, such knowledge collaborations will help to distribute the costs of academic research between partners (Veugelers, 1997; Bradley et al., 2013) and therefore reduce the costs associated with the product development stage. In fact, external partners facilitate the development of inventions by scientists with higher levels of technological complexity and application (Hoye and Pries, 2009), which reduces the costs and uncertainties associated with the commercial readiness of inventions.

Fourth, sharing information on innovation activities in the industry and with third parties helps to generate networks (West et al., 2014) which otherwise would be unavailable for a focal academic entrepreneur (Siegel and Wright, 2015). Fifth, the collaboration with an external partner can function as a positive signal to non-academic audiences, including investors, associations and companies interested in a newly available technology (Mueller et al. 2012). Finally, collaboration with external stakeholders can function as a core strategy for exploiting the boundaries of university knowledge applicability (Lee, 1996) and for facilitating university-industry linkages (Markman et al., 2009; Rasmussen et al., 2011). We hypothesize:

Hypothesis 2: Collaboration with external stakeholders increases academic entrepreneurship (bridging the micro-macro divide).

6.2.4 Bridging the micro-organizational-macro divide

Bridging the micro-organizational-macro divide requires the alignment of organizational and external mechanisms to facilitate knowledge commercialization (Link et al., 2015; Fini et al., 2016). Scientists will draw on multiple external and organizational sources of knowledge commercialization to different degrees as they reinforce one another. On the one hand, greater interaction with external stakeholders is likely to reinforce a scientist's capacity to identify commercial opportunities and engage with organizational stakeholders to fund and support the idea. On the other hand, increased interaction with non-

academic users can lead to the development of inventions with higher levels of technological resolution (Hoye and Pries 2009), which reduces the uncertainties regarding commercial readiness of inventions. Organizational mechanisms such as TTOs, patent agencies, support programs and business incubators offer market expertise, resources and capabilities to increase researchers' awareness of private industry and market needs. This is an important layer in knowledge transfer from a university, which is the source of knowledge, to the private industry, which is the recipient of knowledge (Bozeman et al., 2015).

Several empirical studies (Siegel et al., 2007) have illustrated that the creation of a formal technology transfer/licensing offices is the first step towards increasing the enforcement of intellectual property ownership by and at universities (Grimaldi et al., 2011). Early TTO activity at universities consists of multiple stakeholders from inside and outside of the university (e.g. academics/principal investigators, industry liaison staff and local policy-makers) who met on "a monthly basis to discuss the technology transfer activities that were taking place within the university" (Miller et al., 2014).

Despite TTOs becoming facilitators of knowledge transfer in many European universities, the spread of TTOs in several countries where universities had owned the IP and the patenting activity was weak (Baldini, 2009). Grimaldi et al. (2011) associates this finding with inadequate internal support mechanisms due to the relatively nascent nature of most TTOs. In Germany, the 'professor's privilege' ('Hochschullehrer-Privileg') was in place until 2002 (Grimpe and Fier, 2010). This privilege entitled academics in Germany to use their scientific results – at least in part – for private commercialization, even if the underlying research was carried out at and financed by the university or other public sources (Kilger and Bartenbach, 2002).

Unfortunately, the professors' right to commercialize research directly resulted in a significantly lower number of German university patents (Czarnitzki et al., 2014). Business and technology consulting and cooperation became much more important. However, since the abolishment of the professor's privilege in Germany in 2002 (paragraph 40-42 of "Gesetz über Arbeitnehmererfindungen" - the Law on Employee Inventions)[7], the property rights on

[7] According to § 42 of the German Employee Invention Act ("Arbeitnehmererfindungsgesetz") the following special provisions apply to inventions made by university employees: 1) The inventor is entitled to disclose the service invention *(aw-> SH, what exactly is meant by "service invention")* within the scope of his or her teaching and research activities if the inventor has notified the employer in time; i.e., generally two months in advance. 2) If an inventor refuses to disclose his or her service invention, he or she is not obliged to report the invention to the employer. If the inventor wishes to disclose his or her invention at a later time, he or she must

an invention are transferred from the scientist to his organization (Bartenbach and Volz, 2019). The role of TTOs in supporting academic research commercialization has therefore fundamentally changed (Hülsbeck, 2010). TTOs at universities aim to provide incentives for academic entrepreneurs, including legal requirements and IP of knowledge, market search, and patent applications and licencing. Even though TTOs have been recently criticized for possessing a number of organizational and human resources issues – including with the recruitment of qualified technology transfer personnel, poor IP protection and too much bureaucracy (Wright et al., 2008a; Siegel and Wright, 2015) - this seems to hold first and foremost for university knowledge transfers in developed and developing economies (Belitski et al., 2017).

In addition, university TTOs can enhance research results by building on direct contacts between scientists, private industry and investors. TTOs have market-related knowledge which is important for academics who keen to commercialize their research. Interactions with TTOs and also industry practitioners are shown to be strong predictors of entrepreneurial activity among scientists (Grandi and Grimaldi, 2005; D'Este et al., 2012). Such interactions will keep TTO functions decentralized (Huyghe et al., 2014; 2016a; 2016b) in order to facilitate connectivity between researchers and private industry, as well as researchers and investors (Link et al., 2005; Siegel et al., 2007; Aldridge and Audretsch, 2011; Perkmann et al., 2013). In sum, we hypothesize:

Hypothesis 3a: University TTOs will facilitate collaborations with private industry and investors for academic entrepreneurship

Although knowledge transfers between external firms and inventors can be lengthy (Audretsch et al., 2019), the inventor will wish to protect innovation by using various intellectual property rights (IPR). Patenting an invention can reduce the opportunistic behaviour of external stakeholders and allows for appropriation of research outcomes. Moreover, strong IPR protection can mitigate the fear of potential opportunistic behaviour between scientists, universities and partners in order to effectively collaborate and transfer knowledge to third parties without free riding (Hellmann, 2007). There are several reasons

immediately notify the employer of the invention. 3) In the case that the job-related invention is claimed, the inventor has a non-exclusive right to use the job-related invention within the scope of his teaching and research activities. 4) If the employer exploits the invention, the remuneration is 30 % of the income generated by the exploitation

why poor IP protection will reduce the incentives for academic entrepreneurship. First, poor IP protection is a potential knowledge leakage related to collaboration with other scientists, who may label someone else's work as their own, or may slightly modify the combination of inputs which can result in a completely different and hard to track output. Distinguishing between different types of external collaborators, the probability is high that collaborations between scientists will produce more tacit and complex knowledge, which may grow in value and require a greater level of protection. At the same time the type of protection may remain ambiguous, as co-development and co-creation is common practice in STEM specialities (Helmers and Rogers, 2015).

Although IP protection is required across various collaboration partners, it is a new technology-based protection developed within scientific communities, university-industry consortia and alliances, increased faculty consulting for industry and professional (Lee, 1996) as well as highly specific associations that may require a greater degree of legal IP protection to fully exploit innovation in the market. An example of "The Bayh-Dole Act" (Grimaldi et al., 2011) turned out to be an accelerator for campus innovation as universities that would previously have let their intellectual property lie fallow (Aldridge and Audretsch, 2011) began filling for IPR and getting patents at high rates. In addition, protection of knowledge may prevent leakage and secure the quality of collaborations within academic communities (Wright et al., 2008b). In this context, we argue that in countries with strong institutions and respect for IPR, like Germany, the use of patenting of inventions is likely to limit free-riding and increase the outcome of academic entrepreneurship. Consequently, this will particularly protect scientists when collaborating within other scientists and research institutes. We therefore hypothesize:

Hypothesis 3b: Patent agencies will facilitate collaboration with scientists and professional associations for academic entrepreneurship

The technologies developed in universities are intended to become a public good with a variety of university support programmes exist to catalyse collaboration among scientists and customers (Mian, 1996). These support programs may include entrepreneurial boot camps, university accelerators, mentoring, TED-talks, business clinics, panels with entrepreneurs and coaching events (Clarysse et al., 2007). These programs play a key role in fostering new ideas by focusing on frequent interactions with customers, which provide critical insights about which markets to enter and which customer problems and needs should

be addressed (Von Stamm, 2004) by the new inventions or technologies. Entrepreneurship and digital marketing courses offered at business schools to academics and executives are important for new venture creation and promotion (Shane, 2004b; Shane and Delmar, 2004). Spin-off support programs at universities can also help external partners to access on- and off-campus facilities and labs in collaboration with other institutions and secure grants, win competitions and awards, and connect researchers to prospective customers (Heaton et al., 2019). This approach to the knowledge-based antecedents of academic entrepreneurship corresponds to a demand-driven approach (Agarwal and Shah, 2014) in which researchers benefit from the market context and customer knowledge.

However, scientists face at least two challenges when collaborating with customers. First, there is a considerable gap between the technologies developed by scientists and those demanded in a market. In this instance, collaboration with customers and other scientists enables more advanced, ready-to-use solutions which can be co-developed (Agarwal and Shah, 2014) and introduced to the market quickly. This form of collaboration with a subsequent protection of knowledge is likely to reduce the risks of unexpected costs and uncertainty (Hellmann, 2007).

Second, the successful commercialization of university technology may require the support of other scientists. However, the prior literature suggests that scientists who adhere closely to their institutions may perceive significant barriers to collaboration with other academics such as industry scientists (Sauermann and Stephan, 2013). The coordination of information and communication with other scientists through support programs may help to overcome the misalignment between scientists and facilitate further knowledge development and sharing (Slater and Mohr, 2006). A stock of demand-driven factors is typical of scientists with frequent involvement in programs aiming to establish contacts and agreements with customers, whose research is able to engage both academic and non-academic audiences, and whose work is intended to solve practical problems and address the needs of practitioners (D'Este et al., 2019). Based on these arguments, we therefore hypothesize:

Hypothesis 3c: University support programs will facilitate collaboration with customers and other scientists for academic entrepreneurship.

An alternative measure to provide scientists with access to commercially viable resources is to promote the existence of formal organizational stakeholders like university incubators (O'Shea et al., 2005; Rothaermel and Thursby, 2005). Universities have explored

a number of models of university entrepreneurship incubation, including entrepreneurship centres, university incubators and science parks (Link et al., 2005; 2007; Siegel et al., 2003; 2007; Wright et al., 2008a; Kenney and Patton, 2009; Muscio, 2010) which prepare academic spin-offs to enter markets. In addition to collaboration with IP agencies and TTOs, university incubators serve as an important pillar of knowledge exploration, testing and commercialization (Mian, 1996; Heinzl et al., 2013).

University incubators provide office spaces, training, pitching and meetings with entrepreneurs (Schmitz et al., 2017; Kolympiris and Klein, 2017) that also signal to investors (Guerrero and Urbano, 2014; Guerrero et al., 2016). As outlined by Backes-Gellner and Werner (2007), a central problem in the start-up stage is the availability of financial resources because of the high degree of uncertainty. Moreover, especially innovative new ventures like academic spin-offs face severe problems of asymmetric information due to their lack of prior production history and reputation. While the advantages of university incubation include library access, student resources and internships, creative university environments, it is also an exposure to state-of-the-art research (McAdam et al., 2016). Access to technology mentoring and seed-funding is particularly relevant for technology incubators that provide the uniting technical and venture capital hubs (e.g. Berkley's TechStars, Telefonica) needed to facilitate new venture formation (Mian, 1996). Moreover, the presence of star scientists and engineers brings more equity investors and attracts science and engineering faculty, potentially increasing university spinoff activity in incubators (Di Gregorio and Shane, 2003). We hypothesize:

Hypothesis 3d: University incubators will facilitate collaboration with investors for academic entrepreneurship.

Our conceptual framework illustrating the interplay between the individual characteristics of scientists and organizational and external stakeholders with potential mechanisms of interaction between them is illustrated in Figure 6.1.

Figure 6.2 provides the analytical process behind the mechanisms connecting organizational and external stakeholders and illustrates the hypothesized relationships (H1-H3).

Figure 6.1: Conceptual framework.

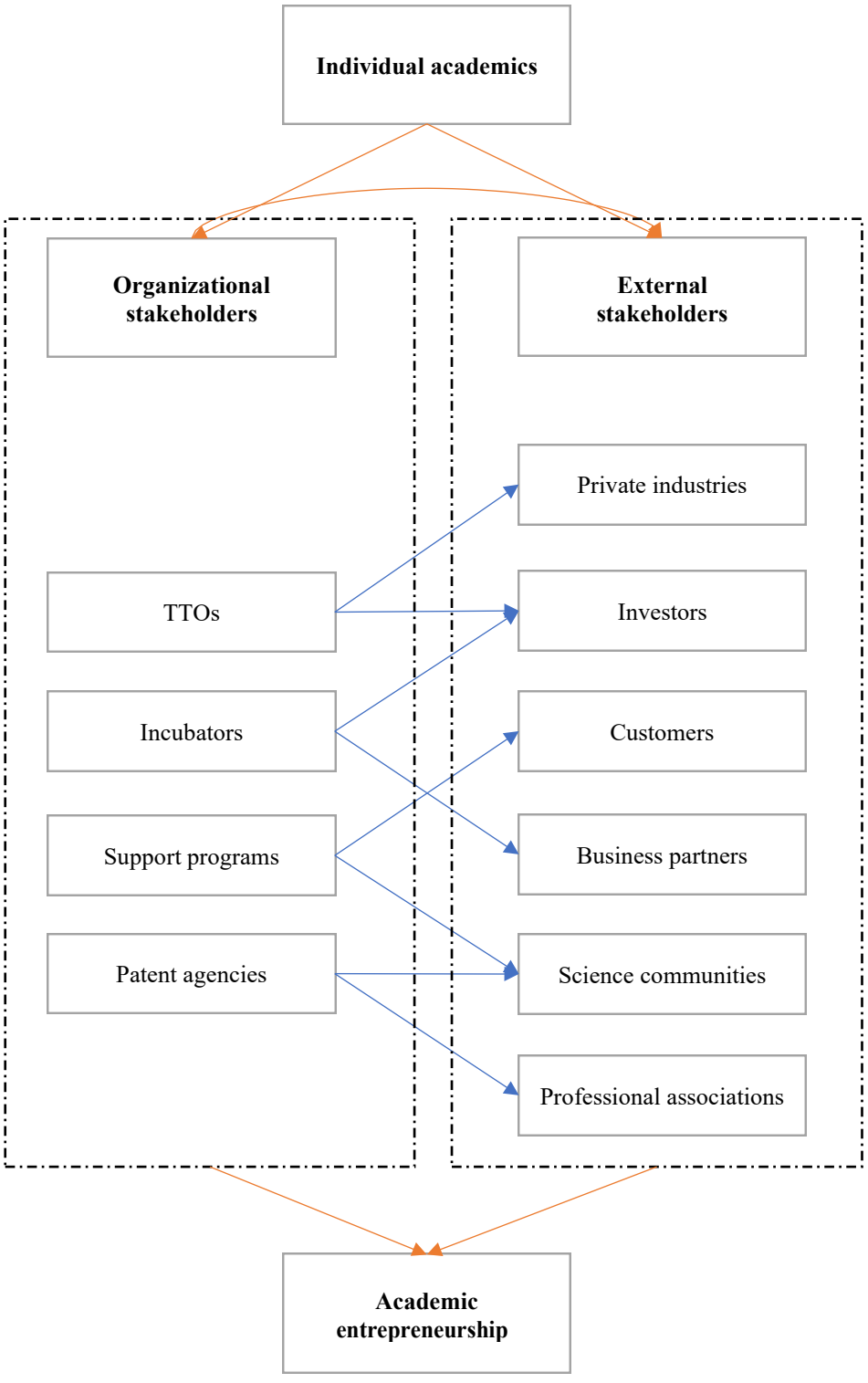
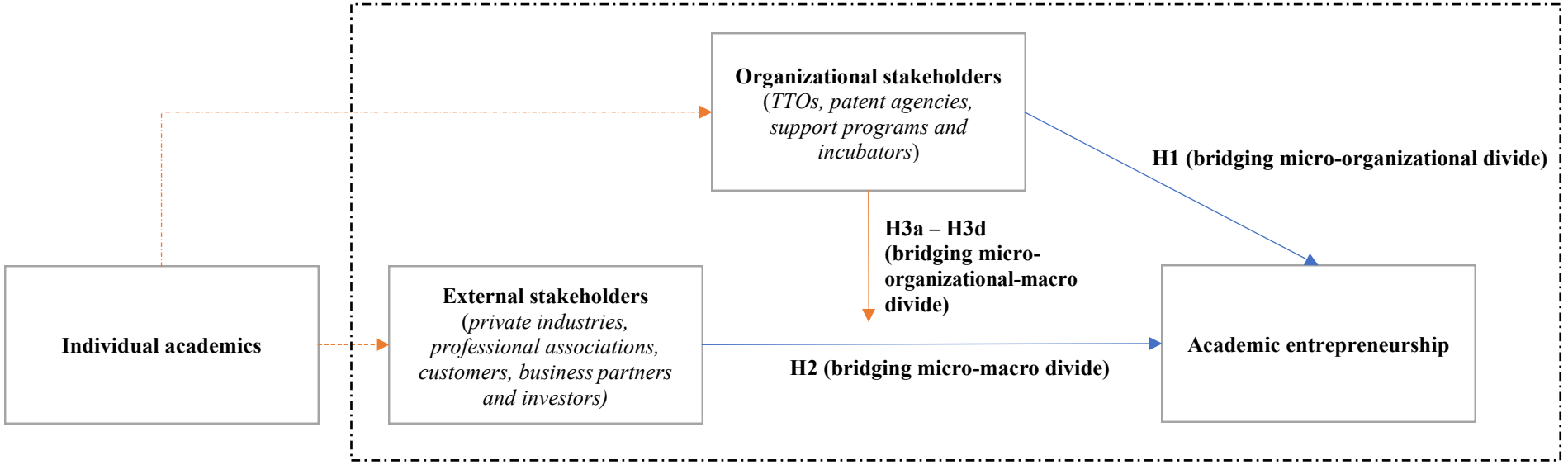


Figure 6.2: Analytical procedure.



6.3 Methodology

6.3.1 Data

Our empirical study is based on data collected in cooperation with the IfM Bonn (Institut für Mittelstandsforschung Bonn) in 2013 and 2016 covering 73 German universities. In the initial survey in 2013, 36,918 scientists from a variety of different types of universities of higher education (research and teaching / universities of applied sciences), faculties (including information and computer science, medicine, engineering and biology) and positions (i.e. from researcher to full professor positions) were questioned. The survey focused on their entrepreneurial propensities and any actions they have undertaken to start new businesses (gestation activities). Responses from 7,342 scientists were received. The scientists who were surveyed in 2013 were then invited to participate in a follow-up survey in 2016. A total of 1,252 completed questionnaire were returned, which corresponds to a response rate of approx. 17%. After excluding those with missing values on start-up activities (e.g. for example those who had abandoned their plans on commercialization), information was available from 826 scientists who were observed between 2013 and 2016 at different stages of start-up activity. We use this sample to empirically test our research hypotheses.

6.3.2 Dependent and explanatory variables

Table 6.1 describes the micro, organizational and macro level variables we use in our regression models with their summary statistics. The first column of Table 6.1 also includes the year (2013 or 2016) where scientist's characteristics were observed.

Table 6.1: Variable descriptions.

Variable (year observed)	Description	Mean	Std. Dev.	Min	Max
Dependent variable:					
Start-up activities (2016)	Dependent variable: Number of activities undertaken to advance a start-up project by university scientists (from zero to 18). Please refer to section 3 for description of each item.	1.476	2.819	0	18
University characteristics:					
Invention at university (2013)	Binary variable=1 if founder has made an invention based on a research project at the university, zero otherwise	.183	.387	0	1
Applied science university (2013)	Binary variable=1 if founder works at university of applied science, zero otherwise	.792	.406	0	1
Faculties:					
STEM (2013)	Binary variable =1 if founder works at the faculty of science, technology, engineering, math (STEM) as well as physics and other natural sciences, zero otherwise	.702	.458	0	1
Economics/ Social science (2013)	Binary variable =1 if founder works at the faculty of economics/ social science, zero otherwise	.145	.353	0	1
Architecture (2013)	Binary variable =1 if founder works at the faculty of architecture, zero otherwise	.006	.078	0	1
Medical technology (2013)	Binary variable =1 if founder works at the faculty of medicine/ health management, zero otherwise	.017	.129	0	1
Arts (2013)	Binary variable =1 if founder works at the faculty of Music, design, art, zero otherwise	.011	.104	0	1
Positions:					
Professor (2013)	Binary variable =1 if founder is a full professor, zero otherwise	.149	.356	0	1
Assistant professor (2013)	Binary variable =1 if founder is an assistant professor, zero otherwise	.179	.384	0	1
Research assistant (2013)	Binary variable =1 if founder is a research assistant, zero otherwise	.551	.498	0	1
Individual characteristics:					
Age (2013)	Metric variable. Please state your age	36.929	10.309	23	65
Gender (2013)	Binary variable =1 if founder male and zero if the founder is female	.323	.468	0	1
Migration background (2013)	Binary variable =1 if founder has been migrated from another country; zero otherwise	.086	.280	0	1

(Table continues on the next page)

Table 6.1 Variable descriptions. (continued)

Start-up experience (2013)	Binary variable =1 if founder has ever been self-employed/freelance, zero otherwise	.183	.387	0	1
Risk-taking willingness (2013)	Are you generally a risk-averse person or do you try to avoid risks? (from 1 to 5): 1= low risk-taking propensity; 5= high risk-taking propensity	2.686	.990	1	5
Entrepreneurial cognition (entrepreneurial self-efficacy) (2016)	Please indicate to what extent you agree with the following statements: 1) I have the capability to establish my own firm. 2) I have faith that the launching of my own firm will be a success. 3) I have all the necessary knowledge to start my own firm. 4) I have the entrepreneurial skills to start my own firm. (1 - strongly disagree; 5 strongly agree)	2.946	1.033	1	5
Entrepreneurial orientation (attitude towards science) (2016)	Please indicate to what extent you agree with the following statements: 1) Science and entrepreneurship are not compatible. 2) Knowledge should not be commercialized 3) Knowledge transfer between science and industry leads to social prosperity. 4) In my faculty, entrepreneurial self-employment is not welcomed. 5) In academia, Publication has a higher recognition than the commercialization of knowledge. (1 - strongly disagree; 5 strongly agree)	2.500	.639	1	5
Entrepreneurial obstacles:					
Fear of failure (2016)	What prevented you from further advancing your start-up project: The risk of failing as an entrepreneur is too high (1 - strongly disagree; 5 strongly agree)	3.530	1.332	1	5
Lack of material resources (2016)	What prevent you from further advancing your start-up project? I do not have enough financial resources (1 - strongly disagree; 5 strongly agree)	3.450	.964	1	5
Lack of support (2016)	What prevent you from further advancing your start-up project? I do not have enough support from the private industry (1 - strongly disagree; 5 strongly agree)	3.491	1.171	1	5
Lack of time (2016)	What prevent you from further advancing your start-up project? I do not have enough time to further advance my founding plans (1 - strongly disagree; 5 strongly agree)	2.685	1.198	1	5

(Table continues on the next page)

Table 6.1 Variable descriptions. (continued)

Organizational stakeholders:					
TTO (2013)	Binary variable =1 if founders have attended start-up promotion offers by a TTO and were satisfied with them, zero otherwise	.048	.215	0	1
Patent agency (2013)	Binary variable =1 if founders have attended start-up promotion offers by patent agencies and were satisfied with them, zero otherwise	.031	.175	0	1
Support programs (2013)	Binary variable =1 if founders have attended support programs by the university and were satisfied with them, zero otherwise	.056	.229	0	1
Incubator (2013)	Binary variable =1 if founders have attended start-up promotion offers by start-up incubators and were satisfied with them, zero otherwise	.065	.247	0	1
External collaborators (stakeholders):					
Private industry (2013)	Binary variable =1 if an academic has contacts with contacts in private industry which are helpful for the implementation of the project, zero otherwise	.177	.382	0	1
Other scientists (2013)	Binary variable =1 if an academic has contacts with scientific community at her own university or another university (institution) which are helpful for the implementation of the project, zero otherwise	.150	.357	0	1
Associations (2013)	Binary variable =1 if an academic has contacts with professional and industry associations which are helpful for the implementation of the project, zero otherwise	.123	.329	0	1
Customers (2013)	Binary variable =1 if an academic has contacts with potential customers, which are helpful for the implementation of the project, zero otherwise	.067	.249	0	1
Business partners (2013)	Binary variable =1 if an academic has contacts with potential Business partners (e.g. suppliers or service providers), which are helpful for the implementation of the project, zero otherwise, which are helpful for the implementation of the project, zero otherwise	.119	.324	0	1
Investors (2013)	Binary variable =1 if an academic has contacts with capital investors, which are helpful for the implementation of the project, zero otherwise	.139	.346	0	1

Source: Individual scientist data collected by Institut für Mittelstandsforschung (2013-2017)

We measure academic entrepreneurship by an extent to which start-up project has been advanced in 2016. Specifically, the advancement of a start-up project can include one or more out of eighteen related start-up gestation activities we have information about. These are: *(1) scientists have a specific founding idea; (2) scientists have reserved money for implementation of my founding idea; (3) scientists have negotiated with outside creditors and/or inside investors; (4) scientists have invested their own money in implementation of their founding idea; (5) scientists have started with the product or service development; (6) scientists have built a prototype/ further developed the company offer; (7) scientists have recruited a co-founder/ funding team; (8) scientists have developed a business plan; (9) scientists have collected information about markets and competitors; (10) scientists have purchased/leased equipment/materials/rooms; (11) scientists have set a date for establishment; (12) scientists have taken care of the exploitation rights; (13) scientists have registered at the at the tax office; (14) scientists have started advertising campaigns and marketing; (15) scientists have met potential customers; (16) scientists have accepted first orders; (17) scientists have acquired/ contacted important business partners; (18) scientists have used start-up supports inside and outside the university.*

Although there is a spectrum of activities, associated with a different degree of exploration or exploitation of start-up project steps, we constructed an additive index score measure by adding score one for each step undertaken by scientist (zero otherwise) with a minimum number of steps equal to zero and a maximum number of steps equals to 18. Thus, our dependent variable is the overall index which ranges between zero and 18. As part of a robustness check, please note that we excluded items 17 and 18 from the dependent variable because of potential endogeneity issues with the independent variables.[8]

Our first group of explanatory variables include the following collaborations with organizational stakeholders who aim to provide support on how to commercialize academic research. Such support was offered within TTOs, patent agency, support programs and university incubators between 2013 and 2016. We therefore created a set of binary variables which equal "1" if the scientists have participated in such a stakeholder events (TTO, patent agency, support programs and incubator activity) and found that the information provided by the organizational stakeholder was useful, zero otherwise. Our second group of

[8] Specifically, when estimating regression models with either dependent variable (16 and 18 items), our results remain robust, i.e., the coefficient signs and confidence interval have not changed.

explanatory variables include the following external (environmental) stakeholders: private industry, scientific community at scientist's own university or another university, professional and industry associations, potential customers and capital investors. Again, we generated a set of binary variables for each external partner which equals "1" should scientist have these contacts with external partners, zero otherwise. In order to test H3a-H3c, we included interaction terms reflecting different combinations of collaboration of scientists with our organizational and external stakeholders. All thing equal, we expect the number of activities to be higher if the scientists collaborate with different stakeholder types – reflected in positive interaction effects.

In addition to our explanatory variables and in line with prior research (McAdam et al. 2016), we included a rich set of control variables. The scientist's *field of specialization* (e.g. STEM, biology, social sciences, etc.) was included because prior studies have demonstrated that scientists from biomedical and engineering faculties have a higher spin-off creation (Zucker et al., 2002; Gittelman and Kogut, 2003; O'Shea et al., 2005; Abreu et al., 2016). We also control for scientist's perception of *entrepreneurial constraints* such as fear of failure, lack of financial resources (Wright et al., 2003) and entrepreneurial knowledge, time constraints. These variables have shown to affect the creation of spin-offs (Markman et al., 2005; 2009; Agarwal and Shah 2014).

Additionally, entrepreneurial challenges affect the perceptions of legitimization of the novel opportunities (Busenitz et al., 2000). For example, *risk-aversion*, *confidence in entrepreneurial skills* and *time availability to start a business* are positively associated with new business start-ups (Arenius and Minniti, 2005). Together, the scientist's perception of opportunities and challenges will influence the recognition and exploitation of entrepreneurial opportunities (Shane, 2000) as well as the combination of activities that a scientist will choose to pursue to start a business. Finally, we control for the scientists' age, gender, migration background, position, start-up experience, entrepreneurial cognition and orientation (Aldridge and Audretsch, 2010). Migration background of scientists has attracted attention in entrepreneurship cognition and commercialization research (Siegel and Waldman, 2019). Table 6.2 presents a table of correlation between the variables used in this study. Note that the correlation between the explanatory variables is of only moderate size. Moreover, the variance inflation factors for all variables are less than 10. Thus, multicollinearity should not be an issue.

Table 6.2: Table of correlation**.**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
DV_1: Degree of start-up project advancem	1.00																																	
TTO	.14	1.00																																
Patent agency	.16	.57	1.00																															
Support programs	.14	.49	.41	1.00																														
Incubator	.13	.56	.35	.53	1.00																													
Private environment	.25	.06	.01	.05	.12	1.00																												
Other scientists	.27	.21	.14	.22	.25	.48	1.00																											
Associations	.25	.19	.12	.21	.18	.37	.65	1.00																										
Customers	.18	.10	.04	.06	.17	.31	.28	.33	1.00																									
Business partners	.32	.16	.11	.16	.22	.43	.40	.42	.49	1.00																								
Investors	.30	.22	.15	.22	.22	.43	.47	.39	.41	.61	1.00																							
University type	-.01	-.04	.06	-.02	.03	-.06	.01	.01	-.05	-.12	-.09	1.00																						
F_MINT	-.05	.02	.01	.02	.00	-.12	-.05	-.05	-.12	-.15	-.08	.20	1.00																					
F_Economics/ Social science	.04	.02	.00	.03	.06	.12	.01	.03	.14	.14	.07	-.07	-.63	1.00																				
F_Architecture	.09	-.02	-.01	-.02	-.02	.05	.05	.02	-.02	.02	.06	-.11	-.12	-.03	1.00																			
F_Medical technology	-.02	.06	.08	.01	.00	.01	.00	-.02	.04	.04	.03	-.05	-.20	-.05	-.01	1.00																		
F_Arts	-.01	-.02	-.02	-.03	-.03	-.05	-.01	-.04	-.03	-.04	-.04	.03	-.16	-.04	-.01	-.01	1.00																	
F_Others	.01	-.07	-.04	-.06	-.05	.04	.06	.04	.02	.05	.03	-.17	-.56	-.15	-.03	-.05	-.04	1.00																
Pos_Professor	.13	.27	.16	.12	.15	.07	.06	.14	.20	.18	.13	-.36	-.05	.08	-.03	.02	-.01	-.01	1.00															
Pos_Assistent professor	.00	-.05	-.01	-.02	-.03	-.05	-.03	.00	.00	-.01	-.02	.21	.09	-.06	-.04	-.04	-.02	-.03	-.20	1.00														
Pos_Research assistent	-.05	-.14	-.10	-.04	-.04	.00	.01	-.07	-.15	-.11	-.04	.21	.00	.03	.01	-.03	.02	-.04	-.46	-.52	1.00													
Pos_Others	-.06	-.03	.00	-.06	-.07	-.02	-.05	-.05	.01	-.02	-.04	-.18	-.05	-.07	.07	.07	.00	.10	-.16	-.17	-.41	1.00												
Gender (1=Male, 0=Female)	-.14	-.12	-.05	-.07	-.07	-.04	-.11	-.13	-.05	-.09	-.09	.00	-.10	.02	.05	.09	.00	.07	-.13	-.05	.07	.09	1.00											
Age	.05	.23	.12	.11	.11	.06	.04	.11	.18	.13	.08	-.34	-.04	-.04	-.01	.07	.08	.06	.53	.05	-.53	.17	-.14	1.00										
Migration background (1=Yes, 0=No)	.04	-.01	-.03	.02	.01	.07	.00	.04	.09	.01	.04	.05	.05	-.04	-.02	.03	-.03	-.02	-.04	.00	.03	-.01	-.02	-.06	1.00									
Risk taking willingness	.23	.11	.09	.06	.08	.20	.13	.18	.13	.19	.17	.01	-.04	.10	-.01	-.02	-.04	-.03	.16	.04	-.08	-.10	-.12	.09	.08	1.00								
Self efficacy	.32	.05	.06	.10	.11	.26	.24	.21	.20	.25	.24	-.07	-.22	.25	.06	-.04	-.01	.04	.10	-.04	.04	-.13	-.13	.00	.08	.43	1.00							
Attitude towards science	-.13	-.08	-.06	-.11	-.08	.00	-.02	-.07	-.05	-.10	-.11	.04	.03	-.11	-.01	.08	.07	.03	-.08	.06	-.05	.08	.06	.00	-.03	-.11	-.19	1.00						
Invention at university (1=Yes, 0=No)	.19	.16	.15	.06	.04	.01	.11	.16	.07	.11	.17	.06	.16	-.16	-.04	-.01	-.02	-.04	.11	.10	-.11	-.06	-.18	.15	.04	.14	.07	-.10	1.00					
Start-up experience (1= yes; 0= no)	.12	.08	.00	.09	.07	.13	.10	.06	.13	.09	.15	-.17	-.17	.13	.12	.01	.04	.05	.16	.03	-.16	.03	-.03	.24	-.03	.13	.23	.01	.00	1.00				
Obst1_Fear of failure	-.21	-.07	-.09	-.10	-.11	-.16	-.12	-.11	-.10	-.15	-.19	.02	.08	-.13	-.03	-.06	.02	.05	-.16	-.04	.08	.10	.14	-.11	-.09	-.37	-.40	.13	-.06	-.14	1.00			
Obst2_Lack of material resources	-.16	-.02	-.06	-.05	-.05	-.16	-.03	-.04	-.12	-.19	-.11	.07	.21	-.30	.01	-.07	.04	.04	-.18	.01	.08	.07	.10	-.11	-.02	-.30	-.43	.12	.03	-.19	.49	1.00		
Obst3_Lack of support	-.43	-.08	-.06	-.14	-.13	-.21	-.18	-.18	-.17	-.25	-.28	.03	.08	-.09	-.10	-.03	.01	.02	-.13	.01	.05	.05	.13	-.11	-.10	-.37	-.52	.17	-.08	-.19	.47	.46	1.00	
Obst4_Lack of time	-.04	.04	.00	-.04	-.06	-.05	.02	.04	-.05	-.08	-.05	.03	.10	-.16	.00	-.06	.01	.05	-.04	-.01	.03	.01	-.04	.02	.01	-.13	-.20	.05	.06	-.06	.32	.52	.23	1.00

Note: N= 826

6.3.3 Analysis

As mentioned above, we use two waves of panel data consisting of scientists (founders) who were initially surveyed in 2013 and then again in 2016. In this time frame, these individuals had to decide how much research to commercialize and, consequently, how many steps to take for a start-up, i.e., our qq^*. This can be modelled the following way: We use qq^* to denote a degree of the start-up project advancement measured on the scale between zero and eighteen. Accordingly, qq^* of each individual i is an (observable) indicator function if individual i has (or reports) any activity undertaken, zero otherwise.

$$qq^*_{iiii} = \alpha\alpha_0 + \sum_{kk=1}^{pp} \beta\beta_{kk} FF_{iiii} + \sum_{ll=1}^{qq} \gamma\gamma_{ll} RR_{ii} + \delta\delta MM_{tt} + \sum_{nn=1}^{ii} \mu\mu_{nn} MM_{iiii} \times RR_{ii} + \sum_{h=1}^{nn} \beta\beta_h CC_{iiii} + ee_{iiii} \quad (1)$$

qq^*_{iiii} is a censored indicator variable such that a scientist (founder) i decides to perform (or to report) any start-up activity and vary between zero activities to a maximum of 18 start-up advancement activities in 2016; FF_{iiii} is our set of explanatory individual characteristics of a scientist (founder) i employed at university j, which affect a start-up decision-making. RR_{ii} is a vector of binary variables equals to one if a scientist (founder) has attended any start-up promotion offers by TTO, patenting agency, support program or university incubator j in 2013 or earlier and was satisfied with it, zero otherwise [9]. MM_{iiii} is a vector of binary variables equal to one if our scientists (founders) have contacts with external stakeholders s (private industry, scientific community at her own university or another university, professional and industry associations, customers and capital investors) between 2013 and 2016, zero otherwise. CC_{iiii} is a vector of control variables related to university type, scientists' professional and individual characteristics which were observed from the survey between 2013 and 2016; $ee_{iiii}$is the error term.

Accordingly, our hypotheses were tested using hierarchical (nested) OLS and TOBIT regression models. That is, we regressed the number of start-up activities on the potential individual, organisational and environmental drivers discussed above with a specific focus on potential interaction effects. We started with the OLS regression as a first test of the hypothesized relationships. However, given the censored nature of our dependent variable (i.e. a large proportion of scientists have taken no steps to found an academic start-up

[9] In the questionnaire, scientists were asked if they attended an event, or are currently attending or plan to attend a startup promotion offer at the university. We only considered scientists who attended or are attending a startup promotion offer in 2013 or earlier.

between 2013 and 2016), Tobit regression models were estimated to mitigate measurement bias (Greene, 2003; Wooldridge, 2002).

First, we calculate a model including only the control variables (Model 1, Table 6.3 and 6.4). In Model 2, we then include the organisational indicators. In Model 3-6 we then include all control variables, organisational variables and interactions between external stakeholder and organizational stakeholders piecewise. Finally, in Model 7 (Table 6.3 and 6.4) we include all variables and interactions.

6.4 Results

Estimations are presented in Table 6.3 (OLS) and Table 6.4 (Tobit). We discuss further results using Tobit estimation. Hypothesis 1 is partly supported: For German scientists, the collaboration with university TTOs is positively associated with start-up project development ($\beta=0.605$, $p<0.10$, Table 6.4 Model 7). Interestingly, the OLS estimation also show a positive and significant effect of collaboration with patent agencies, however the effect disappears once controlled for organizational stakeholders such as TTOs and incubators, with a TTO emerging as the strongest indicator of institutional support in line with a traditional model of knowledge commercialization (Link et al., 2007; Clarysse et al., 2011a; Bradley et al., 2013). Participation in support programs organized in universities is negatively associated with the number of start-up activities. This finding indicates that support programs may be used as substitutes of entrepreneurial action, or it may point to the fact that scientists who participate in such support programs are in more early stages of business creation ($\beta=-0.607$, $p<0.10$, Table 6.4 Model 7).

Contacts with patenting agency per se do not facilitate start-up activities. We believe that this finding reflects a lack of scientist' incentives to commercialize the knowledge in the market. As noted above, in Germany intellectual property rights are owned by the universities who participate from commercialization of university knowledge transfer. The scientists' invention is a patentable or utility-eligible invention made by an employee as part of his service for the employer (university).

Table 6.3: OLS estimation of academic entrepreneurship.

DV_1: Degree of start-up project advancement	**Model 1** (OLS Regression)			**Model 2** (OLS Regression)			**Model 3** (OLS Regression)			**Model 4** (OLS Regression)			**Model 5** (OLS Regression)			**Model 6** (OLS Regression)			**Model 7** (OLS Regression)		
	Coef.	Std.	P>|t|	Coef.	Std.	P>|t|	Coef.	Std.	P>|t|	Coef.	Std.	P>|t|	Coef.	Std.	P>|t|	Coef.	Std.	P>|t|	Coef.	Std.	P>|t|
Control variables																					
Invention at university	1.000	(.302)	***	.796	(.288)	***	.809	(.294)	***	.839	(.286)	***	.874	(.287)	***	.888	(.290)	***	.849	(.288)	***
Applied science university	.174	(.259)		.115	(.252)		.161	(.249)		.041	(.246)		.148	(.251)		.143	(.240)		.041	(.237)	
Faculties																					
STEM	-.245	(.298)		-.112	(.295)		-.107	(.292)		-.087	(.292)		-.113	(.293)		-.155	(.295)		-.156	(.296)	
Economics/ Social science	-.135	(.366)		-.163	(.357)		-.177	(.355)		-.236	(.353)		-.160	(.356)		-.155	(.357)		-.268	(.362)	
Architecture	1.734	(.718)	**	1.592	(.765)	**	1.634	(.734)	**	1.588	(.770)	**	1.635	(.749)	**	1.644	(.709)	**	1.607	(.719)	**
Medical technology	-.246	(.636)		-.463	(.584)		-.538	(.533)		-.984	(.564)	*	-.215	(.577)		-.207	(.589)		-.841	(.517)	
Arts	-.006	(.630)		.364	(.592)		.367	(.599)		.401	(.604)		.317	(.589)		.300	(.583)		.370	(.602)	
Other fields				…	…		…	…		…	…		…	…		…	…		…	…	
Positions																					
Professor	.722	(.366)	**	.546	(.358)		.448	(.353)		.508	(.351)		.499	(.351)		.478	(.346)		.534	(.346)	
Assistant professor	.030	(.306)		.092	(.296)		.021	(.296)		.032	(.296)		.048	(.299)		.038	(.298)		-.020	(.290)	
Research assistant	-.102	(.246)		-.048	(.246)		-.125	(.243)		-.049	(.241)		-.115	(.244)		-.141	(.244)		-.116	(.240)	
Others position (Associate)				…	…		…	…		…	…		…	…		…	…		…	…	
Individual characteristics																					
Age	-.019	(.011)	*	-.265	(.162)		-.232	(.161)		-.229	(.162)		-.265	(.162)		-.266	(.159)	*	-.216	(.161)	
Gender	-.319	(.164)	*	-.021	(.011)	**	-.022	(.011)	**	-.023	(.010)	**	-.020	(.011)	*	-.021	(.010)	**	-.027	(.010)	***
Migration background	-.066	(.327)		-.021	(.315)		-.002	(.320)		-.021	(.317)		-.065	(.324)		.013	(.318)		.059	(.327)	
Start-up experience	.184	(.276)		.197	(.263)		.184	(.266)		.221	(.259)		.206	(.265)		.212	(.253)		.189	(.253)	
Risk taking willingness	.077	(.097)		.027	(.093)		.014	(.095)		.035	(.093)		.010	(.095)		.001	(.094)		.035	(.090)	
Entrepreneurial cognition	.312	(.112)	***	.200	(.108)	*	.202	(.109)	*	.174	(.108)		.227	(.110)	**	.195	(.107)	*	.152	(.102)	
Entrepreneurial orientation	-.133	(.121)		-.123	(.121)		-.102	(.121)		-.130	(.118)		-.103	(.119)		-.104	(.119)		-.078	(.118)	
Entrepreneurial obstacles																					
Fear of failure	.020	(.090)		.029	(.086)		.008	(.084)		.012	(.083)		.012	(.083)		.019	(.084)		.016	(.084)	
Lack of material resources	.176	(.124)		.169	(.120)		.122	(.120)		.155	(.119)		.133	(.119)		.151	(.120)		.142	(.116)	
Lack of entrepreneurial knowledge	-.875	(.103)	***	-.797	(.102)	***	-.778	(.100)	***	-.793	(.101)	***	-.765	(.101)	***	-.768	(.100)	***	-.776	(.101)	***
Lack of time	.083	(.081)		.065	(.079)		.088	(.078)		.081	(.077)		.084	(.077)		.055	(.078)		.066	(.077)	
Organizational stakeholders																					
TTO				-.242	(.735)		.166	(.117)											.202	(.153)	
Patent agency				1.666	(.917)	*				.262	(.120)	**							.166	(.135)	
Support programs				.146	(.550)								.075	(.102)					-.224	(.106)	**
Incubator				-.125	(.603)											.012	(.092)		.062	(.157)	

(Table continues on the next page)

Table 6.3: OLS estimation of academic entrepreneurship. (continued)

External collaborators																				
Private industry				.502	(.345)		.209	(.143)		.212	(.139)		.157	(.149)		.180	(.147)		.195	(.146)	
Other scientists				.389	(.470)		.128	(.177)		.234	(.171)		.165	(.180)		.118	(.178)		.225	(.175)	
Professional (Associations)				.243	(.540)		.159	(.188)		.041	(.181)		.157	(.193)		.252	(.188)		.160	(.187)	
Customers				-.210	(.581)		-.069	(.166)		-.015	(.158)		-.104	(.166)		-.101	(.167)		-.060	(.167)	
Business partners				1.250	(.474)	***	.418	(.186)	**	.410	(.175)	**	.457	(.185)	**	.352	(.191)	*	.305	(.189)	
Investors				.064	(.422)		.068	(.170)		-.007	(.162)		.046	(.168)		.069	(.176)		.078	(.170)	
Interactions:																				
TTO x Private industry							.247	(.184)											.416	(.150)	***
TTO x Other scientists							.063	(.181)											-.384	(.179)	
TTO x Associations							-.267	(.164)											.210	(.161)	
TTO x Customers							-.149	(.147)											-.390	(.169)	**
TTO x Business partners							.125	(.157)											.027	(.154)	
TTO x Investors							.062	(.121)											.287	(.167)	*
Patent agency x Private industry										.067	(.118)								-.196	(.131)	
Patent agency x Other scientists										.819	(.225)	***							1.075	(.182)	***
Patent agency x Associations										-.792	(.181)	***							-.846	(.140)	***
Patent agency x Customers										.283	(.108)	***							.562	(.165)	***
Patent agency x Business partners										-.281	(.126)	**							-.527	(.138)	***
Patent agency x Investors										-.011	(.148)								-.099	(.146)	
Support Programs x Private industry													.213	(.126)	*				-.119	(.103)	
Support Programs x Other scientists													.051	(.149)					-.057	(.121)	
Support Programs x Associations													-.136	(.135)					.130	(.095)	
Support Programs x Customers													.044	(.120)					.423	(.164)	**
Support Programs x Business partners													.039	(.127)					-.243	(.128)	*
Support Programs x Investors													.064	(.125)					-.335	(.155)	**
Incubator x Private industry																.184	(.104)	*	.123	(.112)	
Incubator x Other scientists																-.002	(.120)		.118	(.152)	
Incubator x Associations																-.288	(.123)	**	-.480	(.136)	***
Incubator x Customers																-.123	(.117)		-.450	(.118)	***
Incubator x Business partners																.309	(.099)	***	.604	(.132)	***
Incubator x Investors																.107	(.098)		.352	(.141)	**
Constant	3.415	(1.009)	***	3.302	(1.007)	***	3.918	(1.005)	***	4.006	(.996)	***	3.679	(1.010)	***	3.837	(.962)	***	4.191	(.948)	***
N	826			826			826			826			826			826			826		
R^2	.2405			.2940			.3013			.3210			.2983			.3154			.3660		
F	9.52	***		7.39	***		7.21	***		8.29	***		7.84	***		8.63	***		11.84	***	

Note: Robust standard errors in parentheses. Other fields of research are a reference category. Other position (Associate) – associate professor is a reference category. * $p \leq .10$, ** $p \leq .05$, *** $p \leq .01$ Source: Authors calculations based on individual scientist data collected by Institut für Mittelstandsforschung (2013-2017)

Table 6.4: Tobit estimation of academic entrepreneurship.

DV_1: Degree of start-up project advancement	**Model 1** (Tobit estimation)			**Model 2** (Tobit estimation)			**Model 3** (Tobit estimation)			**Model 4** (Tobit estimation)			**Model 5** (Tobit estimation)			**Model 6** (Tobit estimation)			**Model 7** (Tobit estimation)		
	Coef.	Std. Err.	P>|t|	Coef.	Std. Err.	P>|t|	Coef.	Std. Err.	P>|t|	Coef.	Std. Err.	P>|t|	Coef.	Std. Err.	P>|t|	Coef.	Std. Err.	P>|t|	Coef.	Std. Err.	P>|t|
Control variables																					
Invention at university	1.750	(.549)	***	1.380	(.543)	**	1.449	(.537)	***	1.452	(.531)	***	1.554	(.537)	***	1.586	(.532)	***	1.539	(.522)	***
Applied science university	.353	(.614)		.254	(.611)		.347	(.606)		.119	(.600)		.293	(.604)		.305	(.599)		.179	(.591)	
Faculties																					
STEM	-.846	(.669)		-.579	(.645)		-.568	(.643)		-.504	(.632)		-.568	(.647)		-.668	(.637)		-.672	(.616)	
Economics/ Social science	-.748	(.840)		-.860	(.815)		-.854	(.813)		-.963	(.799)		-.822	(.814)		-.812	(.804)		-1.000	(.780)	
Architecture	2.256	(2.302)		1.997	(2.207)		2.078	(2.197)		1.964	(2.164)		2.037	(2.205)		2.072	(2.176)		1.941	(2.089)	
Medical technology	-.594	(1.811)		-1.164	(1.777)		-1.277	(1.794)		-2.233	(1.847)		-.655	(1.754)		-.660	(1.728)		-1.888	(1.784)	
Arts	.377	(2.048)		1.135	(1.963)		1.138	(1.956)		1.220	(1.926)		1.042	(1.964)		.957	(1.940)		1.078	(1.862)	
Other fields	…	…		…	…		…	…		…	…		…	…		…	…		…	…	
Positions																					
Professor	1.676	(.908)	*	1.368	(.886)		1.223	(.891)		1.299	(.872)		1.295	(.886)		1.256	(.874)		1.371	(.863)	
Assistant professor	.573	(.861)		.698	(.830)		.559	(.826)		.575	(.815)		.623	(.827)		.608	(.817)		.387	(.800)	
Research assistant	.281	(.775)		.357	(.749)		.220	(.743)		.336	(.734)		.243	(.746)		.229	(.738)		.166	(.719)	
Others position (Associate)	…	…		…	…		…	…		…	…		…	…		…	…		…	…	
Individual characteristics																					
Age	-.064	(.029)	**	-.069	(.028)	**	-.070	(.028)	**	-.071	(.028)	**	-.067	(.028)	**	-.066	(.028)	**	-.083	(.027)	***
Gender	-1.179	(.495)	**	-.996	(.478)	**	-.927	(.475)	*	-.937	(.469)	**	-.976	(.477)	**	-.989	(.473)	**	-.856	(.457)	*
Migration background	.118	(.715)		.076	(.698)		.097	(.697)		.056	(.685)		.020	(.699)		.091	(.692)		.159	(.672)	
Start-up experience	1.057	(.548)	*	1.020	(.536)	*	.962	(.538)	*	1.038	(.526)	**	1.018	(.538)	*	.967	(.530)	*	.931	(.521)	*
Risk taking willingness	.177	(.248)		.056	(.241)		.027	(.240)		.065	(.236)		.031	(.243)		.005	(.239)		.084	(.234)	
Entrepreneurial cognition	.888	(.271)	***	.611	(.265)	**	.620	(.265)	**	.567	(.261)	**	.637	(.266)	**	.589	(.262)	**	.503	(.256)	**
Entrepreneurial orientation	-.198	(.358)		-.170	(.346)		-.108	(.345)		-.186	(.340)		-.125	(.347)		-.131	(.342)		-.080	(.334)	
Entrepreneurial obstacles																					
Fear of failure	.004	(.193)		-.003	(.187)		-.042	(.187)		-.032	(.184)		-.032	(.188)		-.015	(.186)		-.023	(.181)	
Lack of material resources	.671	(.315)	**	.652	(.308)	**	.570	(.307)	*	.594	(.303)	*	.609	(.307)	**	.628	(.304)	**	.529	(.299)	*
Lack of entrepreneurial knowledge	-2.354	(.242)	***	-2.200	(.236)	***	-2.161	(.234)	***	-2.170	(.231)	***	-2.156	(.235)	***	-2.143	(.232)	***	-2.084	(.224)	***
Lack of time	.252	(.215)		.232	(.207)		.271	(.206)		.266	(.203)		.254	(.207)		.194	(.205)		.222	(.201)	
Organizational stakeholders																					
TTO				.078	(1.215)		.271	(.253)											.605	(.346)	*
Patent agency				2.178	(1.328)					.401	(.249)								.093	(.316)	
Support programs				.007	(1.033)								.024	(.257)					-.607	(.321)	*
Incubator				-.286	(.981)											-.098	(.259)		-.077	(.329)	

(Table continues on the next page)

Table 6.4: Tobit estimation of academic entrepreneurship. (continued)

External collaborators																		
Private industry			1.588	(.582)	***	.669	(.243)	***	.638	(.238)	***	(.250)	.016	.659	(.242)	***	.582	(.242)	**
Other scientists			.584	(.735)		.163	(.279)		.306	(.275)		(.282)	.370	.188	(.279)		.344	(.278)	
Professional (Associations)			.658	(.743)		.331	(.267)		.206	(.263)		(.272)	.245	.423	(.267)		.259	(.271)	
Customers			-.005	(.852)		.010	(.244)		.063	(.237)		(.245)	.784	-.007	(.245)		.019	(.243)	
Business partners			1.775	(.763)	**	.574	(.303)	*	.576	(.290)	**	(.303)	.041	.476	(.305)		.410	(.303)	
Investors			-.308	(.724)		-.028	(.288)		-.141	(.278)		(.291)	.778	-.068	(.287)		.049	(.288)	
Interactions:																		
TTO x Private industry						.310	(.220)										.781	(.399)	*
TTO x Other scientists						-.099	(.253)										-.911	(.402)	**
TTO x Associations						-.240	(.204)										.439	(.343)	
TTO x Customers						-.267	(.186)										-.460	(.379)	
TTO x Business partners						.274	(.196)										.171	(.344)	
TTO x Investors						.059	(.192)										.513	(.319)	
Patent agency x Private industry									.043	(.234)							-.353	(.338)	
Patent agency x Other scientists									.901	(.346)	***						1.591	(.454)	***
Patent agency x Associations									-.968	(.308)	***						-1.260	(.393)	***
Patent agency x Customers									.299	(.222)							.703	(.379)	*
Patent agency x Business partners									-.311	(.259)							-1.027	(.404)	**
Patent agency x Investors									-.019	(.217)							-.008	(.271)	
Support Programs x Private industry												.235	(.176)				-.206	(.307)	
Support Programs x Other scientists												-.028	(.211)				-.218	(.382)	
Support Programs x Associations												-.093	(.187)				.449	(.324)	
Support Programs x Customers												.035	(.172)				1.055	(.372)	***
Support Programs x Business partners												.154	(.197)				-.365	(.349)	
Support Programs x Investors												.065	(.190)				-.844	(.354)	**
Incubator x Private industry														.154	(.192)		-.131	(.290)	
Incubator x Other scientists														-.102	(.223)		.363	(.369)	
Incubator x Associations														-.302	(.191)		-.926	(.374)	**
Incubator x Customers														-.238	(.160)		-1.196	(.410)	***
Incubator x Business partners														.492	(.198)	**	1.122	(.355)	***
Incubator x Investors														.207	(.195)		.856	(.336)	**
Constant	2.618	(2.526)		2.805	(2.471)		3.841	(2.470)		4.176	(2.423)	*	3.504	(2.460)		3.769	(2.437)		4.694	(2.377)	**
N	826			826			826			826			826			826			826		
Pseudo R^2	.1015			.1173			.1189			.1216			.1178			.1217			.1348		
LR chi2	253.99	***		293.69	***		297.47	***		304.41	***		294.95	***		304.56	***		337.40	***	

Note: Robust standard errors in parentheses. Other fields of research are a reference category. Other position (Associate) – associate professor is a reference category. * p ≤.10, ** p ≤ .05, *** p ≤ .01 Source: Authors calculations based on individual scientist data collected by Institut für Mittelstandsforschung (2013-2017)

According to the Law on Employee Inventions, the employer is in principle entitled to the rights to the service invention, whereas the employee only has a compensatory right to compensation. Special provisions also apply after the abolition of the so-called university teacher's privilege for the inventions of employees at a university. The law also regulates the treatment of such creative achievements of workers who are not protected by a patent or a utility model or otherwise eligible for intellectual property but who improve the performance of a company ("technical improvement proposals") (Bartenbach and Volz, 2019).

We also find some support for hypothesis 2. However, this support is limited to the effect of private industry on start-up activity (β=0.582, $p<0.05$, Table 6.4, Model 7). The private industry such as contacts with private firms, industry and capital investors is the most advanced way of a direct engagement of scientists in commercialization (Wright et al., 2006). Some scholars (Di Gregorio and Shane, 2003; O'Shea et al., 2005) find a positive correlation between availability of venture capital in the university area and venture creation by universities. Surprisingly, we find that the private industry effect on start-up activity dominates all other external stakeholders' effects. The results however confirm Clarysse and Moray (2004), Clarysse et al. (2014) and Miller et al. (2014) that knowledge spill-over of academic entrepreneurship to industry is affected by the environmental context, including the opportunities offered by the local industrial sector and private companies (O'Shea et al., 2005).

Our findings support H3a which states that university TTO facilitates collaboration with private industry for academic entrepreneurship for the private industry (β=0.781, $p<0.10$, Table 6.4, Model 7) (Siegel and Wright, 2015). However, we do not find empirical evidence that TTO is an efficient conduit for external capital investors to facilitate start-up activity in German universities (β=0.513, $p>0.10$, Table 6.4, Model 7). This brings us to the literature on challenges related to the "red tape" of TTOs at universities (Siegel et al., 2003; Kolympiris and Klein, 2017), i.e., after .having secured the capital investor, the role of a TTO is likely to be diminished.

Surprisingly, we also do not find TTOs in German universities facilitating commercialization activity based on potential customers and professional associations' contacts. This does not look like an issue of the TTO itself as also other intermediaries such as patent agencies and incubators do not directly affect the scientist's start-up activities. Although, there has been some criticism on the efficacy of TTOs in facilitating university-industry linkages (Siegel et al., 2003; 2007; Kenney and Patton, 2009; Markman et al., 2009),

our finding demonstrate that TTOs in German universities in fact facilitate university-industry linkages to help researchers build stronger ties with industry partners, but this does not work with securing contacts with professional associations (Rasmussen et al., 2011). It may be the case that industry and professional associations in Germany are a club-like societies aiming at networking and establishing contacts between various members, including industry and academics. That is, once the contact has been established it will move towards "private industry" contacts which has positive and significant effect supporting H3a. Finally, and rather surprising, we find negative coefficients of TTO and contacts with scientists at university and other universities (scientific community) (β=-0.911, $p<0.05$, Table 6.4, Model 7).

Given that contacts with scientists are likely to be around basic (highly theoretical study with limited applicability, e.g. Newton laws of motion) than applied research, it limits the mechanisms of the knowledge spill-over. The most straightforward route is patenting an invention and later licensing it to industry; however, this will have no effect on scientist's start-up intentions and activity. While TTO leaders may not be able to distinguish between basic and applied knowledge (Audretsch, 2014) and hence they are limited in what help they can offer to commercialize research through TTO route. A TTO needs to learn how to spill over both basic and scientific knowledge and to embed the scientific collaborations (Meyer, 2003).

Our H3b which states that patent agencies will facilitate collaboration with scientists and professional associations for academic entrepreneurship is partly supported. Scientists who collaborate with patent agency and other scientists will have higher start-up activity (β=1.591, $p<0.01$, Table 6.4, Model 7). The interaction coefficient of collaboration with patent agency and contacts with professional association is negative (β=-1.260, $p<0.01$, Table 6.3, Model 7). The result is surprising but understandable and is rooted in the nature and a mission of professional networks as well as scientist's motivation to participate in such networks.

Collaboration between scientists involved in professional networks and association does not target direct commercialization of research, rather than expanding existing professional networks, meeting practitioners, looking for new ways of applicability of the basic research developed within a university. In addition, contacts in professional associations may be an indicator of a scientists aiming to switch its career to working for industry. Legal protection of inventions by members of professional societies are rare

(Fosfuri et al., 2012). Scientists which join professional communities may be limited in appropriation of knowledge and the extent they can own and protect it, which limits start-up creation and therefore several steps undertaken to launch a business. Joint patents with professional associations are rare (Helmers and Rogers, 2015).

Our H3c is partly supported as university support programs facilitate collaboration with customers and lead to more start-up activities (β=1.055, $p<0.01$, Table 6.4, Model 7), while collaboration with scientists and participating in support programs decreases start-up activity (β=-0.844, $p<0.05$, Table 6.4, Model 7). Scientists who collaborate with other universities and scientific communities aim at co-creating completely new knowledge, rather than re-producing and disseminating existing one. This purely exploratory activity embedded research work is likely to bring scientists together to the support programs. For the same reason as with patenting, knowledge co-created as a result of such collaboration is unique and may not belong to a single researcher or institution to appropriate. The negative sign demonstrates that support programs include scientists who collaborate on a very niche area and who develop mutual relational trust between each other as a result of such programs (Mosey and Wright, 2007).

Finally, H3d is supported. In fact, scientists that are involved in the incubator and collaborate with capital investors will undertake more steps to launch a business (β=0.856, $p<0.05$, Table 6.4, Model 7). In addition, they are more likely to find business partner in the incubator which will also facilitate start-up activity (β=1.122, $p<0.01$, Table 6.4 Model 7) (Di Gregorio and Shane, 2003; O'Link et al., 2015). This is an interesting finding as business incubation results in testing of products, market exit as well as discussion and complementarities between residents as a result new merges are likely to happen. These findings are robust using OLS estimation with the coefficient for capital investors (β=0.352, $p<0.05$, Table 6.3, Model 7) and for business partners is (β=0.604, $p<0.01$, Table 6.3, Model 7). Interesting that the effect of launching business partnership in the incubator is double to what is achieved by investors for start-up activity demonstrates that incubators are an efficient tool for networking in Germany with both co-founders and investors. In addition, collaboration with customers (β=-1.196, $p<0.01$, Table 6.4, Model 7) and professional association (β=-0.926, $p<0.05$, Table 6.4, Model 7), significantly limits start-up activity by founders if they choose to participate in incubator. Very likely the channel is time and delaying product introduction by an extending incubation period rather than working with a customer directly.

Other interesting findings not related to our research hypotheses should be discussed. First, fear of failure of entrepreneurial venture is the one which decreases start-up development by scientists. Second, a lack of support from the private industry for commercialization perceived as an obstacle have not changed the behaviour or scientists on research commercialization. It is entrepreneurial cognition, rather than entrepreneurial orientation (Ireland et al., 2003; Kuratko et al., 2014) which facilitates academic entrepreneurship in German universities.

A type of university (applied or research-based) does not change the number of start-activities, neither entrepreneurship experience as self-employed matters for start-up development at university. Interestingly, this demonstrates that academic entrepreneurship is a skill which can be learnt during the academic career, independently whether a scientist has ever experienced doing business or not. Prior research has demonstrated that several industries, such as biological sciences and STEM are more important to licensing activity than other sciences (Thursby and Kemp, 2002). It is also known that areas where inventions are more of applied nature such as engineering have better market opportunities and orientation toward markets in bio-engineering and medical sciences (Aldridge and Audretsch, 2011). In addition, technological advances in biomedical areas, molecular biology, computer technology, and other sciences became increasingly prominent in university research (Geuna and Nesta, 2006; Siegel and Wright, 2015).

We do not find this for German scientists. Our STEM variable is not statistically significant which means that scientists in all fields in German universities are equally likely to commercialize their knowledge by starting a business. This demonstrates that German university system enables knowledge development and successful commercialization across different fields, from economics, arts to physics and health technology.

6.5 Discussion

We provide some insights for managers and policymakers. The empirical evidence supports the co-occurrence of different channels and mechanisms to knowledge commercialization in German universities. Universities oriented to fostering academic entrepreneurship should therefore take account of these heterogeneous channels through differentiated policies and strategies. Incentive structures, TTOs, incubators and support programs to promote academic entrepreneurship should aim to stimulate various combinations of collaboration with customers, private industry, investors and the scientific

community. This is because these external stakeholders can contribute, separately or jointly, to enhancing the exploitation of academic research.

Several important findings have attracted our attention. First, we did not find that TTOs facilitate academic entrepreneurship by being a conduit to capital investors. We explain this is because scientists will not need to liaise with TTO if two conditions hold: scientists appropriate an invention and investors have the capital to bring the product directly to market. A similar result was obtained by Aldridge and Audretsch (2010), who found that 30% of highly productive scientists tend to choose a 'backdoor route' to commercialize their research results.

Our first finding is that university stakeholders such as TTOs may act as bottlenecks rather than facilitators of knowledge spill-over (Siegel et al., 2007; Litan and Mitchell, 2010). TTOs at universities are more likely to capitalize on private industry involvement in the start-up process, as private firms often approach university TTOs or knowledge transfer units (Guerrero et al., 2015). Firms may co-apply for public and private grants together with universities, which makes private firms eligible to cover some of the R&D and technology costs. The role of commercialization units such as university TTOs remains in bridging the micro-macro divide (Aldridge and Audretsch, 2011).

Our second finding was that collaboration with other academic communities and scientists on basic and applied research is beneficial for start-up activity and may be facilitated using the patent agency. Collaboration with other scientists increases the quality of knowledge creation but may also have a risk of free-riding (Wright et al., 2008b). University scientists should be able to protect their inventions via patenting and other legal forms of IP protection so they can exploit their invention further. While patenting remains a post-invention decision of all parties involved, it is often impossible to conclude who owns or co-owns an invention and how the work was distributed. There is the possibility that joint patents protect particularly valuable inventions.

Third, another important finding relates to university incubation programs, most of which aim to become proof of concept centres (POCC) (Gulbranson and Audretsch, 2008). These institutions transform university inventions into commercial applications. To our surprise, we do not find a link between university incubators and scientist's contacts with potential customers and professional associations. First, professional associations serve as incubators of ideas, networks and access to potential investors, with the results

commercialized within professional associations or in corporate incubators. Professional associations are likely to be substitutes for incubators providing technical and mentorship to their members in the marketing of invention, consultancy and IP protection, product validation and looking for investors, that are usually also members of professional associations (e.g. meeting at golf or football clubs). Second, in case of potential customers, it is likely that the product or service has already been developed and what is required is market entry via establishing a firm. Incubation is a pre-start-up and product development stage, when finance and business contacts are required to continue product development. The future of a product may still be ambiguous, and then more time is required to shape the idea, fund product development, create and test prototypes before getting to your prospective customers.

6.6 Conclusion

Entrepreneurial university and knowledge transfer research aim to understand the role that micro, organizational, and macro factors play in academic entrepreneurship. For many scientists, efforts to facilitate collaboration within universities and with academic communities as well as external knowledge collaborators have been limited, which has not helped start-up development (Audretsch, 2014). It remains unclear what conduit (TTO, patent agency, support programs, incubator) should be chosen to facilitate start-up activities in collaboration with private industrial funding, capital investment, customers, business partners and academic and professional communities.

German academia is one of the world's leading engines of technological progress, economic development, and growth in Europe. However, very little is known about the conduit of university knowledge transfer, its channels, financing, and external partners. Our results expand the research agenda in Germany and other developed countries on the role of the individual, organizational and ecosystem contexts for academic entrepreneurship (Agarwal and Shah, 2014). This furthers our understanding of how different types of external stakeholders, along with scientists and universities, can shape an individual's decision to engage in firm creation.

This study adds to academic entrepreneurship and knowledge transfer literature in the following ways. First, this study develops and tests a theoretical model which brings together scientist's characteristics, organizational mechanisms and external stakeholders in supporting academic entrepreneurship across 73 German universities (2013-2016). Second,

this study demonstrates the extent to which organizational structures can serve as direct antecedents to contacts with external stakeholders interested in the results of academic research. Our empirical findings confirm a variety of organizational mechanisms can be employed to maximize returns from external collaborations for start-up activity.

The main limitation of the data is its cross-sectional character and self-reporting on steps in starting a business. Therefore, future research could investigate university and patent office data with focus on using longitudinal data as well as look into new channels of knowledge transfer. The results should be tested across different institutional and cultural environments (e.g. other regions in Europe) and across developing and developed countries. Subsequent studies will focus on investigating start-up development activities at universities by splitting them into exploration-oriented and exploitation-oriented groups, as well as home and foreign market oriented, self-employment or enterprise oriented. They can then test the multilevel model of micro-university-macro characteristics which affect each of the outcome.

7 Conclusion

7.1 Summary and discussion per chapter

Table 7.1: Key findings of the research questions addressed in this thesis.

Chapter	Research question	Key findings
Chapter 2	**RQ 1.1:** *What drives academics to become entrepreneurs?*	- 1) *Micro-level*: intrinsic & extrinsic motivations; human & social capital; demographic & personality traits; psychological & cognitive factors; research type, quality & discipline, 2) *Meso-level*: university characteristics & research orientation; support mechanisms, 3) *Macro-level*: regional & national context
	RQ 1.2: *Which barriers must academics overcome during the venturing process?*	- 1) *Micro-level*: lack of entrepreneurial capabilities, knowledge & resources; fear of failure; attitude towards science, 2) *Meso-level*: lack of entrepreneurial culture & incubation services; bureaucracy; management style, 3) *Macro-level*: regional & national context
	RQ 1.3: *Which factors influence the success of academic spin-offs?*	- 1) *Micro-level*: initial competence endowments; firm strategies, objectives & structures, 2) *Meso-level*: relation with universities; university capabilities, 3) *Macro-level*: regional openness; governmental policies; venture capital support
Chapter 3	**RQ 2.1:** *Which motivating factors play the most significant roles for academic entrepreneurship?*	- Transfer motives (application of research ideas, self-realization, and knowledge & skill utilization) matter most, followed by economic (monetary rewards and necessity motives) and lifestyle motives (work-life balance).
	RQ 2.2: *How do these motivating factors affect the venturing progress of academic entrepreneurship?*	- Self-realization, the desire for application as well as necessity motives affect the venturing progress positively, whereas the desire for better utilization of professional knowledge has a negative effect.
Chapter 4	**RQ 3:** *How do the psychological factors of university scientists affect the extent to which they perceive entrepreneurial obstacles?*	- The perception of entrepreneurial obstacles depends (a) positively on the degree of individual decision paralysis and the attitude towards science and (b) negatively on entrepreneurial self-efficacy and individual risk-taking propensity.
Chapter 5	**RQ 4:** *How do individual working conditions, institutions, and networks affect the likelihood of engaging in entrepreneurial activities (nascent entrepreneurship) amongst academics?*	- 1) Entrepreneurial peers and performance-based monetary incentives have a strong positive effect on the entrepreneurial intentions, 2) little awareness of university support infrastructures among academics, 3) market-related networks have a strong positive effect on entrepreneurial intentions, whereas networks within university do not have any impact.
Chapter 6	**RQ 5:** *How does the interplay between scientists, organizational (university) context and the collaboration between external stakeholders advance academic entrepreneurship?*	- The following combinations of knowledge collaborations would facilitate academic entrepreneurship: 1) TTOs enable collaboration with private industry; 2) patent agencies facilitate collaboration with other scientists and potential customers; 3) university incubators facilitate collaboration with capital investors and develop new business contacts; 4) support programs facilitate collaboration with customers.

Table 7.1 provides a brief overview of the key findings per chapter; the corresponding research questions are also outlined.

7.1.1 Venturing process of academic spin-offs: an overview of determinants (Chapter 2)

Following the basic procedure outlined by Tranfield et al. (2003) for conducting a systematic literature review, Chapter 2 provides a holistic and in-depth exploration of the factors that drive, impede and are critical for the venturing process of ASOs by reviewing 193 relevant articles. The findings reveal that an ASO's venturing process is complex, long-term and dynamic and, involves influencing factors from multiple dimensions (Rasmussen, 2011). With regard to **RQ 1.1** (*What drives academics to become entrepreneurs?*), academics' entrepreneurial intentions and behaviours may be motivated by distinct intrinsic (Puzzle) and extrinsic (Ribbon and Gold) rewards (Lam, 2011). Furthermore, psychological and cognitive factors such as attitude, perceived behavioural control, entrepreneurial self-efficacy, role identity and value orientation could significantly affect academics' entrepreneurial propensity (Krabel and Mueller, 2009; Prodan and Drnovsek, 2010; Prodan and Lam, 2011; Knockaert et al., 2015). Another key determinant is an academic's human and social capital. In addition, research disciplines and types of research also affect the likelihood of academics becoming entrepreneurs.

Meanwhile, given their peculiar nature, the creation of ASOs is also determined by the characteristics and orientation of parent organisations. Universities that focus on applied research and possess prior industry cooperation experiences and traditions have a higher propensity to engage in technology transfer activities (Arvanitis et al., 2008; Fischer et al., 2017). Moreover, some investors consider the reputations and prestige of universities as positive signs of commercial technology potential (Gras et al., 2008). Therefore, a university's status facilitates academic entrepreneurs in acquiring resources and networks to start their businesses by enhancing their credibility in the market (Avnimelech and Feldman, 2015). In addition, favourable entrepreneurial milieus within universities and departments could encourage academics to engage in spin-off creation and other entrepreneurial activities (Hayter, 2011; Huyghe and Knockaert, 2015; Foo et al., 2016; Feola et al., 2019; Rasmussen et al., 2014; Zollo et al., 2017).The existence of well-established university support mechanisms can significantly facilitate the ASO venturing process (Fini et al., 2011).

At the macro-level, variations of performance and intensity in academic entrepreneurship may be attributed to the different levels of regional economic development (Davey et al., 2016), location factors (Van Geenhuizen and Soetanto, 2013; Calcagnini et al., 2016), government support instruments and specific policies (Rasmussen, 2008; Botelho and Almeida, 2010). Specialised government funding programmes with different rationales could help ASOs overcome thresholds encountered during different development phases (Rasmussen and Sørheim, 2012).

With regard to **RQ 1.2** *(Which barriers must academics overcome during the venturing process?),* the review shows that academics with conservative attitudes towards entrepreneurship, such as risk and stress aversion or fear of failure, are less likely to start their own businesses (Maes et al., 2014; Singh Sandhu et al., 2011), particularly for female researchers, who may perceive entrepreneurial obstacles during the spin-off formation phase much more acutely than their counterparts (Abreu and Grinevich, 2017; Ebersberger and Pirhofer, 2011). In addition, homogeneous social network composition was found to be a hurdle to entrepreneurship (Hayter et al., 2017). Moreover, conflicted objectives, internal corporate governance issues and a lack of entrepreneurial competences among the founding teams may disrupt the consistent development of ASOs (Vohora et al., 2004; Zhou et al., 2011; Davey et al., 2016; Neves and Franco, 2016). Regarding barriers at the meso-level, an organisation with weak entrepreneurial culture, infrastructure and support mechanisms would significantly impede the emergence of individual entrepreneurial intentions as well as the further development of ASOs (Botelho and Almeida, 2010; Davey et al., 2016; Zhou et al., 2011; Bhayani, 2015; Neves and Franco, 2016). Furthermore, internal governance issues and management style within a faculty have also been identified as hurdles (Bhayani, 2015). As for the macro-level, a major barrier to effectively commercialising university technologies is the limited availability of private funding sources (Munari et al., 2018). Attracting external venture capital support is considered the most significant challenge with most ASOs, due to the problem of information asymmetries from both the demand and supply sides. In addition, complicated and time-consuming application and granting processes for governmental subsidies also impede the ASO venturing process. Specific regional and country contexts also determine the perception of barriers during the ASO venturing process.

With regard to **RQ 1.3** *(Which factors influence the success of academic spin-offs?)*, the success of ASOs is determined significantly by firms' genetic characteristics, as well as their initial competence endowments. Sufficient and diverse human, social and technological knowledge resource bases are key predictors of ASO success (Clarysse et al., 2011b; Colombo and Piva, 2012; Hayter et al., 2017). The composition and characteristics of the founding and management team are also critical in determining the development paths and successes of ASOs (Knockaert et al., 2011; Visintin and Pittino, 2014). A balanced demographic structure, coupled with heterogeneous and complementary expertise backgrounds, can lead to superior ASO performance in regard to survival rate and growth (Gimmon and Levie, 2010; Hayter, 2013; Fernández-Alles et al., 2015; Nielsen, 2015). Such a founding and management team may also be regarded positively to investors, which would significantly increase the possibility of ASOs obtaining early-stage funding support (Huynh, 2016). With respect to external factors, the successes of ASOs are also influenced by ties with the parent organisation, in terms of intensity, duration and multiplicity (Rasmussen, 2011; Fackler et al., 2016; Huynh, 2016). Furthermore, venture capitalists are critical throughout the venturing process as important financial resource providers as well as valuable resource intermediaries for ASOs (Hayter, 2013; Samila and Sorenson, 2010). Positive evaluations by VCs (venture capitalists) could enhance ASO credibility in the market, facilitating their ability to acquire additional key resources and services for their evolution in later development stages (Chugh et al., 2011; Fernández-Alles et al., 2015).

7.1.2 Micro-level determinants (Chapters 3 and 4)

Chapters 3 and 4 focus on individual academic stakeholders and explore the determinants of the ASO venturing process from two opposing perspectives. Chapter 3 focuses on individual motivations and examines what specific motives drive academics to engage in entrepreneurship, as well as the extent to which these motives influence the venturing processes of ASOs. Building upon the previous literature stream, Chapter 3 classifies academic entrepreneurial motivations into three major dimensions, namely 1) transfer motives (application of research ideas, self-realisation, and knowledge and skill utilisation), 2) economic motives (monetary rewards and necessity motives) and 3) lifestyle motivations (work–life balance), using a comprehensive dataset of 611 academic entrepreneurs from 73 universities in Germany. The findings demonstrate that academics are driven by a variety of motives when deciding to engage in entrepreneurship.

Regarding **RQ2.1** *(Which motivating factors play the most significant roles for academic entrepreneurship?)*, the most important motivating factors are self-realisation, the need for better knowledge and skill utilisation and the desire to apply one's own research ideas. Economic motives are the second most important motive for academics to start a company. Lifestyle motives are relatively less important in promoting academic entrepreneurship. With regard to **RQ 2.2** *(How do these motivating factors affect the venturing progress of academic entrepreneurship?)*, the findings show that both transfer- and economic motives decisively affect the venturing progress of academic entrepreneurship. Specifically, while self-realisation, the need for application and necessity motives positively affect the venturing progress of academic entrepreneurship, the need for better knowledge and skill utilisation impede it.

Several interesting findings must be addressed. Firstly, compared to other types of founders, academic entrepreneurs remain dominated by their role identities when participating in commercialisation activities, which also explains why transfer motives matter most to them. Entrepreneurship is considered a means for pursuing inner realisation, as well as the 'need for utilisation'. Their purpose is to improve society by transferring and disseminating technology (Morales-Gualdrón et al., 2009; Berggren, 2017; Iorio et al., 2017). Moreover, role identities may also explain why monetary motive shows no significant effect amongst academics. Most scientists would consider financial rewards not as their primary goal when engaging in entrepreneurial activities, only as a form of collateral compensation (Lam, 2011; Morales-Gualdrón et al., 2009; Goethner et al., 2012).

Secondly, aligned with the findings of Kirkwood (2009), Chapter 3 indicates that necessity founders tend to make more venturing progress. This could result from the working conditions at German universities. Due to limited or part-time working contracts, scientists must constantly extend or search for new jobs to avoid being unemployed. However, whether this finding is generalisable must still be tested. Regarding lifestyle motive, no significant effect on venturing progress can be explained by the relatively flexible working schedule of scientists; it enables them to manage their time relatively freely, and therefore, the issue of balancing between work and personal life is less of importance for academic entrepreneurs.

Chapter 4 helps to answer the question of why many academic entrepreneurs stop or postpone pursuing their business ideas by focussing on exploring the psychological mechanisms that trigger such avoidance reactions. Building upon three well-known psychological theories, namely the decision conflict theory from Janis and Mann (1977), the

theory of planned behaviour from Ajzen (1991) and institutional theory from Meyer and Rowan (1977). Chapter 4 focuses on the psychological factors of individual decision paralysis, self-efficacy, attitude towards science and risk-taking propensity and analyses how these factors affect the extent of perceived entrepreneurial obstacles.

Using a two-wave dataset of 711 academic entrepreneurs from 73 German universities, the findings show that the extent of perceived entrepreneurial obstacles is strongly determined by the individual psychological factors of the founders. With regard to **RQ 3** *(How do the psychological factors of university scientists affect the extent to which they perceive entrepreneurial obstacles?)*, the results show that the extent of entrepreneurial obstacles perceived are 1) positively associated with the degree of individual decision paralysis and the attitude towards science and 2) negatively associated with entrepreneurial self-efficacy and individual risk-taking propensity.

Scientists are more likely to fall into decision paralysis because of their professional nature. Academics are more rational and analytical than other types of founders, so they are prone to constantly seek more optimal solutions when making decisions. However, no perfect solutions exist in the world, which often causes scientists to doubt themselves and be uncertain. This dilemma consequently leads scientists to decision paralysis, and the degree of entrepreneurial obstacles are perceived more strongly. Similarly, the nature of academia may also explain why attitudes towards science are positively associated with the extent of entrepreneurial obstacles perceived. The 'publish or perish' culture in academia entails that scientists' promotions are primarily measured by the number and quality of their publications (O'Gorman et al., 2008; Wright et al., 2009), since the commercialisation of research results has not yet been widely recognised (Bijedić et al., 2017), it forces scientists to concentrate more on publishing their research than on seeking opportunities to exploit it, and entrepreneurial obstacles are accordingly perceived strongly.

In contrast, the negative effect of entrepreneurial self-efficacy and risk-taking propensity could be explained by the skills and capability of scientists. In general, scientists are experts in their research fields, and they are constantly learning new knowledge and skills over the course of their careers. Meanwhile, they also learn how to better exploit their expertise to start a business. Scientists with high entrepreneurial self-efficacy are consequently more convinced that they can overcome various entrepreneurial obstacles based on their capabilities. However, the risks associated with starting a business are mostly skill related, and people are more willing to take risks only if the outcomes of their decisions

depend upon skills (Macko and Tyszka, 2009). Most academics lack market knowledge or entrepreneurial expertise (Agarwal and Shah, 2014; Van Geenhuizen and Soetanto, 2009). In this situation, they have no control of the outcomes and therefore perceive the entrepreneurial obstacles as greater.

7.1.3 Interplay between micro- and meso-level determinants (Chapter 5)

Chapter 5 focuses on investigating the interplay between micro- and meso-level determinants, in particular, how and to what extent 1) individual working conditions (e.g. peers, working atmosphere, work contract incentives, wage satisfaction), 2) institutions (e.g. technology transfer offices, patent exploitation agencies, chair in entrepreneurship or awards for academic entrepreneurship) and 3) network relationships simultaneously affect the likelihood of engaging in entrepreneurial activities (nascent entrepreneurship) in academia. Using unique data collected from 5,992 academic scientists in 73 German universities, the results show that specific working conditions and institutional offers, as well as most network relationship dimensions, affect the propensity of scientists to start new ventures.

With regard to **RQ 4** *(How do individual working conditions, institutions, and networks affect the likelihood of engaging in entrepreneurial activities (nascent entrepreneurship) amongst academics?)*, firstly, the findings show that entrepreneurial peers and certain performance-based monetary incentives exert a strong positive effect on entrepreneurial intentions. Monetary incentives demonstrate conflicting impacts on entrepreneurial propensity, depending upon their purpose; incentives for research, lecturing and art are beneficial for fostering entrepreneurial propensity, whereas incentives aiming at administrative activities are counterproductive. This finding aligns with the conclusions of previous empirical studies, which confirm that the influence of monetary incentives is always context specific (Antonioli et al., 2016; Hayter, 2011; Lam, 2011; Rizzo, 2015). The results also show that satisfaction with one's current salary has a negative effect on the propensity to become an entrepreneur, which should be considered a push factor. Furthermore, the entrepreneurial propensities and behaviours of academics are strongly affected by their professional peers, particularly those close and visible role models who are engaged in entrepreneurial activities.

Secondly, regarding the impact of specific institutional factors, the results have identified a statistically significant, positive effect of the variety of used services on the entrepreneurial activity of academics. However, although a comprehensive support

infrastructure for start-ups in German academic institutions exists, these services still face the problems of awareness and receptiveness by academics. For example, TTOs show no impact on facilitating the entrepreneurial activities of scientists, which may be explained by the tedious and complicated application procedures and bureaucracy of the institutions. Most scholars, particularly highly productive scientists, choose a 'back-door route' to bypass TTOs and contact directly with external industrial partners or investors to commercialise their research results (Aldridge and Audretsch, 2010; Fini et al., 2009). Hence, the role of university commercialisation units in linking scientists to external stakeholders needs to be reconsidered, and the cooperation mechanisms should be redesigned. Moreover, no evidence could be found in Chapter 5 that attendance at entrepreneurship lectures increases the likelihood of developing on entrepreneurial spirit. However, this does not mean that such lectures exert no impact. Fostering entrepreneurial mindsets amongst academics is equally as important as providing infrastructure and policies. The effects of entrepreneurship education such as basic awareness trainings, cannot be measured immediately, and their impacts or benefits may be observed over a long period (Bijedić, 2013).

Thirdly, network relations have been found to be a key feature in explaining entrepreneurial propensity and behaviour amongst German scientists. Market-related networks strongly correspond with high entrepreneurial intentions, whereas networks within one's own university exert no impact. However, the positive effect of networks on facilitating academic entrepreneurship diminishes as the size of the network reaches a certain degree, which suggests that academics should find the balance between diversity and quality when implementing their social capital. Moreover, prior studies indicate that scientists from biological sciences and STEM disciplines are more likely to engage in licensing activities than their colleagues from other research fields. It is also known that areas where inventions are of a more applied nature, such as engineering, have better market opportunities and orientations towards markets (Aldridge and Audretsch, 2011). However, this STEM variable is not particularly statistically significant, which suggests that scientists from all research fields in German universities are equally likely to start businesses at a university. This is an interesting finding which deserves further investigation.

7.1.4 Bridging divides across various levels (Chapter 6)

Chapter 6 focuses on bridging the micro, meso and macro divide in university knowledge transfer, building upon the endogenous economic growth and the knowledge spill-over of entrepreneurship theory. Chapter 6 develops a multi-level model that explains the interplay between the individual characteristics of scientists, the organisational (university) context and the collaboration between scientists and external stakeholders. Using the dataset collected in cooperation with the IfM Bonn (Institut für Mittelstandsforschung Bonn) in 2013 and 2016 at 73 German universities, 826 scientists from various research disciplines and positions are included in the final sample.

With regard to **RQ 5** *(How does the interplay between scientists, organizational (university) context and the collaboration between external stakeholders advance academic entrepreneurship?)*, the empirical findings confirm that scientists who attend events at university TTOs are more likely to engage in a number of start-up development activities, while the same events organized by patent agencies and university incubators via different support programmes do not affect the scientists' entrepreneurship activities. Moreover, private industry partnerships and contacts with capital investors increase the start-up development activities of scientists in Germany. The findings also reveal that 1) collaborations with external scientists and customers along with activities at patenting agencies; 2) collaborations with business partners and investors, along with incubator activities; 3) collaborations with customers within support programmes, as well as 4) collaborations with private industry and TTOs all have a positive and significant effect on academic entrepreneurship.

Several interesting findings deserve attention. Firstly, TTOs in academic entrepreneurship may act as bottlenecks rather than facilitators. The results reveal no evidence that TTOs can facilitate academic entrepreneurial activities by acting as conduits between scientists and capital investors, which align with several other empirical findings. TTOs face the problems of awareness and receptiveness amongst academics (Huyghe et al., 2016b; Muscio, 2010). Scholars, especially highly productive scientists, tend to choose a 'back-door route' to deliberately bypass TTOs and directly contact with external industrial partners or investors to commercialise their research results (Aldridge and Audretsch, 2010; Fini et al., 2009). However, TTOs might help bridge the micro–macro divide by connecting to private industry. As private firms often contact TTOs and co-apply for public andprivate

grants with universities, this makes private firms eligible to cover some of the R&D and technology expenses during the start-up process (Guerrero et al., 2015).

Secondly, patent agencies advance academic entrepreneurship by facilitating cooperation between scientists and other academic communities and scientists. Collaborating with other scientists helps researchers obtain valuable insights more efficiently and effectively; however, this occurs at the risk of free-rider problems. Patent agencies enable scientists to further exploit their inventions by protecting them via patents and other legal forms of IP protection.

Thirdly, no link between university incubators and scientists' contacts with potential customers and professional associations was identified. This may be explained by, on the one hand, professional associations serving as substitutes for incubators by offering similar functions, such as helping foster ideas, introducing networks and access to potential investors, and providing marketing consultancy, IP protection and, product validation services, while on the other hand, incubation remaining in a pre-start-up stage; thus, the future of an immature technology or prototype may still be blurred. Hence, more time is required to reshape ideas and, test prototypes before introducing them to potential customers.

7.2 Implications for theory and practice

7.2.1 Implications for theory

Each chapter of this dissertation deepens the existing understanding of academic entrepreneurship from a specific perspective. Taking together, this thesis offers various important insights for scholars to further develop possible new theory constructs and quantitative measurements.

Firstly, this thesis contributes to the literature on the intention–action gap and push and pull theory by highlighting that necessity-driven academics often outperform others in academic entrepreneurship (Chapter 3). The findings suggest that push factors such as stability (i.e. limited work contracts and non-tenure positions), the pressure of 'publish or perish', bureaucracy and governance issues may more effectively lead scientists to engage in entrepreneurship. This interesting group of founders provides scholars a new perspective for examining the motivating mechanism by reverse thinking.

Secondly, while existing studies have advanced understanding of which factors drive academics to start their own businesses (e.g., Hayter, 2015a; Iorio et al., 2017; Lam, 2011), a paucity of research has explored why many academics stop or postpone pursuing their entrepreneurial ideas. This thesis sheds more lights on such an avoidance phenomenon by analysing how certain psychological factors affect a scientist's perception of entrepreneurial obstacles, which could trigger avoidance reactions (Chapter 4). Moreover, in terms of theories, most research applies Ajzen's (1991) theory of planned behaviour to explain the entrepreneurial intentions and behaviour of academics. This thesis contributes to the current psychological theories by introducing a new construct (i.e. decision paralysis), to explain the decision-making behaviour of academics. By combining degrees of vigilance and procrastination (Luce, 1998; Janis and Mann, 1977; Mann et al., 1998), how academics perceive obstacles and their decision-making processes can be measured more comprehensively and objectively. Therefore, the construct serves as a new starting point for decision-making research in early-stage ventures. The potential causes and consequences deserve further analysis, for example, regarding the extent to which paralysis tendencies vary between different types of founders or the extent to which the effects of decision paralysis on start-up progress are mediated or moderated by perceived entrepreneurial obstacles or other factors. In addition, if decision paralysis persists, the question of whether it would continue to affect the venturing process at later stages must be explored.

This thesis also contributes to the literature related to female academic entrepreneurship (Chapters 2 and 3). Many scholars have addressed the gender issue regarding differences in intention, behaviour and performance between female and male counterparts. However, some stereotypically feminine traits, such as being relationship-oriented, nurturing and caring, are more important for the success of academic entrepreneurship (Díaz-García and Jiménez-Moreno, 2010). Scholars should therefore consider adopting a more female-oriented view to analyse the potential predictors of entrepreneurship success. Moreover, this dissertation provides evidence that gender differences diminish once individual psychological factors are included (Chapter 4), which suggests that gender effects should not be treated separately; the interaction with other factors can enhance or offset the effects.

Thirdly, this dissertation also provides a methodological contribution by developing a multilevel model to investigate the joint impacts and, interplay between various determinants and stakeholders (i.e. individual, organisational and macro-environmental) in

academic entrepreneurship (Chapters 5 and 6). Prior studies have mainly adopted an isolated perspective to analyse characteristics, predictors or outcomes at certain levels. Specifically, this thesis adds to the knowledge transfer literature by testing how the entrepreneurial propensities of academics are simultaneously affected by specific individual and institutional working conditions (Chapter 5). Moreover, this thesis demonstrates the extent to which organizational structures can serve as direct conduits to link various external stakeholders with academics and highlights that finding the right organisational channel can maximise the returns from external collaborations for academics (Chapter 6).

7.2.2 Implications for practice

The findings of this dissertation provide several practical implications for stakeholders at various levels. Firstly, given the distinct conditions of each region, the outcomes of general policies or programmes might vary depending on regional settings (Sternberg, 2014). Hence, government policymakers and university administrators who intend to facilitate academic entrepreneurship should first have a clear understanding of the disciplinary, industry and geographic contexts in which ASOs are embedded before starting to design polices and support mechanisms (Hayter, 2015b). More importantly, differentiated and customised policies and support programmes are required to adapt to the different regional contexts and to meet the diverse needs of academics (Rizzo, 2015). For example, Chapter 3 shows that research-related motives are the most relevant in advancing venturing progress. Thus, knowledge transfer programmes should focus specifically on meeting these needs. As for the group of necessity founders, universities should readjust their coaching and mentoring programmes to provide the necessary help.

Secondly, the knowledge transfer performance of a university depends largely on human factors (Shane et al., 2003). In other words, human assets matter most in academic entrepreneurship. Hence, to improve or incentivise performance, university administrators should attempt to retain and recruit high-quality personnel by offering entrepreneurship-oriented policies, such as leaves of absence, conflicts of interest and IP ownership. These targeted policies could meet the diverse individual needs of academics, which would also significantly stimulate their entrepreneurial propensities and facilitate them to start own businesses. The findings of Chapters 2 and 5 highlight the importance of having role models within departments and universities. Such role models are often seen as entrepreneurial champions and thus possess more prestige and are more persuasive in convincing their peers

to engage in commercialisation activities (Johnson et al., 2017). University administrators should therefore attempt to expand the influences of role models amongst their colleagues. Additionally, regarding tenure and promotion policies, assessments are still primarily based on scientific productivity, such as number of publications. Such orientations constrain the entrepreneurship commitment of academics, particularly younger and non-tenured scientists. Hence, university administrators should reconsider the existing promotion policies and include more entrepreneurial accomplishments as measurable indicators for promotion and tenure (Clarysse et al., 2011a; Huyghe and Knockaert, 2015).

Thirdly, to facilitate the venturing processes of ASOs, policymakers should consider reducing transaction costs, such as simplifying bureaucratic administrative procedures and, providing tax incentives. With regard to the relationship between support mechanisms at the university and regional levels, universities should be more proactive in establishing support mechanisms for ASOs, where in the regional environment generally favours entrepreneurship. When regional support mechanisms have been well established, universities should reduce their investment in support mechanisms to avoid the duplication of effort (Fini et al., 2011). Moreover, policymakers should seek to improve entrepreneurial regional absorptive capacity while focussing on enhancing the technology transfer performance of academic institutions. The success of academic entrepreneurship depends on bilateral efforts that need to be well balanced (Avnimelech and Feldman, 2015). Additionally, as Chapter 5 suggests, universities can serve as direct conduits to link external stakeholders interested in research results with academics who have the results. Therefore, university administrators need to seek long-term collaboration opportunities for academics; both informal and formal commercialisation activities must be considered.

Fourthly, considering that entrepreneurship is a long and dynamic process in which many contingent factors are involved (Landry et al., 2007; Rasmussen, 2011), it is clear that academics' role identities and competencies cannot be formed or altered in a short period, nor can networks outside of academia be established quickly. The benefits or outcomes created by ASOs also may also be observed over time. Hence, policymakers need to adopt long-term and dynamic strategies when designing and implementing policies. To ensure the effectiveness and efficiency of implemented support programmes at different venturing phases; and to adjust them in time, follow-up monitoring systems are required (Hossinger et al., 2020).

Fostering entrepreneurial mindsets amongst academics is equally as important as providing support infrastructure and policies. Based on the findings of the previous chapters, entrepreneurship education has been proven as an effective means to enhance entrepreneurial skills and increase the entrepreneurial self-efficacy of academics. Moreover, this helps academics who possess little knowledge about entrepreneurship to train their awareness and thus, enables them to make rational decisions about self-employment (Bijedić, 2013; Walter and Block, 2016). However, the effects of such basic awareness trainings cannot be measured immediately, and their impacts or benefits may be observed over a long period (Bijedić, 2013). In light of this, university administrators should customize the contents of entrepreneurial curricula according to the different regional or national contexts, as well as genders. Considering that male and female academics are driven by distinct motives and perceive support differently, universities aiming at increasing female entrepreneurial involvement should develop 'gender sensitive programming' (Díaz-García and Jiménez-Moreno, 2010). In addition, different events, such as lectures, entrepreneurial workshops and seminars, should be regularly hosted. In this way, academics can not only learn new knowledge but also have the opportunities to extend their networks.

As one the most important external stakeholders, venture capitalists hold different expectations for their investment decisions, whereas the existence of the information asymmetry problem often causes a mismatch between the demand and supply sides, which constrains the venturing process of ASOs. Hence, to reduce this mismatch, ASOs and universities should signal their capabilities and objectives to potential investors. Meanwhile, venture capitalists should conduct more comprehensive and thorough due diligence before making investment decisions.

7.3 Limitation and future research avenues

As with every study, this dissertation is not without limitations. Firstly, with regard to research design, the dataset used is derived from self-reported surveys, in which scientists answer the questions based on their objective opinions and feelings at the time. Therefore, the results are inevitably affected by various bias such responder bias and selection bias. Secondly, due to the cross-sectional character of the dataset, each participant is observed at a single point in time. Hence, it is difficult to strictly determine the causal relationship of the analysed determinants; considering the data were measured only once, the issue of reverse causality could exist as well (Sedgwick, 2014). Although a follow-up survey in 2016 was

conducted to assess outcomes over time, the dataset still partly suffers from responder bias and selection bias. Furthermore, the classification between each founding stage is unclear, which also undermines the validity of the results, to a certain extent. Thirdly, the dataset used in this thesis only focusses on one country (Germany), which jeopardises the generalisability of the results. Considering the variety of regional and national institutional and cultural environments, stakeholders with different backgrounds may decide to engage in entrepreneurial activities for various purposes. Therefore, the findings may vary in countries with different cultural and regulatory backgrounds, as well as between developing and developed countries.

In spite of the limitations, this dissertation offers a number of avenues for future research. As the phenomenon of academic entrepreneurship remains ongoing, and the upsurge has not ceased, the future of this research field is promising. While this thesis adopted a multi-level perspective to investigate the relationship between determinants and outcomes amongst certain level of stakeholders, as well as the joint impacts and interplay across different levels, the development and phenomenon of academic entrepreneurship is still far from being fully explored. Therefore, this thesis can serve as a starting point for those researchers wishing to tackle new challenges. With regard to the research design, firstly, researchers should continuously consider the issue of sample selection bias. For example, when investigating venturing or decision-making processes, it is necessary to distinguish nascent entrepreneurs from those who have succeeded in creating an ASO or possess a similar experience. Using multistage models would help explain this phenomenon in a clearer and more objective manner. For example, a stage focuses specifically on whether to become an entrepreneur, and another stage aiming at the decisions or actions have occurred.

Secondly, considering academic entrepreneurship is a long, complex process (Rasmussen, 2011), future research should consider adopting more dynamic and diverse analytical techniques to investigate the phenomena relating to this topic. Current research remains largely static. Hence, it is important and necessary to describe the evolution of this phenomenon over time. For example, the skills and capabilities of academic entrepreneurs may evolve over time during the ASO venturing process. It would be very interesting to conduct a longitudinal analysis to test how the evolution of academics' profiles affect their decision-making processes and entrepreneurial behaviours and what factors influence this relationship. Such studies are particularly important for the further development of theories to explain the variance of effects of certain determinants during different venturing phases.

In addition, using more mixed methods with the combination of both qualitative and quantitative approaches, could further promote the development of new theory constructs and quantitative measurements.

Similar to Chapters 5 and 6, future research could conduct a more thorough multi-level investigation into the determinants and outcomes of academic entrepreneurship, considering the heterogeneity of founders, firms, and regional and national contexts. The interactions of various determinants amongst stakeholders at different levels would be particularly interesting to address. The use of multi-level analysis would help researchers obtain more accurate estimates, and better understand this phenomenon in a comprehensive manner.

Moreover, in light of the major limitation of this dissertation, future research should consider multi-national comparisons using data from regions or countries with different cultural contexts. Most scholars currently still focus on Western countries, whereas the phenomenon on some of rapidly developing continents, such as Asia, remains under-researched. A greater understanding of the roles of different regional or national contexts in affecting the factors that facilitate or impede academic entrepreneurship would provide researchers a better comparison and, in this way, help them to better understand the complexity of this phenomenon.

With regard to future research opportunities, one of the major streams is to identify the antecedents and outcomes of academic entrepreneurship. A certain degree of consensus has been reached amongst scholars regarding the factors at the individual level, whereas notable contradictions still exist between the findings at other levels. Therefore, future research should focus more on the meso- and macro-levels; for example, the possible moderating effects of institutions on the relationship between academic entrepreneurship and economic development is a promising topic. In particular, prior studies show that support infrastructures and programmes provided by universities help the development of ASOs in early phases. However, the questions of whether the effectiveness and efficiency of the support are constant in the early and later phases, and if not, what the consequences are in terms of ASO performance, deserve further analysis. Similar to Chapter 6, using longitudinal data to conduct a further multilevel analysis on the collaboration channels through universities as well as look into new knowledge transfer channels, would also be very interesting; understanding how different types of external stakeholders, along with scientists and universities, can shape an individual's decision to engage in firm creation and finding

the most optimal combinations would benefit both academic entrepreneurs and external stakeholders. The results should be tested across different institutional and cultural environments and across developing and developed countries.

Similarly, in terms of the management and sustainable development of ASOs, it would also be interesting to test the effectiveness and efficiency of the strategies and decisions made in the early stages and their long-term effects using longitudinal data. An interesting research stream would be to determine the optimal combination of strategies for ASOs to follow based on the life-cycle stage, which may serve as means for ASOs to considerably improve their performance. Moreover, inspired by the genealogical imprinting theories (Ciuchta et al., 2016), the following questions should be explicitly explored: the link between the inherited characteristics and orientations of the parental organisation and performance of ASOs, and specifically, the extent to which these characteristics and orientations affect the venturing paths of ASOs, as well as what the consequences entail.

Furthermore, as the most vital stakeholders in academic entrepreneurship, individual academics should be the continual focus of future research. In addition to focussing on economic outcomes, researchers should expand the scope of analysis to explore the impact of entrepreneurship on other aspects of development, such as the well-being of academics (happiness, health, life quality, job satisfaction, etc.) or hybrid entrepreneurship. It would also be interesting to conduct a further analysis on the relationship between scientific output and entrepreneurial engagement. Prior studies have found both trade-off effects and complementary relationships between these two activities. However, to what extent and in exactly what way this interaction occurs, as well as the subsequent outcomes, should be addressed more precisely in future research. In terms of individual psychological factors, similar to Chapters 3 and 4, future research should also consider other psychological constructs to explain the entrepreneurial intentions and behaviours of academics. In addition, considering the heterogeneity of academics, the effects of either motivating or inhibiting factors could vary across different types of academics. Thus, it would be interesting to investigate to what extent the effects of these factors vary across different types of founders and how these effects could be moderated or mediated by the types of research, faculties or their positions within the university. Moreover, future research should also adopt a phase-specific perspective and analyse how the effects of these factors vary in different venturing phases and possible consequences of this.

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