Dissertation

Commercialization of Academic Research

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Abstract

The central research subject of this dissertation is the influence of certain factors on the commercialization of university research. Knowledge and technology have become the most important resources in modern economies in recent decades. This fact is particularly true for innovation-based economies, including countries such as Germany and the US, in which technological knowledge and progress are essential. As a result, universities, as producers of knowledge and technology, play a central role in this new economic system. In order to gain or keep those technological advances, the commercialization of university research is the most important channel of knowledge transfer from the world of academia to practice.

The transfer of university knowledge into practice and thus the commercialization of a scientist's research takes various forms. Knowledge can be introduced directly into the market via a university spin-off or through other channels, such as consulting, licensing, sales, or even the cooperation between researchers and companies during the creation of knowledge. The basis of this 'new' model of relationship between business, science and the state is the triple helix model by Etzkowitz and Leydesdorff (2000). In this model, separation between the tasks of the university, the economy and the state become increasingly blurred, and each participant begins to act in the spheres of the other participants. This creates a dense network of interrelations between the participants.

The transfer of knowledge and networks between the economy, universities and the state have already been investigated. However, these analyses were usually related to the technical functions of the transfer of knowledge or to the organizational interdependence of the participants. Of course, these points are important and the findings from these research areas should not be ignored in this dissertation. This dissertation is, however, intended to be focused on a widely neglected research topic at the commercialization of university research. Therefore, the following dissertation will focus on the individual researcher as the central research subject. In particular, the question of what

factors are decisive for a researcher to commercialize his or her research is central. Following the homo economicus approach, it typically is assumed that researchers are particularly motivated by extrinsic, mostly monetary, incentives, which is why most incentive systems also focus primarily on such incentives. Certainly, monetary incentives also play a role in the commercialization of research, but other factors also influence researchers. Therefore, the classical view with the premises of the homo economicus approach will be expanded by adding peer effects, personal networks into industry and the orientation of the research to the analyses. Effective incentive systems with the aim of motivating university researchers to commercialize their research also need to consider these factors.

Acknowledgment

Writing a dissertation is similar to taking a long journey, only the trip does not occur comfortably by plane or by ship and there are no long nights at the beach or all-inclusive buffets by the pool. It is more like a trekking path through the mountains: it is difficult to climb uphill and the path winds through the landscape. Fortunately, you do not have to do this long march alone. Therefore, I would like to thank all the people who have accompanied me on the way and helped me with advice and support.

First, I would like to thank my supervisor in the doctoral phase, Prof. Dr. Petra Moog, without whom writing my dissertation would not have been possible. Her support and experience have been valuable guides for me. She not only gave me the opportunity to graduate but also the opportunity to gain valuable experience in the university and at international conferences. I would also like to thank my other two examiners, Prof. Dr. Arndt Werner and Prof. Dr. Giuseppe Strina, for their willingness to accompany me during the time of my doctorate.

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Writing a dissertation may be an arduous path, curvy and sometimes rocky, but when you have reached the end of the path and are finally at your destination, a beautiful panorama opens before you that compensates for all the effort you put into the project dissertation. I am grateful I followed this path until the end. It has been a rewarding experience.

Stefan Houweling

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List of abbreviations

biotech	biotechnology
CERN	European Organization for Nuclear Research
df	degrees of freedom
DNA	deoxyribonucleic acid
e.g.	exempli gratia
et al.	et alii; et aliae; et alia
EU	European Union
H1	hypothesis 1
H2	hypothesis 2
H3	hypothesis 3
H4	hypothesis 4
H5	hypothesis 5
H6	hypothesis 6
i.e.	id est
n	sample size
OLS	ordinary least squares
PhD	philosophiae doctor
prob	probability
R&D	research and development
SBIR	Small Business Innovation Research
SJR	Scimago Journal Rank
SME	small medium-sized enterprises
TTO	technology transfer offices
UK	United Kingdom
US	United States
VIF	variance inflation factor

1. Introduction

In recent decades, the progressive specialization of society has accelerated. While some people complain about this, it is this specialization that divides modern from traditional and less developed societies. However, specialization also creates problems that must be solved by society. The universal genius, who corresponds to the traditional image of a globally or generally expert and scholar, can no longer exist, because of the progressive specialization that has taken place not only in various social spheres but as well in the scientific sphere. In other words, all our environments (social, scientific) etc. have become too complex to allow for the existence of universal geniuses. Even individual scientific fields have such high specialization that one cannot talk of physicists or biologists, but must identify them according to the different areas of physics or biology for example.

Since individual spheres are indeed specialized to such an extent, it has become almost impossible for an outsider to get even a glimpse, let alone an overview, of a particular field. This applies not only to science, but also to the other sub-systems of society, such as politics or the economy. However, all of these specialized systems belong to the superior system of society that must, if possible, cooperate functionally. Such cooperation between specialists and specialized subsystems is difficult because knowledge is distributed differently, and the habitual patterns of behavior and thought patterns are differently designed and socialized. Despite the high level of specialization, there has to be a modus operandi of cooperation between the spheres.

This need for cooperation between government, industry, and university is particularly important in technology-based economies. Etzkowitz and Leydesdorff (2000) developed the triple helix model of the interaction between the three players. In this model, the boundaries of the individual spheres blur and overlap, which means that one sphere, can take over the tasks of the other spheres to a certain extent. For example, the classic division of responsibilities between business and science could be shared so that business would participate in basic research (even if only as a sponsor), while science would foster commercialization for the practical implementation and introduction of research into society. In the model, the government should also be included in the process, for example, to promote the commercialization of academic research via government-launched development programs for university spin-offs.

Implementation of such a model requires the reduction of the cognitive distance between the three spheres. There are some fundamental differences in self-concept and perspectives of the different spheres (Wayne and College 2010). To overcome these cultural differences, it is necessary to implement the successful cooperation between them. In academic science, for example, the Mertonian norms occupied a dominant position for a long time that gave academic science a culture that was independent from materialistic or economic constraints. A focus on the practical applicability of scientific results is not provided in this culture (Merton 1957; 1973). For enhanced cooperation with industry, if this is desired, a fundamental cultural change in science is necessary. However, this development is not just one-sided. Economy also has to have a greater degree of understanding of the academic culture to make cooperation possible (Samsom and Gurdon 1993).

Since culture is an individual characteristic, a change in the structures of the organizations is necessary, as well as a change of personal beliefs on an individual level. These changes can only fully succeed if they are supported by a change in incentives, and a collective change in thought patterns and habitus. For example, structural changes to support the commercial activities of scientists involve establishing technology transfer offices (TTO) or introducing new incentives aimed at commercialization. However, while these changes are certainly helpful, extrinsic motivation factors alone will not achieve a significant increase in the commercial activities of university scientists (Göktepe-Hulten and Mahagaonkar 2010; Bercovitz and Feldman 2008). The emphasis also has to involve intrinsic factors, which are influenced by a change of habitus and role models. For young scientists newly socialized in universities, role models are very important (Huyghe and Knockaert 2015; Haas and Park 2010). If these role-models and other peers have a negative attitude toward the commercialization of university research, it may impact the attitude of individual researchers. Therefore, this thesis will determine which factors influence the commercialization of university research and whether the influence is positive or negative.

Commercialization itself can occur in various forms. For example, it can occur in the form of university spin-offs, consulting, or licensing (Jain et al. 2009; Rothaermel et al. 2007). The first part of this thesis will present the theoretical basis and definitions used in the following analyses. The personal motivation of researchers, the types of research output, and the personal beliefs of researchers regarding the tasks of university research will also be discussed. This paper will analyze how extrinsic and intrinsic motivations affect professional activities of scholars and the commercialization of research, as well as whether certain research outputs are better suited for commercialization purposes than others. Starting with these basic considerations, other papers in which certain aspects have been discussed will be closely examined. In the second paper, the question about how the prestige of a scientist affects the probability of commercializing academic knowledge and the type of commercialization will be addressed. In the third paper, the focus will be on how peers and the work-life balance affect the commercialization of the activities of scientists. In the final fourth paper, the effects that federal support programs have on the commercialization of academic knowledge and technology will be analyzed to determine how the programs affect an individual scientist's decision to participate in commercial activities. This dissertation will finally also summarize the results of the previous analyses.

Table 1: Integrated studies

Authorship	Keywords	Research topics	Main theoretical concepts	Methodology and data
Paper 1: Scientists' Motivation and Cooperation between Industry and Science				
Stefan Houweling, Petra Moog	Scientists' motivation; Scientific norms; Scientific outputs; Industry-science-cooperation	The effects of scientists' motivation, scientific norms and scientific outputs on industry-science-cooperation	Self-determination theory; Triple helix model	Quantitative; n=338
Paper 2: Scientific Prestige and the Commercialization of University Scientists' Research				
Stefan Houweling, Sven Wolff	Commercialization of research; Scientific prestige; University-industry cooperation; University spin-offs	The effects of scientific prestige, peers and contacts into industry on different types of commercialization	Several prestige indicators; Triple helix model	Quantitative; n=441
Paper 3: The Impact of Skills, Working Time Allocation and Peer Effects on the Entrepreneurial Intentions of Scientists				
Petra Moog, Arndt Werner, Stefan Houweling, Uschi Backes-Gellner	Jack-of-all-Trades; Entrepreneurial intentions; Academic entrepreneurship; Peer effects	The effects of skill sets of scientists, working time allocation and peers on the founding of university spin-offs	Jack-of-all-trades approach; Triple helix model	Quantitative; n=480
Paper 4: The Impact of Federal Programs on University Spin-offs				
Stefan Houweling	Academic entrepreneurship; Federal programs; Peer effects	The effect of a scientists' basic budget and federal programs on the commercialization of research	Triple helix model	Quantitative; n=337

2. Entrepreneurship

There is no strict definition of entrepreneurship or entrepreneur (Acs et al. 2014). Entrepreneur originates from the French verb ‘entrependre’, which means ‘to do something’ or ‘to undertake’. Basic theories about entrepreneurship have been revealed in ancient Rome, although philosophers probably discussed the topic in earlier epochs. In the mid-eighteenth century, economist Richard Cantillon developed the first theoretical foundations about entrepreneurship (Iversen et al. 2008). According to his definition, an entrepreneur was a self-employed person who bought a product or service at a certain price and sold it at an undetermined price. This economic transaction achieved profit or loss under a certain risk (Vermeulen and Curşeu 2008). Those basic thoughts established entrepreneurship as its own research discipline.

Another important representative of early research into entrepreneurship was Jean-Baptiste Say, a French economist. In addition to emphasizing the business uncertainty under which entrepreneurs acted, he focused his attention on the special abilities that entrepreneurs needed to have. For Say, an entrepreneur had to be able to plan for the future and have a deep understanding of the products and the process used to manufacture those products; in particular, an entrepreneur needed to have a ‘moral’ judgment and be able to raise capital (Long 1983).

As the founder of modern research into entrepreneurship, Austrian economist Joseph Schumpeter emphasized that innovation and originality were key components in his definition of entrepreneurship. The realization of new combinations of factors, associated processes, products, and markets were key factors in his definition (Volkmann and Tokarski 2006). An entrepreneur did not have to be the inventor of new combinations of factors, but needed to be the initiator of product innovation and, thus, an extension of the product range. Schumpeter differentiated between the roles of managers and entrepreneurs. A manager was responsible for ensuring that production ran smoothly and reached the highest possible efficiency. An entrepreneur, however, dealt with the products and tried to improve them. The process of ‘creative destruction’ was the driving force for economic development (Parker 2012). Thus, Schumpeter created a revolutionary approach in which the old structures and ideas were displaced with new structures and ideas. While Schumpeter believed that starting a business was implicitly the best way to implement new factor combinations, he did not feel that it was explicitly needed.

Another theory that influenced the understanding of entrepreneurship was created in the 1970s by Kirzner. He felt that one could not assume that the economy was in balance. Therefore, a scope for economic decisions to form equilibrium had to be present. The task of an entrepreneur was to provide new opportunities to meet the demands of customers and to create a stable balance at the markets (Shane et al. 2003). Permanent economic fluctuations and unforeseen events affected a market’s equilibrium, however unattainable. The central point of Kirzner's theories was to follow the existence of opportunities, and to recognize and use them. This brief overview identified a variety of approaches used to define entrepreneurship and entrepreneurs. Due to the unclear definition of entrepreneurship, a wide range of (commercial) activities can fall under the term of entrepreneurship. Therefore, in this dissertation, the commercial activities of scientists will not only focus on university spin-offs, but also on other forms of commercialization of research, like licensing or consulting, to show a comprehensive picture of academic entrepreneurship.

Overall, it can be assumed that there is no uniform definition of entrepreneurship. However, some commonly accepted elements exist in the different approaches to entrepreneurship. Such correlative core elements include actions taken under uncertainty and the concomitant assumption of risk, the presence of specific individual skills and creativity, and the ability to use already existing or created opportunities.

3. Entrepreneurial motivation and personality

The motivations to start a business can be diverse and often depend on the personality of the entrepreneur. However, there are usually few differences in the motivations to found classical and academic start-up companies. In general, the basis for human action is the presence of motives, which creates an incentive for taking actions (Kulbe 2009). Maslow (1943) identified needs as driving forces for individual actions, which can be divided into five types of needs: basic needs, security needs, social needs for belonging and esteem, individual needs, and the need for self-realization. From these basic needs, Maslow created his hierarchy of needs, placing self-actualization at the top, which is particularly important for the motivation of entrepreneurs. Actions are needed to fulfill needs, which may be either consciously or unconsciously motivated (Kulbe 2009). Positive or negative evaluations of subjects or objects are based on motivation, which therefore are recognized as personal characteristics (Vollmeyer and Brunstein 2005). The resulting motivated behavior is shaped by the characteristics of the pursuit of the effective organization of goal commitment and goal distancing (Heckhausen and Heckhausen 2005). In order to achieve these goals, an individual must perform acts that result from personal motivation.

Individual needs are not exclusively physiological, such as the satisfaction of hunger. Emotional needs can also provide strong incentives (Goschke and Dreisbach 2011). For example, the feeling of pride in achieving a goal represents an emotional need. As a result, achievement-motivated people search for opportunities to improve their skills by repeatedly trying to exceed their own targets. Their emotions intensify their motivated actions, which is particularly characteristic of entrepreneurs and researchers (Vollmeyer and Brunstein 2005).

Furthermore, motivation itself is the result of these incentives to act. Therefore, the root word of motivation derives from the Latin verb ‘movere’, which means to move (Correll 2006). Motivations arise in situational interactions among driving forces (Schneider and Schmalt 2000). This situational origin does not imply permanence of motivation but is limited over time (Kirchler and Rodler 2002). Because of the complexity of incentives and the resulting motives, motivation cannot be homogeneous. Even individual actions are usually driven by different motives. Therefore, motivation is always a heterogeneous construct. Actions therefore can be constructed by external influences or be self-referential, that is, motivated by the person. The first case is referred to as extrinsic motivation; the second case as intrinsic motivation. Intrinsic motivation refers to the internal or the so-called true motivation (Rheinberg 2004), which lays in the act itself or its destination (Heckhausen and Heckhausen 2005). The so-called “puzzle” motivation of scientists is an intrinsic motive because the action taken to solve a problem itself has value. In the case of extrinsic motivation, however, individuals are motivated by only external incentives. In the case of entrepreneurs, for example, an extrinsic motivational factor can be an increase in income. A driving force of extrinsically motivated actions is therefore a foreign incentive (Kulbe 2009). The actual action itself has no value but only serves in the achievement of objectives.

On an emotional level, extrinsic motivation can be compared with the feeling of being moved by external forces. Intrinsic motivation on the other side is produced by inner needs, which are the origins of its driving force (Rheinberg 2004). It is possible to strengthen both intrinsic and extrinsic motivation. For example, pride is an intrinsic amplifier during an action, whereas a social reward, such as attention, is an extrinsic amplifier (Narciss 2011). In the working environments of universities, for example, scientific research can be controlled and regulated by superior institutions and supervisors. The proposal of certain research topics has a significant impact on the motivation of an individual. Researchers and every other individual with larger independence are often more intrinsically motivated and therefore do not need to be strongly motivated by additional extrinsic factors (Deci and Flaste 1996). The feeling of having control over one's own actions and the ability to shape the environment therefore has an effect on intrinsic motivation. However, freedom in their decisions has positive affects only if the individual is able to use it in productive ways. Too much independence, combined with the absence of vital information, may also have negative effects (Deci and Flaste 1996).

Motives can be broken down into three types of scales: achievement, power, and social. The achievement motive involves orientation to a quality scale (Vollmeyer and Brunstein 2005). The quality scale provides the comparison of the performance with the performance of others. It may also be a measure of the success or failure of an action (Schneider and Schmalt 2000). The main concern of the achievement motive is to surpass or reach a fixed scale. Specifically, the achievement motive refers only to an act on the scale of which is determined by self-assessment, and external reviews are disregarded (Rheinberg 2004). The power motivation focuses on the influence on third parties. Thus, this motivation aims at influencing the behavior and experience of others (Vollmeyer and Brunstein 2005). This need can only be satisfied when people's behavior is influenced, thus showing a predefined behavior (Rheinberg 2004). The social motive concerns establishing mutual positive relationships with other people (Vollmeyer and Brunstein 2005).

The specific motivations and characteristics of entrepreneurs increase their likelihood of founding a start-up. For example, the achievement motive leads to taking even more responsibility for actions and more time and energy focused on one goal. Although the motivation seems to have a positive influence on the willingness to found a start-up, those motivational factors can also occur in employee relations, if the employee has enough freedom to carry out his or her own projects (Shane et al. 2003). In addition to achievement, power, and social motives other motivations and character traits have a positive effect on the tendency to found a business. The locus of control concerns the extent to which individuals believe that their actions and characteristics can influence their lives and the outcome of their work and the extent to which they are able to influence their environment. People with a high locus of control prefer situations in which they can act and determine the results that are achieved by their deeds (Shane et al. 2003). The need for risk is the willingness of an individual to take risk. Previous studies (e.g. Shane et al. 2003) dealt with the question of whether entrepreneurs demonstrate a greater willingness to take risks than non-entrepreneurs do. Entrepreneurs, who usually have a high need for achievement, will be interested in taking a balanced risk. However, there is always the risk of failing, and thus they may avoid risks. Because entrepreneurs achieve an insecure income based on their autonomy and independence, it cannot be denied that they are willing to take more risks than most other people are. However, it is possible that they perceive a risk as an opportunity (Shane et al. 2003). Similarly, risk-averse scholars could be discouraged to found their own spin-off, but they could use other ways to commercialize their research (Abreu and Grinevich 2013). Self-efficacy is the belief of an individual to have the skills, human characteristics, and abilities to solve a predefined task in order to achieve a certain outcome. Self-efficacy also refers to task-specific self-confidence. Individuals with a high degree of self-realization invest more effort and time in order to achieve a certain goal, and they evaluate setbacks in order to establish better strategies (Shane et al. 2003). Goal setting refers to the extent to which entrepreneurs can set their own goals. Individuals who set goals and pursue self-imposed targets usually have a high motivation to achieve them. Individuals with self-imposed targets tend to create an environment in which they can achieve these goals. If this is not possible in their current (working) environment, founding an own business is an attractive alternative. The need for independence refers to the extent to which individuals take responsibility for their own lives and activities and trust their own judgment. In dependent employment, the guidelines and barriers of everyday work limit the independence of such individuals. For example, if researchers at universities have limited freedom in choosing their own research topics, they could be discouraged, which would increase the attractiveness of choosing alternatives, such as founding their own firm (Shane et al. 2003).

Various portraits of the human personality can be derived from these different types of motives. For example, homo sociologicus refers to the social roles within a society. In a community, following rules, which are referred to as norms, is mandatory if they are widely recognized and seen as binding (Weise 1989). The social collective decides the recognition and binding of norms.

These rules are subject to the model of homo sociologicus as part of society. When individuals follow these norms, they meet the expected and accepted behavior of the community. Thus, they are motivated to act in compliance with the expectations of the group members (Schimank 2010). Because individuals have no direct influence on these social norms, they try to follow the norms of society (Dahrendorf and Abels 2010). A normative standard is not necessarily unchangeable; if it is merely tolerated by a weak majority, the survival of the norm is at risk. If the majorities shift, the norms can change, and other habits can be declared as norms (Dahrendorf and Abels 2010). Thus, scientists are highly influenced by institutional norms and the expectations of their colleagues with regard to their research and their attitudes toward commercialization. University scientists are, knowingly or unknowingly, a social group that is heavily influenced by their social (e.g., work) environment. If strong norms against the commercial exploitation of research exist in the work environment, it may negatively affect the willingness to participate in commercialization (Samsom and Gurdon 1993; Stuart and Ding 2006). Although the non-adherence to norms leads to social sanctions, following norms brings security in the affiliation to a social group (Dahrendorf and Abels 2010). Homo sociologicus therefore fulfills an ascribed role in society. Conversely, homo sociologicus expects that others also comply with these guidelines and therefore show socially accepted behaviors (Weise 1989). Because each individual is part of society and thus actively sanctioning and/or may not comply with norms, homo sociologicus can play two roles within the social group (Weise 1989). The sanctions are based on formal laws and informal regulations. A distinction is made between the expectations that the individual must, should, and can follow (Dahrendorf and Abels 2010). If 'must-expectations', which are regulated and formulated by laws, are not met, prosecution and negative sanctions are the consequences (Dahrendorf and Abels 2010). One possible negative sanction is a prison sentence for the violation of formal laws. Must-expectations can also be contracts. Non-compliance with these contracts, such as the breach of an employment contract, is followed by legal and social sanctions (Schimank 2010). Norms that should be followed, but are not formal laws, are directives that are also monitored by institutions and are similar in design to must-expectations (Dahrendorf and Abels 2010). Thus, the code of conduct, which is monitored by the ethics committee of a company, is an example of such norms. Violators are negatively sanctioned, in the form of disapproval and reprimands. Continuing compliance with a norm, in the form of exemplary behavior, can lead to positive sanctions (Schimank 2010). Finally, some norms can or cannot be followed, which are manifest in voluntary activity and can be positively sanctioned by the appreciation and benevolence of fellow reference groups (Dahrendorf and Abels 2010). This subdivision clarifies that both negative and positive sanctions are possible in a society or social group. Because of the hundreds of laws and regulations, clear separation of expectations is not always possible. Thus, the transitions from the norms that must be, should be, and can be followed are fluent.

The terms homo economicus originated in the social sciences. In economics, the term is used as the basis for determining or describing economic activity (Dahrendorf and Abels 2010). Therefore, the economic action of a person is geared to achieve the maximum individual benefit (Kirchgässner 2008). In addition, it is assumed that the acting individual decides rationally and in his or her self-interest (Falk 2003). In the interaction of expectations and restrictions, the individual weighs all alternatives within his or her scope of action and decides according to the preferential formation of the alternative that comes closest to the preferred action (Kirchgässner 2008). The underlying rationality reflects the influence of the norms, values, and expectations of society on an acting individual (Nida-Rümelin 2008). Homo economicus has complete information in this decision-making process. He or she knows all the relationships, influential factors, and so on (Treibel 2006). Intrinsic motivation is not observed because of the assumption of rationality in this model (Nida-Rümelin 2008). In the concept of homo economicus, the cost-benefit calculation has no room for the inner motivation of an individual in a decision-making situation. The influence of altruism results in the limited rationale of self-interested behavior, which is not provided for in the homo economicus model (Suchanek and Kerscher 2006).

4. University spin-offs

The importance of scientific knowledge and its implementation in innovations for technical progress is steadily growing (Stiller 2005). Since the 1990s and even earlier, university spin-offs in Europe have developed into one of the most important channels of the technology transfer of new scientific findings from academic research into industry and then into society (Degroof and Roberts 2004). The reason is that there is a high potential to transfer knowledge from research to industry and to exploit research results commercially (Lockett et al. 2005). Institutions want to contribute to the exploitation of research results by encouraging university spin-offs, which are prevalent especially in knowledge-intensive industries such as biotechnology (biotech) and nanotechnology (Shane 2004). University spin-offs thus represent an important channel for the commercialization of innovative technology.

The term ‘spin-off’ dates from the 1960s. Its origin is in the state-subsidized American aerospace and defense industry and is used to refer to the by-products of large-scale research projects that were not significant in the actual research field. However, such by-products opened up new fields of application (Nörr 2010). A spin-off is therefore the establishment of a separate entity from an already existing one (Pérez and Sánchez 2003). Spin-offs are therefore innovative start-ups because they transfer knowledge, technologies, products, and human capital from an already existing organization (Hemer et al. 2007). The original parent organizations can be industrial companies as well as, in the case of university spin-offs, research institutions, and universities (Nörr 2010). In contrast to “split-offs,” the foundation of a spin-off has the consent of the parent company (Klandt 2006). It is also true that in general, the parent company and the spin-off are organizationally linked, and the spin-off often uses the resources of the parent organization in the start-up phase. These close connections usually exist for a long time, even if the spin-off becomes increasingly independent. Thus, not only does the spin-off benefit, especially in the start-up phase, from the support of the parent company but also the parent company benefits from the close links to the spin-off in the long term.

Even though the importance of university spin-offs is increasing, there is no precise definition of this term in the literature (Roski 2011). Roberts (1991), for example, defined university spin-offs as a company that is founded by a person who has previously studied at a university. Shane (2004) defined a university spin-off as a company in which scientists work as a member of the scientific advisory board. Pirnay et al. (2003: 356) defined university spin-offs as "[…] new firms created to exploit commercially some knowledge, technology, or research results developed within a university.”. A brief summary of the variety of definitions of university spin-offs is shown in Table 2.

Table 2: Definitions of university spin-offs

Authors	Year	Definitions
Mc Queen and Wallmark	1982	“[...] in order to be classified as a university spin-off, three criteria has to be met: (1) the company founder or founders have to come from a university (faculty, staff or student); (2) the activity of the company has to be based on technical ideas generated in the university environment; and (3) the transfer from the university to the company has to be direct and not via an intermediate employment somewhere” (p. 307)
Smilor et al.	1990	“a company that is founded (1) by a faculty member, staff member, or student who left the university to start a company or who started the company while still affiliated with the university; and/or (2) around a technology or technology-based idea developed within the university” (p. 63)
Weatherston	1995	“[…] an academic spin-off can be described as a business venture which is initiated, or become commercially active, with the academic entrepreneur playing a key role in any or all of the planning, initial establishment, or subsequent management phases” (p. 1)

Carayannis et al.	1998	"a new company formed by individuals who were former employees of a parent organization (the university), around a core technology that originated at a parent organization and that was transferred to the new company" (p. 1)
Bellini et al.	1999	"[…] academic spin-offs are companies founded by university teachers, researchers, or students and graduates in order to commercially exploit the results of the research in which they might have been involved at the university [...]. The commercial exploitation of scientific and technological knowledge is realised by university scientists (teachers or researchers), students and graduates." (p. 2)
O'Gorman and Jones-Evans	1999	"[...] the formation of a new firm or organisation to exploit the results of the university research"
Rappert et al.	1999	"University spin-offs are firms whose products or services develop out of technology-based ideas or scientific/technical know-how generated in a university setting by a member of faculty, staff or student who founded (or co-founded with others) the firm" (p. 874)
Clarysse et al.	2000	"[…] Research-based spin-offs are defined as new companies set up by a host institute (university, technical school, public/private R&D department) to transfer and commercialize inventions resulting from the R&D efforts of the departments" (p. 546)
Klofsten and Jones-Evans	2000	"[…] formation of new firm or organisation to exploit the results of the university research" (p. 300)
Steffensen et al.	2000	"A spin-off is a new company that is formed (1) by individuals who were former employees of a parent organization, and (2) a core technology that is transferred from the parent organization" (p. 97)

Pirnay et al. (2003): 357.

De Cleyn and Braet (2010) combined elements of the approaches of different authors in their definition of university spin-offs. Their definition comprises four key elements: "A spin-off is (1) a new legal entity (company) (2) founded by one or more individuals seconded or transferred (sometimes part-time) from a parent company (3) to exploit some kind of knowledge (4) gained in the parent company and transferred to the new company." (De Cleyn and Braet 2010: 54). Provided with a supplementary, the authors provide a definition of academic spin-offs as being "[…] from an academic parent organization (e.g. university, university college, public research organization)." (De Cleyn and Braet 2010: 55).

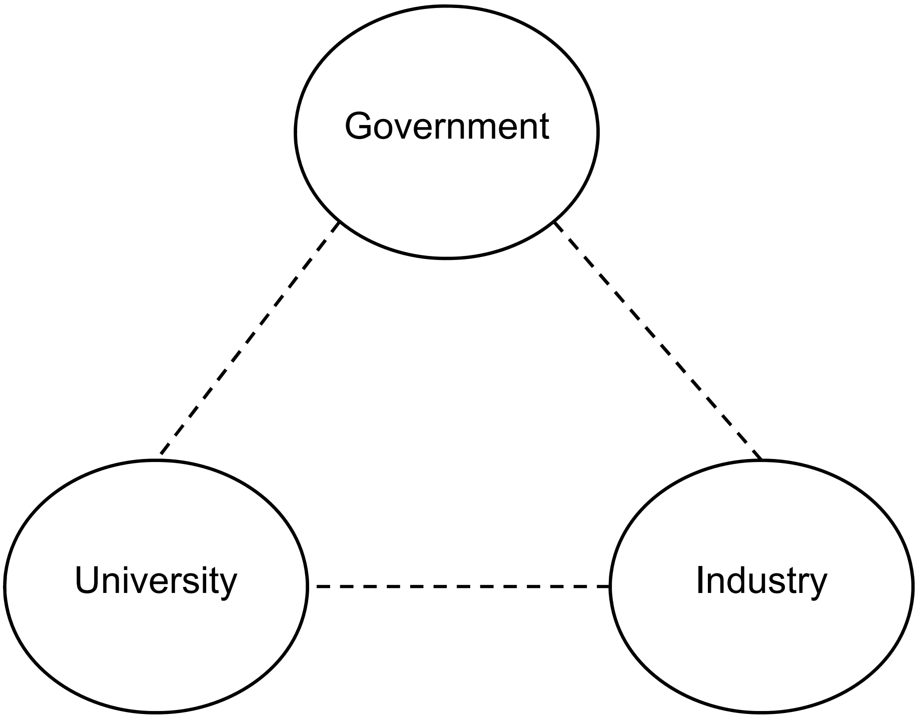
Although university spin-offs are the most prominently discussed commercialization of university research in the literature, they are by far not the only channel of commercialization. University spin-offs are one important form of commercialization, but when scientists want to transfer their scientific results into practice, they can choose from a variety of possibilities. Although the patenting of research is often taken as indicator of commercial activities by university researchers (e.g. Stephan et al. 2007; Audretsch and Aldridge 2009), a patent per se is neither required nor sufficient for commercialization. Especially considering the trend toward the patenting of basic research, many patents are not used to transfer knowledge into practice (Ito et al. 2016). However, particularly in the life sciences, patenting can facilitate other forms of commercialization.

Sales and licensing are possible ways of commercialization. The sale of patents or expertise to a company is probably the simplest kind of commercialization by scientists. At least in theory, a sale is a singular event when the property of the patent is handed by the scientists or the university to a company (Rothaermel et al. 2007). In practice, scientists might attend the implementation of the new technology in a firm, but legally the property is transferred. In the case of licenses, the property of the patent or the invention is not transferred (License Phan and Siegel 2006). The firm has only the right to use the patented knowledge. In both cases, the scientist and the university receive a payment. The payments are usually monetary, but other forms of payment can also occur. An alternative to the commercialization via spin-offs is consulting, which does not necessarily need patented knowledge or a new technology. Consulting, for example, can be provided by scientists in the development process of a new product or service or in the evaluation of a new technology. In exchange for a payment, scholars usually provide their expertise as specialists in their field of technology. Licensing and sales, as well as consulting, are alternative possibilities for the commercialization of university research and can be seen as forms of commercialization the scientist(s) is less involved in or tied to (Jain et al. 2009). They have less commercial potential than university spin-offs, but they are less risky and need less personal involvement than spin-offs. Therefore, some scientists may choose those alternatives to commercialize in order to transfer their research results into practice. Although two papers in this thesis are focused on university spin-offs, because the alternatives should not be neglected, they are considered in the thesis.

5. Traditional university models and the Triple-Helix

Etzkowitz and Lydesdorff's (2000) triple helix model is the predominant theoretical framework used to examine university spin-offs. As the starting point for the evolution of this model, two different initial positions can be identified: the laissez-faire model and the statist model. Each of the three models describes different kinds of relationships among three actors: the state, industry, and academia. The need for cooperation among these spheres for scientific, social, and economic progress is undeniable. However, this cooperation has changed markedly in recent decades.

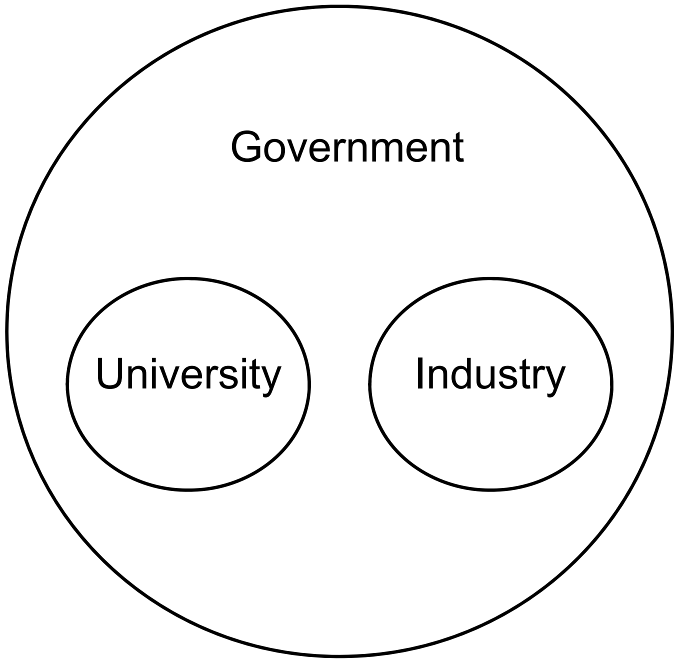
Figure 1: Laissez-faire model



Etzkowitz and Leydesdorff (2000).

The predominant driving force in the laissez-faire model of scientific, social, and economic development is industry (Etzkowitz 2007). A typical example of a laissez-faire regime is the US in the first half of the 20th century. In the laissez-fair model, the three spheres of state, industry, and academia are strictly separated. Each sphere has a specific area of duties. For example, the main task of the university is the generation of new knowledge. Patents and licenses may be generated in close context of this research process, but, without exception, are created, within the sphere of industry (Etzkowitz et al. 2007). It follows that the relations among the spheres tend to be indirect and hostile. Thus, to reach a certain sphere, knowledge may need to pass through another sphere because direct contact is ideologically excluded. The guiding principle of the strict differentiation of tasks is however undermined because indirect relationships between the spheres arise when one sphere is in contact with another sphere to interact with the third sphere. Under these circumstances, the laissez-faire regime then evolves to a triple helix (Etzkowitz et al. 2007).

Figure 2: Statist model



Etzkowitz and Leydesdorff (2000).

The state-centered model is the antithesis of the laissez-faire approach. The primary driving force of the statist model is the government (Etzkowitz 2007). University and industry play minor roles. Examples of the state-centered model are China, the countries of the former Soviet Union, and weaker in several countries in Europe and Latin America (Etzkowitz et al. 2007). In the statist model, various functions are organized by the state throughout central planning and coordination mechanisms. In addition to the coordination of various processes, the government takes the lead in launching new initiatives and allocating resources to industries and universities. Universities are primarily teaching institutions that have no direct connection to industry (Etzkowitz 2007). The statist model relies on specialized organizations that are hierarchically associated with the central government. In the former Soviet Union, for example, to gain access to new academic knowledge, industry needed a resolution from the central planning authority. The wait for such a decision often led to the blockage of the technology transfer because industry and academia could not legally conduct their affairs directly with each other. Hence, in this model, the state ensures its authoritarian role and maintains power. However, in the statist model, the economic and technological development of an economy is restrained and change and technological progress are very difficult to implement.

The transformation of this system seems to be necessary mainly because of bureaucratic coordination, focusing only on initiatives by the government and suppressing suggestions from the other spheres (Etzkowitz 2007). Nevertheless, if the positions of the university and industry are strengthened, such as by the voluntary inwardness of the state, the state-centered model is changed to a laissez-faire approach.

In China, for example, the importance of university spin-offs in the national economic strategy increased after the opening of the country to a more or less free market system. Therefore, the government implemented a strategy to foster the transfer of academic knowledge into the economic sphere via university-owned firms. Such firms had a greater degree of freedom in their activities while remaining part of the national strategy of technological and economical “catch-up” with the West. Although the strong influence of the government persisted, the statist model was weakened. Some of the most prominent Chinese firms, such as Lenovo, which originated at the Chinese Academy of Sciences, were founded as university-owned firms. Although university spin-offs had been important in a more or less government-controlled program, since 2001, there has been a shift toward the laissez-fair model (Eun et al. 2006).

The evolutionary process of the relationships among the three actors has reached the point where the innovation systems of most industrialized and post-industry nations have fused into a regime where strict distinctions must be overcome and the tasks and responsibilities of the spheres overlap. Etzkowitz and Leydesdorff (2000) called this model the triple helix model.

Metaphorically, there is a triple helix of three strands that are winding around themselves and each other. The individual strands, similar to the two strands of a DNA double helix are connected by links with each other. In the triple helix model academic institutions, industry and government form strands of the helix. Three aspects are included in the triple helix model. Therefore, the role of academic research institutions in the knowledge society is enhanced to come to an equal status with the other two strands. This equation leads to a closer relationship among the three actors, wherein each of the three spheres takes over parts of the functions of the other two (Etzkowitz 2007). This overlap is implemented by the changing relationships among the individual spheres, which provide feedback regarding the institutional arrangements (Leydesdorff and Meyer 2003).

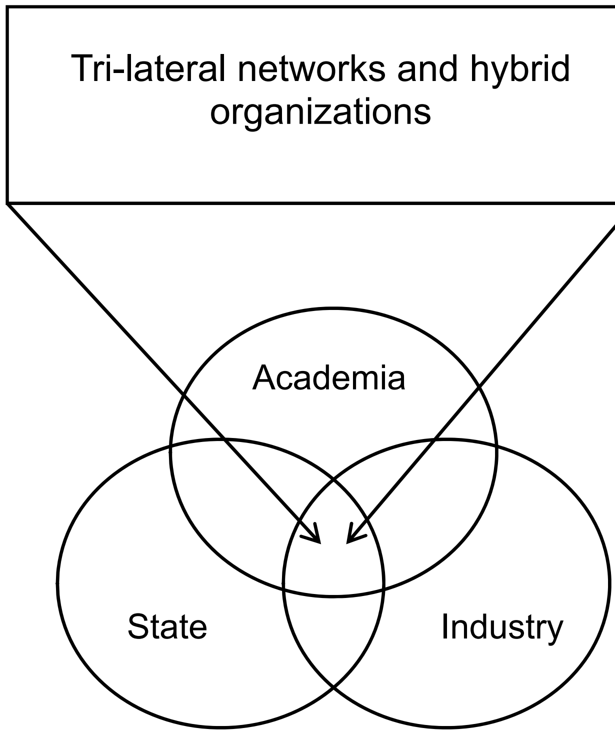
A triple helix system usually arises when university, industry, and government are linked reciprocally to promote mutual benefits (Etzkowitz and Leydesdorff 2000). In the first step, the interest of the three spheres in innovation is the key factor. The triple helix thereby changes its twist with the increasing exposure to technology and knowledge production and thus the growing importance of the university. As a result, the university is the driving coil in the model, whereas industry and government play supportive roles for technological development in the society. By transferring their mutual roles, the relationships in the model evolve from bilateral interactions between university and industry, university and government, and industry and government to trilateral interactions among university, industry, and government (Etzkowitz 2007). In contrast to the double helix, no continuous stability is expected of the triple helix because cultural evolution differs from biological evolution. Because cultural evolution is not controlled by natural conditions but by individuals and groups, it is considerably more complex (Etzkowitz and Leydesdorff 2000).

The intensified relationships of the various players require new structures because the logics and goals of the individual spheres usually differ significantly. To unify these different ideologies it is necessary to create new hybrid organizations that act as links between the spheres. These hybrid organizations manage to unite the logics of different spheres (Samsom and Gurdon 1993).

University spin-offs are a key example of the association of logics. They include the desire for the discovery of new knowledge and because of their origin and their core staff they belong to the university strain. The organizational structure and the primary activity of the university spin-offs, however, lie in the industrial sphere. Accordingly, a university spin-off is also subject to market conditions and logics. Because of the need to distinguish conditions and the frequent promotion of university spin-offs from the state or regional policy with the aim of technology transfer, university spin-offs are linked to the state and are thus actors in the region in which the three spheres overlap. Hence, a university spin-off must act in every sphere. Therefore, it is subject to the logics of individual spheres. This balancing among the spheres is both a challenge and an opportunity. It is difficult to gather divergent logics under one roof. However, there will be opportunities to benefit from the combination of different elements (Samsom and Gurdon 1993).

In addition to the organizational level, the spheres also overlap at the personal micro level. Because organizations consist of people, personal contacts play a significant role in hybrid organizations. In the triple helix model, this results in trilateral networks, which are stretched between people in different spheres. Because the personal backgrounds and the existing expertise vary, a very productive exchange of ideas can arise. Such interdisciplinary collaboration is becoming increasingly important, not only in science but also in the interactions between various actors at the macro level of society. Thus, knowledge, norms, and habitual behaviors can diffuse among the spheres creating trilateral networks in which better understandings of the logics of the other spheres arise. The latter point is especially important for well-functioning technology transfers and cooperation among the spheres because trilateral networks and overlapping authority and responsibilities have the potential for conflict (Wayne and College 2010).

Figure 3: Triple helix model



Etzkowitz and Leydesdorff (2000).

Although it is indisputable that scientific progress is particularly important for technology-driven economies and that the commercialization of academic research is important for this progress, discussion about the tri-lateral networks described above and the commercialization of research has so far mainly focused on the functionality of networks and processes. Likewise, in practice, monetary or other extrinsic incentives are placed in the foreground. This approach, which is strongly oriented to the homo economicus approach, results in the social integration of the individual researcher into the commercialization process of academic research being largely neglected. Especially for scientists, as a peer-oriented group, such a consideration would be urgently necessary (Samsom and Gurdon 1993). In order to close this gap in the literature, an interdisciplinary approach is being pursued in the further course of this dissertation. It does not focus solely on the homo economicus approach, but also takes findings from other sciences, such as sociology or psychology, into account. In doing so, particular environmental factors such as peer effects or academic norms should be emphasized without ignoring other factors such as extrinsic motivation or the type of research being conducted.

Paper 1: Scientists' Motivation and Cooperation between Industry and Science

Abstract

In high technology, such as in the life sciences and nanotechnology, scientific progress is vital for the progress of firms. New inventions are often created in growth industries. In young industries, scientific progress is often driven by universities. Although several previous studies have examined scientific spillovers or cooperation between industry and universities on the organizational level, only a few have focused on individuals. The objective of this paper is to examine the aspects that determine the cooperation between university scientists and industry on the individual level, especially with respect to motivation, scientific output, and internalized norms. Using data gathered from 338 scientists in the life sciences in Germany and Switzerland, we show that extrinsic motivation and classical and entrepreneurial scientific output have positive effects on cooperation, whereas intrinsic motivation and the internalization of Mertonian norms have negative effects on cooperation.

Keywords: Scientists' motivation; Scientific norms; Scientific outputs; Industry-science-cooperation

5.1. Introduction

The scientific environment has radically changed in the last decades (Feller 1997). Universities and their scientists have gained opportunities to participate in the implementation of their research results and inventions (Thursby et al. 2001). However, this deployment also created new requirements for scientists, which not only increased the pressure to deliver practical results, but also induced changes in the conception and ethos of scientific work, which is still difficult for scientists to manage (Shibayama 2012). Therefore, this study will analyze which type of scientists best adapted to these new environmental changes.

In the first part of this study, the theoretical background and the current research are summarized. The focus is on the change in the self-conceptions of universities in new environments, such as the "new" academic capitalism, which has placed new demands on universities (Slaughter and Leslie 1997; Slaughter and Rhoades 2004). The new situation, in which the success and financial support of universities increasingly rely on the practical use of their inventions and research results, also has placed new demands on scientists (Owen-Smith and Powell 2001). The scientists' goals and ethos has been influenced by those developments, and scientists are under increasing pressure to change to align with the university's demands (Renault 2006). Because the motivation of scientists is influenced by different motivational factors, it is difficult to identify the motivational incentives that lead to a favored output. Most previous studies of the cooperation between industries and universities have focused on institutional settings and organizations (e.g. Phan and Siegel 2006; Siegel et al. 2007; Rothermael et al. 2007). Only a few studies have focused on the individual scientist (e.g. Louis et al. 2001; Agrawal and Henderson 2002; Meyer 2005; Allen et al. 2007; Azoulay et al. 2007; Moog et al. 2015). However, no previous study analyzed the motivational and normative aspects as well as the different types of scientific output in relation to each other. The present study aims to fill this research gap by providing a comprehensive examination of these aspects.

Our hypotheses will be derived from theoretical considerations, which include scientists' motivational factors, scientific outputs, and working norms. In the following section of this paper, the dataset and the construction of our indices will be described. In the empirical part of this paper, a regression analysis will be designed to identify the influence of different types of motivation and outputs of university scientists on cooperation with industry. In the last part of this paper, the findings of this study will be summarized and discussed, followed by recommendations for further research.

5.2 Changes in the self-conception of universities

Traditionally, the universities viewed themselves as an institution that generates knowledge, not necessarily for practical use, but for further research (Merton 1973). This stereotypical, and often dogmatic, view of 'ivory tower science', considering that the production of knowledge is mostly for its own sake, began to shift in the 1980s (Karlsson and Wigren 2012). This change in the ethos of universities began in the US, and it was influenced mainly by the Bayh-Dole Act of 1980 (Etzkowitz 1983). This Act gave universities more freedom to benefit from their inventions and knowledge. Before 1980, the intellectual properties and inventions of the members of universities supported by federal governmental funding were the intellectual property of the state, which left no chance for the university or its scientists to benefit directly (Karlsson and Wigren 2012).

The primary goal of the Act was the practical use of inventions of university scientists. Before the Act, only a few of the patents based on university research had been commercialized (Slaughter and Leslie 1997; Owen-Smith 2003). The main rationale for the Act was that if scientists and universities could directly benefit from their knowledge in the form of intellectual properties and patents, they would have a major inducement to commercialize them (Klofsten and Jones-Evans 2000). This appeal would make scientists work harder, because they would benefit from their inventions and thus focus on practically useful inventions that could be commercialized and thus create opportunities for the collaboration of universities and industries (Darby and Zucker 2005).

In relation to this new mode, university policies in the West changed, and the ethos of university research expanded. The new university policies emphasized the generation of more knowledge that could be commercialized (Thursby et al. 2001; Henkel 2007). The money received by state funds, as well as the prestige of the university, thus became more dependent on the economic success of universities (Slaughter and Leslie 1997; Henkel 2007). They were allowed to found spin-offs to commercialize intellectual properties and inventions. The negative side of these policies was that although universities could benefit commercially from their inventions via spin-offs or university-industry partnerships, they had to find new sources of financial income if they did not want to face bankruptcy and lose in the competition against other universities for money or personnel (Hackett 1990). Because of these changes, the cooperation between universities and industries increased considerably (D'Este and Patel 2007; Siegel et al. 2007).

There is still an ongoing discussion about whether the scientific ethos was radically changed or not (e.g. Owen-Smith and Powell 2001a; Trowler 2001; Slaughter and Rhoades 2004; Vallas and Kleinman 2008). From the organizational point of view, the intentions of university research changed on the surface, but scientists have always been motivated by both extrinsic and intrinsic factors (D'Este and Perkmann 2011). Even the "classical archetype" of the scientist is not solely intrinsically motivated. Prestige in the scientific community has always been a major motivation of researchers (Göktepe-Hulten and Mahagaonkar 2010), and cooperation with industry could help to foster their scientific prestige and career (Bozeman et al. 2013). In addition, the distinction between university and industry has been always flexible (Gelijns and Rosenberg 1994; Mowery and Nelson 2004). The question is whether there is a new focus and an (im-)balance in scientists' motivation in favor of extrinsic rewards.

5.3. Different types of motivational factors

Despite the changes, not every scientist is focused on commercialization. Some scientists adopted the new mode of science, while others were not motivated to cooperate with industry (Kenney and Goe 2004; Wright et al. 2008). The motivation of individuals is complex and differs from individual to individual. Motivation is strongly influenced by intrinsic and extrinsic factors. Individuals can be driven by the need to act based on the doctrine of internalized values and norms or external incentives, such as monetary rewards or promotions (Eisenhardt 1989; Balkin et al. 2000). Every individual is motivated by intrinsic as well as extrinsic factors. Nearly all actions taken by an individual are driven by both factors (Lindenberg 2001). The interesting question concerns whether the motivation for a specific behavior tends to be toward the intrinsic pole or the extrinsic pole on this imaginary scale.

The outcomes of individual behavior can be classified according to three categories. First, the materialistic outcome is a strong motivational factor for those who are primarily motivated by extrinsic incentives. This type of motivation is closely related to homo economicus, which is the predominant model used to explain human behavior in economic science. Some previous studies connected this type of motivation and the tendency toward managerial scientific outputs (Owen-Smith and Powell 2001a; Thursby et al. 2001; Lach and Schankerman 2008).

The second type is defined by the affective outcome. Individuals do not act in a specific way because they are motivated by extrinsic incentives, but by the inner need to act because they think ‘it is right’ or to satisfy their curiosity (Levin and Stephan 1991; Stephan 1996; Stephan and Levin 2005). This type of action is only in the first view purpose in its own. Intrinsic motivation, which is closely related to this second type of outcome, is not purely altruistic and does also offer a reward to the individual. The difference is that the reward does not come from an external source but from the inner motivation of the individual. An intrinsic reward could be the positive feeling evoked by having done the ‘right thing’ or by having reached a personal goal or having achieved a professionally satisfying goal (Gulbrandsen 2005; Baldini et al. 2007; Göktepe 2008).

The third type of outcome is related to the social dimension. Individual acting is always embedded in a social context and socially driven actions are neither purely intrinsically nor extrinsically motivated. On one hand, the individual acts in a socially accepted way to be socially rewarded or to avoid social sanctions (related to extrinsic motivation). On the other hand, the individual's actions are guided by internalized social norms (related to intrinsic motivation) (Akerlof and Kranton 2005). In the case of university scholars, the internalization of environmental norms and role models are important influences. This point is particularly important with regard to universities, where a very strong peer-oriented culture is present (Samsom and Gurdon 1993). If their scientific environment favors Mertonian norms or the new mode of academic capitalism, the individual scientist is influenced by other norms of socially accepted behavior. Hence, the propensity to cooperate with industry is influenced by the normative framework of the scientific environment. Huyghe and Knockaert (2015) collected data on 437 research scientists in German and Swedish universities to show that the presence of role models had a positive effect on the engagement on entrepreneurial activities.

The third option is amotivation, which is excluded because this status is not of interest in the present study. Amotivation, or the lack of motivation, does not tend to result in any form of action (Ryan 1995). An amotivated scientist does not produce any knowledge or any other measurable outcome and therefore is irrelevant to the purpose of this study.

Although scientists are rarely motivated by only one kind of motivation, one is often the dominant motivational factor. Therefore, scientists must be predominantly influenced by either extrinsic or intrinsic motivation. If the type of motivation differs from scientist to scientist, it could be a good indicator of the scientific ethos of individuals. Therefore, the question concerns the type of motivation that is related to the type of scientific ethos. In this study, we assume that the type of motivation has a positive/negative impact on the affinity for cooperating with industry. Thus, the following hypotheses are stated:

H1a: In general extrinsically motivated scientists have a high affinity for cooperating with industry.

H1b: In general intrinsic motivated scientists have a low affinity for cooperating with industry.

5.4. Scientists caught between scientific prestige and commercial success?

In context of the changes in university policies, scientists have faced a shifting paradigm of their work environment, and they have had to adjust their self-concept in relation to their field of activity. They straddle two worlds: the Mertonian scientific world and the industrial economic world (Merton 1957; 1973; Merton and Barber 1963; Powell 1996). Moreover, they have to act in both worlds. The problem is that the worlds have different requirements, which scientists have to face in an efficient and effective way (Merton and Barber 1963). Herein lays the potential for (inner) conflict in scientists (Slaughter and Leslie 1997; Pratt and Foreman 2000; Hackett 2005). What is productive in one world can be counterproductive in the other (Liebeskind 2001). For example, to ensure a prestige and career in the scientific community, it is best to publish new inventions or scientific findings as quickly as possible. Hence, scientists ensure that their published findings are cutting-edge and their prestige is enhanced in the scientific community (Karlsson and Wigren 2012). With regard to the economical dimension, in the context of spin-offs or industrial cooperation, it could be best to hide such inventions or scientific findings for as long as possible; otherwise, the scientist would reveal his or her secret and allow competitors to copy the invention, thus losing the competitive advantage (Slaughter et al. 2002; Crespo and Dridi 2007).

Scientists have to find a balanced answer to this problem. The difficulty described above is one example of the conflicted relationship between industry and the scientific community. Prestige versus economic success is just one dimension of this conflict and is strongly related to extrinsic motivation. However, it would not meet the requirements of the complexity of human motivation to point out that only extrinsically motivated scientists have the propensity for industry-science cooperation or the founding of spin-offs. As Shinn and Lamy (2006) pointed out, also mainly intrinsically motivated scientists have a significant interest in such cooperation. However, their interest is not primarily in economic success for their personnel enrichment (Mansfield 1995; Meyer-Krahmer and Schmoch 1998; Fini et al. 2009). Göktepe-Hulten and Mahagaonkar (2010) analyzed a dataset of 2,500 scientists from 67 institutes in Germany. They found that most scientists did not cooperate or were involved in commercialization and patenting because of the monetary benefits but mainly for the positive effects on their prestige inside and outside the scientific community. While also pointing out the importance of prestige effects; in their analysis of data collected from 208 Italian scientists, Baldini et al. (2007) showed that scientists used entrepreneurial outputs to raise their research funds. The scientists did not bolster their research funding to enrich themselves but to enlarge their research capacity, which was strongly correlated with their intrinsic need for ‘puzzle-solving’ (Lindenberg 2001). Their findings showed that scientists often viewed cooperation with industry as an unpleasant imperative. However, intrinsic motivation does not necessarily conflict with spin-offs or links between industry and science. From a social perspective, some scientists like to work together in teams, and they try to find new stimuli by working with different kind of scientists (Owen-Smith and Powell 2001; Baldini et al. 2007; D’Este and Patel 2007). Another intrinsically motivation for cooperating with industry may be the need to make their inventions accessible to the public. Hence, the motivation to cooperate is especially prevalent in fields such as medicine and biotechnology (Zucker et al. 1998; Cockburn et al. 1999; Thursby and Thursby 2011).

In addition to motivational factors are other factors that determine the propensity to cooperate with industry. One important factor is the scientific output of university scholars. In this regard, it is common to differentiate between basic and applied or application-oriented research. Several authors have investigated this topic (e.g. Henderson and Cockburn 1994; Ding 2005). Basic research is often seen as non-commercializable because of its mainly theoretical nature. Hence, in industrial research, applied research is predominant because industry has a strong need to commercialize knowledge (Lee and Bozeman 2005; Bekkers and Bodas Freitas 2008; Rosenberg 1990). Investment in basic research capacity is often seen as a waste of resources by industry. The commercial outcome is highly uncertain, and basic research can be reproduced by competitors more easily than the results and innovations of applied research. Nevertheless, basic research is needed for scientific progress of industries. Without the foundation of basic research, the innovational output would decrease (Baumol 2005; Debackere and Veugelers 2005). To solve this problem, some firms established research and development (R&D) networks with universities. Hence, firms can benefit from basic scientific research results, while universities can benefit from the financial support and network contacts in the economic sector (Mansfield and Lee 1996; Dietz and Bozeman 2005; Audretsch et al. 2002; Lee 2000). In their panel analysis, Stuart et al. (2007) found evidence that biotech firms increasingly tried to build network alliances with universities to benefit from basic research activities. Therefore, there is a trend toward more patenting of basic research results and innovations, so university scientists can trade their findings to the economic sector (Bercovitz and Feldman 2008; Czarnitzki et al. 2009). Those firms were not interested in doing basic research themselves, but they provided better equipment and resources for applied research in order to make innovations marketable. Lam (2010) described scientists as actively seeking relationships with the economic sector. She categorized 734 scientists in UK universities according to the types of their scientific outputs. She categorized the outputs as between entrepreneurial and traditional. Her findings showed that most scientists belonged to hybrid categories and combined entrepreneurial and traditional outputs and norms. According to that, those hybrid scientists built an important link between universities basic science and industries applied research, which led to the commercialization of research results (Thursby and Thursby 2011a). However, the collaboration of academic scientists with industry is controversial. Some scientists have argued that the focus on applied research would weaken basic research and lead to major problems in the long run (Vavakova 1998; Florida and Cohen 1999). Other findings are controversial. Van Looy et al. (2003) for example found evidence for the complementary effect of basic and applied research at universities.

In addition, previous studies found a positive correlation between applied research and entrepreneurial activities. However, the literature review shows different results in relation to this subject. Stern (2004) examined basic and applied research as complementary. Industry was perceived as investing in applied and basic research. The findings showed that a balanced set of research activities was the best choice for commercializing results. Toole and Czarnitzki (2009) analyzed a data sample from the Small Business Innovation Research (SBIR) program. Their findings showed basic research is not profitable for companies. The results showed that basic research has specific characteristics, which limit its transferability to the economic sector. Link et al.'s (2007) analysis of a dataset of 766 university scientists involved in working relationships with industry showed the predominance of applied research results leading to entrepreneurial outcomes. They also underlined the importance of informal technology transfers for industry. Bercovitz and Feldman (2008) researched the patenting activities of 1,780 faculty members in 15 medical departments of US universities. They found a positive significant correlation between basic research and patenting activities. In contrast, Lam (2010) did not find a significant correlation between basic research and the commercial engagement of academic scientists. Czarnitzki et al. (2009) also found evidence for the enlarging patenting activities of university scientists. However, they also observed that such activities did not lead to a significantly higher commercialization rate of university scientists. Carlson et al. (2009) researched the different directions of industrial and academic research. They found that industry mainly took part in economically viable research areas, which produced results that could be patented and commercialized, whereas academic research produced basic results, which were less likely to be commercialized but were fundamental to applied research areas and projects. Following the academic life-cycle model, Stephan and Levin (1996) and Klofsten and Jones-Evans (2000) showed that academic scientists did basic research in their younger years and switched their focus to applied science in their later career. These findings indicated that older scientists were more likely to get involved in entrepreneurial activities than their younger colleagues were because applied science increased the likelihood of becoming an entrepreneur. Nevertheless, the question of whether entrepreneurial scientists are older or younger is also highly controversial. Bekkers and Bodas Freitas (2008) analyzed data collected from 575 scientists in Dutch universities in pharmaceutics and biotech, chemistry, mechanical engineering, and electrical engineering departments and from 454 individuals in industry who were involved in R&D. Their results showed a negative effect of age on the likelihood of cooperation between university and industry. However, Haeussler and Colyvas (2011) found a positive relationship between age and cooperation in their analysis of 2,200 German and UK life scientists, while Gulbrandsen and Smeby (2005) found no significant effect of age on cooperation in their analysis of 1,967 tenured university professors in Norway.

If universities and politicians want scientists to be more productive and intensify their cooperation with industry, they have to account for the different dimensions of individual motivation. Many incentive systems provided by universities or state funds rely on monetary incentives (Lam 2010). They cater to the extrinsic motivation of university scientists and do not account for the intrinsic motivational aspects. If scientists continue to be motivated intrinsically, mainly monetary incentive systems could be highly ineffective.

While some scientists produce classical scientific results, others produce managerial or entrepreneurial results (Ambos et al. 2008). The type of scientific output determinates the value of this knowledge for industry. Application-oriented outputs are easier to commercialize than basic/classical knowledge is. Therefore, it can be assumed that scientists who produce commercializable entrepreneurial outputs are more interesting for industry and have a higher probability of cooperation. Thus, the following hypotheses are stated:

H2a: The managerial and entrepreneurial scientific outputs produced by a scientist have a positive effect on industry-science-cooperation.

H2b: The classical scientific outputs produced by a scientist have a negative effect on the cooperation between industry and science.

In addition to the types of scientific outputs or motivational aspects, internalized norms, habitual behavior of peer-groups, or personal beliefs could influence the decision to cooperate with industry. Accordingly, scientists' opinion if Mertonian norms should be the major guideline for their work and research should have a significant influence on their decision to cooperate with industry. Thus, the following hypothesis is stated (Lewis et al. 2003):

H3: A strong belief in Mertonian norms has a negative effect on the intensity of the cooperation between industry and science.

If the founding of spin-offs and cooperation with industry are desirable from an organizational point of view, it should be interesting to identify the type of scientists who are tending to cooperate.

5.5. Dataset and methodology

The dataset includes information about 1,760 Swiss and German university scientists. The data were collected in 2007 via an online questionnaire that was mailed to 7,464 life scientists in Germany and Switzerland. A total of 454 scientists answered all questions relevant to this empirical analysis, which yielded a response rate of 25.8 percent. The comparison of the sample with data from the German Federal Statistics Office and the Swiss Statistical Office and Life Science Federal Organizations in both countries showed a high degree of similarity between the scientists within the sample used in this paper and the scientists in data sources. Therefore, our dataset should cause no relevant bias in the empirical tests.

To test the hypotheses, the authors created new variables. The first two variables are intrinsic motivation and extrinsic motivation. Second, there are classical scientific outputs and entrepreneurial scientific outputs, and a new variable was created to measure the attitude toward Mertonian norms. To measure the intensity of cooperation with industry, another variable was created.

Scientists' intrinsic motivation was operationalized by the statements of respondents about their attitudes to the following: (1) their attitude to a higher degree of freedom in publically funded science; (2) research in their current job satisfying their own interests; (3) choosing their research projects according to their own interests; (4) motivation to help prevent and treat diseases. The scientists' extrinsic motivation was operationalized by the statements of respondents about the importance of the following: (1) the importance of wage (2) hierarchical position (3) importance for further career by their decision for their current job; (4) lack of success in alternative career paths; (5) research projects oriented to external requirements. Classical scientific outputs were operationalized by the number of articles and reviews published in (1) journals (2) journal reviews (3) articles in anthologies and (4) books. Entrepreneurial scientific outputs were operationalized through responses to the following: (1) whether the scientists' research was application-oriented; (2) whether cooperation with industry enhanced their research; (3) whether scientists benefited from their patents; (4) the probability of creating a university spin-off; (5) the general attractiveness of founding a university spin-off. Scientists' opinions about Mertonian norms were measured through their responses to questions about the following: (1) whether cooperation with industry lowered a scientist's prestige; (2) whether it influenced scientific freedom in a negative way; (3) whether life sciences had become too application-oriented; (4) whether there should be a clear separation between scientists in universities and industry; (5) whether application-oriented research led to the neglect of basic research. Finally, the intensity of cooperation with industry was measured by the following: (1) the extent to which scientists' results were based upon cooperation with industry;

(2) how often they exchanged information with colleagues in industry; (3) whether they used industrial infrastructure and equipment; whether they are engaged in (4) short-term or (5) long-term cooperative projects; (6) whether they imagined working in industry in the next few years.

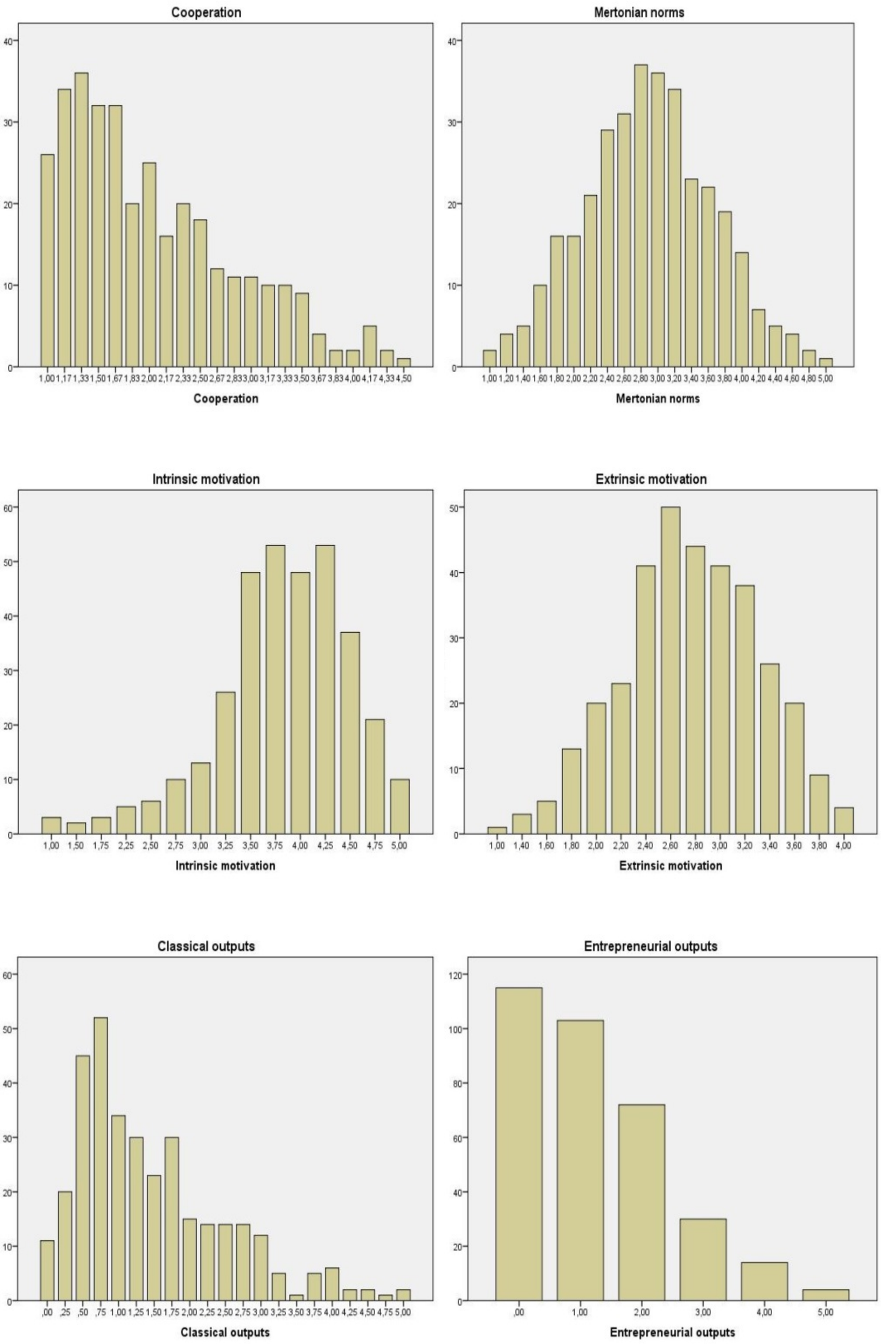
In addition to the main variables were control variables. Not only age, gender, and income but also the national environment could influence cooperation with industry. Therefore, the variables of German or Swiss were added. The last control variable was the question of whether a respondent had children.

Table 3: Descriptives

		Mean	SD	Min	Max
1	Cooperation	2.03	0.82	1.00	4.50
2	Intrinsic motivation	3.81	0.70	1.00	5.00
3	Extrinsic motivation	2.76	0.55	1.00	4.00
4	Classical outputs	1.45	1.04	0.00	5.00
5	Entrepr. outputs	1.22	1.19	0.00	5.00
6	Mertonian norms	2.89	0.77	1.00	5.00
7	Gender (1=female)	0.26	0.44	0.00	1.00
8	Age	51.97	9.31	34.00	89.00
9	German	0.82	0.39	0.00	1.00
10	Income	1.85	0.93	1.00	5.00
11	Children	0.61	0.49	0.00	1.00
12	Family status (1=single)	0.15	0.36	0.00	1.00
13	Scientific award	0.38	0.49	0.00	1.00
14	Public university	0.75	0.44	0.00	1.00
15	TTO	0.85	0.36	0.00	1.00
16	Former colleagues founded Spin-off	1.86	0.95	1.00	5.00
17	Former colleagues in biotech industry	3.00	1.10	1.00	5.00
18	Former colleagues in biotech SME	2.47	1.06	1.00	5.00
19	Spin-off faculty	0.56	0.50	0.00	1.00
N=338					

Regarding the dependent and central variables in the models, the descriptive statistical analysis showed the following results. Not all variables were normally distributed. Although extrinsic motivation and Mertonian norms showed a normalized distribution, cooperation, intrinsic motivation and extrinsic motivation, and entrepreneurial and classical scientific outputs were not normally distributed.

Figure 4: Distribution of dependent and central variables



However, the results of the chi-square test showed that the residuals of the dependent and all central variables were normally distributed. Therefore, there should be no problem with the requirement of normal distribution in our analyses.

Table 4: Chi-Square test on normalized distribution of residuals

	Chi-square	df	Asymtotic significance
Cooperation	176.331	21	.000
Intrinsic motivation	246.201	14	.000
Extrinsic motivation	174.485	14	.000
Classical outputs	270.379	20	.000
Entrepr. outputs	196.852	5	.000
Mertonian norms	183.024	20	.000

With regard to the tests for multicollinearity, neither the variance inflation factor (VIF)-test nor the correlation-matrix indicated multicollinearity. Furthermore, the white test for heteroscedasticity showed no relevant bias caused by homoscedasticity.

Table 5: Test for homoscedasticity

White's test for H0: homoscedasticity; H1: unrestricted heteroscedasticity
Chi-square = 185.74
Prob >Chi-square = 0.3890
df = 181

In section 5.6., a five-step regression model will be presented to analyze the influences of the motivational and output variables as well as the attitudes to Mertonian norms on the intensity of the cooperation of scientists with industry.

Table 6: Pair-wise correlation

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1)	Spin-off	1																		
(2)	Intrinsic	-.031	1																	
(3)	Extrinsic	.214***	.141***	1																
(4)	Classical	.189***	.205***	.069	1															
(5)	Entrepr.	.385***	.104	.090	.283***	1														
(6)	Mertonian	-.214***	.046	-.040	-.014	-.177***	1													
(7)	Gender	-.048	-.148***	-.135**	-.234***	-.166***	.016	1												
(8)	Age	-.041	.146***	-.041	.570***	.256***	-.030	-.214***	1											
(9)	German	-.049	-.175***	-.070	-.040	-.016	-.016	.136**	-.081	1										
(10)	Income	.077	.217***	.101	.446***	.254***	-.059	-.239***	.425***	-.220***	1									
(11)	Children	-.035	.070	.030	.193***	.099	-.062	-.288***	.311***	-.016	.213***	1								
(12)	Family status	.022	-.014	-.033	-.115**	.034	-.074	.117**	.007	.022	-.111**	-.381***	1							
(13)	Award	.051	.186***	.071	.197***	.199***	-.055	.018	.032	-.065	.202***	.000	-.065	1						
(14)	Public university	.029	.055	.031	.142***	.016	-.089	-.033	.133**	.029	.147***	.064	.011	-.015	1					
(15)	TTO	.075	-.061	.006	.019	.022	-.072	-.079	.020	.021	.138**	-.029	.009	.031	.162**	1				
(16)	Colleague spin-off	.195***	.091	.073	.163***	.238***	-.017	-.141**	.192***	-.038	.138**	.123**	.010	-.026	.079	.096	1			
(17)	Colleague industry	.142***	.145***	.003	.036	.114**	-.090	.063	-.013	-.008	.038	-.046	.024	.030	.061	.052	.257***	1		
(18)	Colleague SME	.178***	.044	-.017	.053	.214***	-.121**	-.036	.112**	.011	.056	.122**	-.042	-.002	.018	.074	.506***	.375***	1	
(19)	Spin-off faculty	.105	-.077	.005	.022	.181***	-.017	-.046	-.007	-.109**	.038	.048	-.097	-.008	-.175***	.047	.200***	.047	.125**	1

Significance levels *** p<0.01; ** p<0.05; * p<0.1
N= 338

5.6. Results

Table 7: Regression analysis on cooperation

Cooperation	Model 1	Model 2	Model 3	Model 4	Model 5
Central variables					
Intrinsic motivation		-0.115* [0.066]			-0.120** [0.060]
Extrinsic motivation		0.302*** [0.080]			0.248*** [0.072]
Classical outputs			0.207*** [0.051]		0.210*** [0.049]
Entrepr. outputs			0.254*** [0.038]		0.232*** [0.037]
Mertonian norms				-0.200*** [0.057]	-0.144*** [0.052]
Control variables					
Gender (1=female)	-0.083 [0.108]	-0.056 [0.107]	0.042 [0.100]	-0.084 [0.107]	0.054 [0.098]
Age	-0.010* [0.006]	-0.007 [0.005]	-0.025*** [0.006]	-0.009 [0.005]	-0.022*** [0.006]
German	-0.050 [0.118]	-0.061 [0.117]	-0.146 [0.108]	-0.059 [0.116]	-0.163 [0.106]
Income	0.069 [0.056]	0.062 [0.056]	-0.022 [0.053]	0.063 [0.056]	-0.027 [0.052]
Children	-0.080 [0.106]	-0.081 [0.104]	-0.047 [0.097]	-0.112 [0.105]	-0.070 [0.094]
Family status (1=single)	0.066 [0.136]	0.072 [0.133]	0.054 [0.126]	0.013 [0.135]	0.029 [0.122]
Scientific award	0.069 [0.093]	0.075 [0.092]	-0.109 [0.087]	0.051 [0.091]	-0.103 [0.086]
Public university	0.048 [0.106]	0.042 [0.104]	0.023 [0.097]	0.022 [0.104]	-0.001 [0.094]
TTO	0.071 [0.127]	0.061 [0.125]	0.136 [0.116]	0.052 [0.125]	0.106 [0.113]
Former colleagues founded spin-off	0.106* [0.056]	0.093* [0.055]	0.064 [0.051]	0.107* [0.055]	0.057 [0.050]
Former colleagues in biotech industry	0.047 [0.044]	0.058 [0.043]	0.028 [0.040]	0.041 [0.043]	0.036 [0.039]
Former colleagues in biotech SME	0.074 [0.051]	0.081 [0.050]	0.053 [0.047]	0.060 [0.050]	0.051 [0.045]
Spin-off faculty	0.109 [0.093]	0.098 [0.091]	0.004 [0.086]	0.102 [0.091]	-0.006 [0.084]
R^2	0.078	0.122	0.240	0.111	0.292
F	2.102**	2.976***	6.761***	2.890***	7.309***
Observations	338	338	338	338	338

Standardized effect coefficients; standard errors in brackets. Significance levels *** p<0.01; ** p<0.05, * p<0.1.

Table 7 shows the estimation results of the regression on cooperation. As already mentioned, the regression is divided into five models. The first model includes only the control variables. In this model, only two variables showed a statistically significant effect on the intensity of cooperation with industry. In model 1, age had a negative effect (-0.010) on the intensity of those cooperation, which indicates that older scientists tend to cooperate less with industry. This result is interesting, considering the ongoing discussion of the effect of age with regard to the cooperation between industry and science in the literature (e.g. Lee and Bozeman 2005; Ponomariov and Boardman 2010; Haeussler and Colyvas 2011). The second statistically significant control variable was former colleagues who founded their own university spin-off. While the effect of age was negative, the effect of former colleagues who founded a spin-off was positive (0.106). These findings indicate that peers who are engaged in technology transfer and commercialization activities affect the technology transfer and commercial activities of a scientist. In addition it is interesting that, peers currently working in industry had no significant effect on scientists' cooperation. This finding could indicate the importance of the motivation effect of peers, whereas direct contacts in industry alone do not motivate a scholar to cooperate with industry.

In model 2, the central variables of intrinsic and extrinsic motivational factors were tested, which both showed statistically significant results. As stated in H1a and H1b, intrinsic motivation had a negative effect (-0.115), while a strong extrinsic motivation had a positive effect on the intensity of cooperation with industry (0.302). The positive effect of extrinsic motivation was nearly three times as strong as the negative effect of intrinsic motivation. Several explanations of these findings are possible. One possible explanation is that extrinsic motivation is a stronger driver toward cooperation than intrinsic motivation is a driver away from cooperation. A second explanation is that even if university scientists do not want to cooperate with industry, universities' mission statements often demand technology transfer into practice. Hence, scientists are more or less forced to cooperate with industry, even if they do not like it. Hence, a strong intrinsic motivation has a negative effect on the intensity of cooperation, but contextual factors weaken this effect. Although former colleagues who founded a spin-off again showed a significant positive effect on cooperation (0.093), age had no statistically significant effect in model 2. This finding could be explained by the correlation between age and intrinsic motivation, which decreased the explanatory power of age in model 2.

Model 3 was tested for the influence of classical scientific outputs and entrepreneurial scientific outputs. In support of H2a, entrepreneurial scientific outputs showed a significant positive effect on the intensity of the cooperation between industry and science (0.254). Contrary to H2b, however, classical scientific outputs also showed a significant positive effect on cooperation (0.207). Although the positive effect of entrepreneurial scientific outputs is explained in the theory section, the results for classical scientific outputs probably depended on the discussion of whether the publication and commercialization of research is complementary or contrary, which will be considered at length in the discussion section. With regard to the control variables, in model 3, age was statistically significant and showed a negative effect on cooperation (-0.025), whereas there were no significant peer effects in this model. Taking into account the mediation effects of entrepreneurial scientific outputs and classical scientific outputs, peer effects lose their explanatory importance. Moreover, model 3 had the highest explanatory power of the three models, including only some central variables (models 2 to 4). Accordingly, the types of scientific output had the strongest influence on the intensity of cooperation between university scientists and industry.

Model 4 was tested for the influence of the belief in Mertonian norms on the intensity of cooperation. As expected, a strong belief in Mertonian norms had a significant negative effect on cooperation with industry (-0.200). A strong belief in Mertonian norms, and therefore a classical understanding of the scientist’s role in university and society, decreased the intensity of cooperation between the scientist and industry. With regard to the control variables, again there was a change in statistical significance between age and former colleagues who founded their own spin-offs. Although age was not significant in model 4, the findings showed some positive peer effects on cooperation with industry (0.107).

The final model 5 includes all central and control variables. In this model, all the central variables effects of the previous models were confirmed. As in model 2, intrinsic motivation showed a significant negative effect on cooperation with industry (-0.120), whereas extrinsic motivational factors showed a positive influence on those cooperation (0.248). As in model 3, entrepreneurial scientific outputs (0.232) and classical scientific outputs (0.210) showed significant positive effects on cooperation. As in model 4, a strong belief in Mertonian norms had a negative effect on cooperation (-0.144). It is noteworthy that, while the effects of the other central variables remained relatively stable, the effects of extrinsic motivation and Mertonian norms were relatively reduced. Therefore, the other central variables had a noticeably influence on those two variables. Lastly, with regard to the control variables, in model 5, age was found to have a significant negative effect on cooperation with industry (-0.022).

5.7. Discussion and concluding remarks

The environment of university scientists has changed over the last few decades, and new types of scientists have entered the scientific stage. The new environmental factors created both new opportunities and new requirements for scientists. Regarding the changes, new types of outputs were created, and the role of university science was expanded (Etzkowitz and Leydesdorff 1995). Those changes, accordingly to the new environment, attracted some research. However, to the best of the author’s knowledge, no previous studies have examined the combination of types of scientific outputs and motivational aspects in this clear combination. This paper aimed to close this gap in the research. The only previous paper that addressed this question is the already mentioned work of Lam (2010a). In her paper, she showed three different kinds of motivation and connected them with different types of output. In her study, she showed that financial rewards and the puzzle motivation had positive effects on the commercial activities of university scientists, whereas the prestige-focused motivation showed a negative influence.

The possibilities of creating classical outputs, such as publications in journals, and managerial scientific outputs, such as creating a spin-off or cooperating with industry, are highly discussed in the literature (e.g. Rai 1999; Colyvas et al. 2002; Mowery et al. 2004; Washburn 2008; Göktepe-Hulten and Mahagaonkar 2010; Thursby and Thursby 2011a). For example, the research findings published in journals can be copied by industry or other scientists. Hence, in commercializing research, it might be wiser to withhold research results in order to create managerial outputs. However, Ding and Choi (2011) for example showed a positive relationship between publication and managerial outputs.

Scientists' motivation can be divided into extrinsic and intrinsic motivation. The types of scientific outputs produced by university scientists can be differentiated into classical scientific outputs and managerial scientific outputs. The regression on cooperation showed expected results regarding the extrinsic and intrinsic motivations of scientists. Therefore, extrinsically motivated scientists are more likely to cooperate with industry than intrinsically motivated scientists are. Therefore, H1 is supported. However intrinsic motivation has a significant negative effect on cooperation. Based on these findings, universities and federal funding organizations have to find new, individual, incentive systems for university scientists. A purely financial incentive would not motivate intrinsically motivated scientists to increase their productivity (Göktepe-Hulten and Mahagaonkar 2010). Certainly, it could be a minor motivation because few scientists are driven by only intrinsic motivations. However, few scientists are driven only by extrinsic motivations. Therefore, incentive systems that only focus on extrinsic motivation ignore options to motivate scientists efficiently (Rosenberg 1974). The best way to motivate scientists would be to implement individual hybrid incentive systems that included extrinsic and intrinsic motivational factors. For such incentive systems to be efficient and effective, their providers would have to detect the individual utility function of each scientist. However, the utility function of individuals can only be assumed. Hence, incentive systems can only provide imbalanced, extrinsic, or intrinsic incentives. Therefore, the motivation of scientists must be researched to understand the factors that are indicators in intrinsic motivation and extrinsic motivation.

Although the results for the motivational aspects were clear, the results for the outputs should be discussed. As expected, managerial scientific outputs influenced the probability of cooperating with industry positive. Classical scientific outputs also had a positive effect, which needs further discussion. The research goals of scientists can differ greatly. One goal of scientists could be to create managerial outputs that have a positive influence on cooperation with industry, while others try to build their scientific prestige. Prior research showed no clear tendencies if the goals were in conflict or could be reached simultaneously (Murray 2002; Jensen and Thursby 2004; Calderini et al. 2007; Stephan et al. 2007; Fabrizio and DiMinin 2008). With regard to the classical outputs, similar to managerial outputs, they had a positive effect on cooperation. The results for managerial outputs support H2a, but the effect of classical outputs does not support H2b. Czarnitzky et al. (2007) analyzed a sample of 3,135 German professors regarding their publication and patenting behavior. The findings showed that publication and patenting were not negatively correlated. Although patenting per se was not necessarily a commercialization activity, it was an indicator of actual or planned commercialization activities in the past. Crespi et al. (2011) showed that patenting and publication were complements, at least to some extent and in some fields of research. In application-oriented fields of research there was a crowding-in effect. In basic research-oriented fields, there was a crowding-out effect. These findings indicated the complexity of the question if publication and commercialization are opposites or complements.

A possible explanation for the positive effect of classical outputs on cooperation might be the effect of scientific prestige. Classical outputs, such as publishing in journals, are highly correlated with prestige in the scientific community (Lam 2010; Karlsson and Wigren 2012). Following Powell and Owen-Smith (1998), the higher the scientific prestige, the more likely it is that firms pay attention to the scientist. Hence, the probability of cooperation increases. In their analysis of 82 US and Canadian universities, Wong and Singh (2013) showed that publication was positively correlated with cooperation with industry. This effect occurred especially when scientists had co-published with industry. In their analysis of the cooperation behavior of 301 scientists from the Netherlands, van Rijnsoever et al. (2008) found evidence for the thesis that networking within the scientific community fosters careers, increases the prestige of scientists, and expands networks. The networks are then crucial for cooperation with industry. Therefore, by fostering a scientific career, classical outputs, have direct and indirect effects on a scholar's likelihood of cooperating with industry.

As expected, strong beliefs in Mertonian norms showed a negative effect on cooperation with industry. This finding indicated that the self-concept and habitual norms of scientists at a university are an important influence on individual behavior. If universities want their scientists to cooperate more often and more intensely with industry, they need to create an entrepreneurial climate in their structures and habitual norms. To date most approaches used to stimulate university scientists' cooperation with industry have relied on monetary incentives and ignored habitual norms. If universities want their scholars to cooperate with industry, they have to revise their motivation strategies. Financial rewards can motivate scientists to cooperate with industry, but other incentives, such as sabbaticals, special acknowledgments, and the implementation of university research in practice, should be considered. It is especially crucial to create an environment and norms that support cooperation without offending the followers of Mertonian norms in a faculty.

The findings showed that age had a negative effect on cooperation with industry. Whether cooperating or founding scientists are younger or older is a subject of ongoing debate. The findings may be interpreted in the context of risk aversion increasing with age (Brush and Hisrich 1991; Bates 1995; Jain et al. 2009). The results of models 1, 2, and 4 showed a positive influence of former colleagues who founded a spin-off on scientists' cooperation with industry. Even though this effect was not shown in model 5, it could be interpreted as indicating the importance of peer effects and role models for scientists, which is supported by the literature. For example, in their empirical research, Moog et al. (2015) showed a positive correlation between the peer effects and economic activity of university scientists. Bercovitz and Feldman (2008) showed that the adoption of university agendas concerning commercialization of research could be either symbolic or substantive. Their analysis of data on 1,780 scholars, showed that the compliance with and adoption of those agendas are strongly influenced by the opinions of peers. If peers reject the new mode of academic capitalism, individual scientists would more likely to refuse to adopt this new mode. Stuart and Ding (2006) analyzed the commercial activities of life scientists regarding their spin-off and cooperation activities. They also concluded that peer effects were significant in both. A positive attitude of colleagues and former colleagues toward commercialization has a positive influence on the decision to commercialize research. All other control variables had no significant effect on cooperation with industry.

6. Scientific prestige

Paper 1 showed that both entrepreneurial and classical scientific outputs had a positive influence on cooperation with industry. In the next paper, this effect of classical outputs will be examined in depth. In paper 1, the classical outputs were measured by the number of publications. However, the number of publications is only an indicator of relevant hidden information about the scientists. It could be an indicator of the researcher's productivity or knowledge pool. In the following papers, the publications of a scientist will be used to identify his or her prestige in the scientific community.

Therefore, classical scientific outputs will be examined in depth rather than merely counting the number of publications. Although it is undisputed that publications and publication rates are the best indicators of the prestige of scholars in the scientific community, there is actually a lack of precise indicators that measure the prestige of scientists. The most frequently used indicator, the Impact Factor, is applicable to journal articles published within a short time frame, and it is vulnerable to manipulation (for an overview see Vanclay 2012). Concerning this problem, we constructed an indicator that assigns a certain prestige value to each publication by a scholar in order to overcome the shortcomings of the existing indicators.

The objective of the next paper is to determine whether prestige not only has an effect on commercialization, but also has different effects on different kinds of the commercialization of research. In paper 1, the dependent variable was cooperation. In the next paper, there will be three different dependent variables: founding a spin-off; consulting; and licensing and sales. These variables will be used to measure the commercialization of scientists' research, thus providing deeper insights into one aspect of paper 1. Previous research conducted only superficial examinations of the influence of prestige. Prestige has been measured simplistically, such as the number of publications, or only one kind of commercialization, or even patenting, as a weak indicator of commercialization had been taken into account.

Furthermore, other relevant variables of influence are included in the next paper. Consistent with the thesis as whole, peer effects are also highlighted in this paper. In addition, formal and informal contacts and the type of research are included. Although they are not the focus of this paper, they are identified as important influential factors, and they will be analyzed to determine their influence on the effect of prestige on commercialization.

Paper 2: Scientific Prestige and the Commercialization of University Scientists' Research

Abstract

Star scientists played a major role in the founding and establishment of the biotech industry, but even in today's mature biotech industry, leading university scientists still carry great influence in the field. While there have been multiple analyses on the impact of star scientists in the early era of biotech, few studies address today's established structures in the biotech industry. Our paper seeks to fill this gap and analyze the differences and similarities between the founding years of biotechnology and today's biotech industry. Because of the inadequacy of existing indices, we created a new index to measure the prestige of scientists for our analysis. With data from 441 German and Swiss scientists in the life sciences, we show that besides other variables such as peer effects or informal contacts between scientists and industry, prestige influences the decision for commercializing knowledge and research in different ways.

Keywords: Commercialization of research; Scientific prestige; University-industry cooperation; University spin-offs

6.1. Introduction

The biotech industry is one of the most recent examples of the influence of academic science on industry. While in mature industries, new innovations are often created by firms themselves, the biotech industry almost completely originated from academic science. Although the modern biotech industry has advanced beyond academic science, university-industry links are still important for continued innovation in this sector (Zucker and Darby 2007).

In the 1980s, nearly the entire biotech industry was founded by university scientists via university spin-offs. During this period, the influence of top scientists, the so called 'star scientists', was crucial. They not only established biotechnology as an important field of science, but have also been involved in the major share of entrepreneurial activities (Zucker and Darby 2007). Following this fact, the role of star scientists in the evolution of biotechnology has been highlighted by a number of authors (e.g., Zucker and Darby 2007; Zucker et al. 2002; Schiller and Diez 2010). The wave of entrepreneurship may have ebbed away, but biotechnology is still one of the more innovative scientific and industrial areas. Furthermore, the story of the development of the biotech industry is applicable to newer scientific and commercial fields, such as nanotechnology (Darby and Zucker 2005). Star scientists had a great influence on the formation of biotechnology as a commercial discipline, but as important as they have been and still are, this process required a broader base of scientific human capital to mature and become the prospering industry it is today. While most studies concentrate on the impact of a handful of star scientists, the role of non-star scientists has often been neglected in previous studies. This paper seeks to fill this gap and shed some light on a broader picture of the influence of university scientists on the development of the biotech industry.

The paper is organized as followed. The first section establishes the theoretical framework, after which our hypotheses, derived from the theoretical considerations, will be developed. In the empirical section, our indicator for measuring a scientist's impact will be created and regression analyses will be designed to identify the impact of scientific prestige on three types of commercial activities, namely founding a spin-off, consultancy, and licensing and sales of scientific results (O'Shea et al. 2008; Rothaermel et al. 2007; Phan and Siegel 2006; Jain et al. 2009). In the concluding section, the findings of this study will be summarized and proposals for further research will be discussed.

6.2. You need to be a star!?

The 1980 Bayh-Dole Act in the US was the starting signal for a new mode of academic commercial activity. This legislation provided scientists with more opportunities to participate in the commercial success of their own inventions and research (Thursby et al. 2001). Although university science has been commercialized since there were universities, the Bayh-Dole Act was specifically designed to foster those activities (Audretsch 2014). Emerging from the US, new policies spread to the countries of the so-called western world, which more or less adopted the general spirit of the Bayh-Dole Act. Many universities established policies designated to foster scientists' commercial activities and spillovers from universities into industry. While university spin-offs and collaboration with industry have been an important factor in technological process before, for example, in the founding of Silicon Valley or Route 128 in the US, the biotech revolution created a whole new industrial sector, mainly derived from university spin-offs. Although the success of these policies has been very different from country to country, these policy changes prepared the ground for certain scientists to commercialize their research highly effectively (Karlsson and Wigren 2012).

The most prominent studies related to star scientists are those of Darby and Zucker (see Zucker and Darby 2007 for an overview). With data from the 327 most influential scientists in biotechnology, collected in 1989 during the formative years of biotechnology, they analyzed the impact those scientists had on the development of the biotech industry. For example they found that biotech firms with star involvement, which means that star scientists publicized articles with a firm or with a firm's employee, had a much higher survival rate than those firms without star scientists: the survival rate of firms with star involvement was 80 percent while those firms without star involvement had just a 17 percent survival rate (Darby and Zucker 2001). Similar results were found in an analysis of Californian biotech firms. Firms with deeper star involvement had better results in the case of products on the market, products in development, and employment (Zucker et al. 1998). These effects could also be found for the biotech industry in Japan, in spite of its slightly different industrial structure (Zucker and Darby 2001). In the case of Europe, however, the above findings do not seem to be easily transferable. In the formative years of biotechnology, Europe had a reasonable number of star scientists, but the institutional settings for commercialization and cooperation with industry had been different than in the US (Zucker and Darby 2007). While there was greater independence in the US, that went hand in hand with a greater need to raise external funds, the European universities, excluding the UK and the Netherlands to some extent, relied more on state funds. In most countries, the legal setting did not provide major incentives for university scientists to be involved in commercialization. While some US universities already had a long tradition and professional structures to support commercialization, European universities often had a more conservative attitude toward commercialization and cooperation with industry. Considering that those scientists who cooperated with industry became star scientists in biotechnology, it is not surprising that there have been more star scientists in the US than in Europe. Schiller and Diez (2010) interviewed 39 German scientists working in biotechnology and came to the conclusion that star scientists have a major impact on regional technological development, especially in regard to spin-offs in a region, whereas other forms of industry science collaboration occur frequently, but are less localized. Wong and Singh (2013) linked university industry co-publication to commercialization activities, namely spin-offs, licensing, and patenting. Their data on 82 US and Canadian universities showed a significant impact of co-publication and those commercializing activities.

To gain attention from investors or industry, scientists require a certain prestige in the scientific community. A prominent position or name in this community can help scientists get a foot in the door and foster the progress of commercialization (Lowe and Gonzalez-Brambila 2007). Those scientists with a higher prestige are more likely to speak at scientific, economic or political conferences, which initializes new contacts and expands their social capital. Thus, prestige in the scientific community is one major influencing factor for the commercialization of scientific results (Laudel 2003; van Rijnsoever et al. 2008). While prestige is an abstract construct that is not generally defined, prestige in the scientific community is often measured via publication or citation rates (Teixeira 2011). There is a broad discussion regarding whether the publication and commercialization of scientific results is complementary or contrary (e.g., Murray and Stern 2005; Baldini 2008). The main argument for a contrary position of publication and commercialization is that scientists generating new scientific results need to publish them as quickly as possible before anyone else can do so. The problem is that publicized results can easily be copied by already existing firms (Campbell et al. 2000; Rosenberg 1996). On the other hand, without an adequate prestige, most likely via publication, even the best ideas will stay ideas. For the biotech industry and also most other scientific fields, further studies showed that in most cases, the publication rate and commercialization of knowledge have a complementary relationship (e.g., Stephan et al. 2007; Calderini et al. 2007). Those findings support the importance of star scientists in biotechnology.

Most of these studies, however, focus on the early progression in this industry. The knowledge of those star scientists is in a completely new field of science. Publicized results could not have been easily copied because there were no firms that could do so. While star scientists undoubtedly played an important role in the early biotech industry, a maturing industry needs more than a few experts. Revolutionary breakthroughs are crucial to establishing a new discipline, but afterwards, work based on those breakthroughs is needed to advance scientific progress. Initial breakthroughs often present the most profitable results for commercialization, but subsequent research also produces results that can be commercialized. In addition to the star scientist status, there are certain other important factors in the commercialization of research that are also connected to the prestige of a scientist and must be considered in the question of whether it has an influence on commercialization. Building social capital is crucial for commercialization (Bjørnåli and Aspelund 2012). A higher degree of prestige in the scientific community can help establish networks, thereby building a stock of needed social capital (Cattaneo et al. 2015). Throughout those networks, a scientist comes into contact with more people who can act as role models or provide inspiration. Whether the influence of those peers has a positive or negative correlation with the prestige of an individual is a controversial discussion. Nevertheless, the influence of peers on individuals should not be neglected (Nanda and Sorensen 2010). A final topic linked to prestige that will be analyzed in this paper is the scientist's field of research. Whether the prestige of a scientist influences the type of research they do or the type of research a scientist does influences their prestige is still under debate (Ambos et al. 2008). While this discussion is ongoing, the type of research as a possible influential factor will be included in the analysis in this paper.

Two main obstacles for the commercialization of entrepreneurial ideas are catching the attention of possible customers and partners and the challenge of finding sufficient seed capital to start a business (Sætre et al. 2009). Even if university scientists do wish to commercialize their knowledge via other channels such as consulting or licensing and do not want to start a spin-off, they still need a critical mass of social capital and attention from industry (Cattaneo et al. 2015). Some inventions may sell themselves, but for most ideas, strong support from investors is needed to commercialize scientific knowledge (O'Shea et al. 2005).

Following this consideration, the relationship between publication and commercialization should be analyzed in a now mature industry. Therefore, from the preceding considerations, we derive the following hypothesis:

H1: A higher prestige in the scientific community leads to a higher probability of being involved in commercializing activities.

To test H1, we wished to develop an indicator for scientific prestige based on the publication rate. There are already different approaches that are used to measure the prestige of scientific studies. The most dominant concept is the Impact Factor (Bollen et al. 2009), which has an especially great influence in Europe, where it is used for vocations and the granting of research funds but also in the US. It measures the number of citations an article receives in the reference year for the publications of the two previous years. This number is divided by the total number of all citable articles published in this journal in these two years (Garfield 2006). Thus, the Impact Factor is an elementary citation quote applicable only to journal publications and with a short timeframe. While the influence of the Impact Factor is undoubted, this can be seen as one shortcoming. Other researchers criticize the possibility of manipulating the results through mutual quoting among small groups of scientists (Vanclay 2012). Thus, other approaches try to overcome some of the problems of the Impact Factor. For example the Eigenfactor, which works with an algorithm, weights the citations by their importance and normalizes them by specific fields. It uses a time frame of five years, which is much longer than the Impact Factor, but uses the same database. An even more precise method is represented by the Hirsch Index. It measures the direct citations of each document and does not limit the time frame. There are also many new methods to measure the influence a scientific publication has in the scientific community (see Bollen et. al. 2009 for an overview). Most of them use an algorithm similar to the Google Page Rank algorithm and measure the number of the document queries directly, which measures the average distribution of citations for each article in a journal even better than does the Impact Factor. In sum, all of these indices have their pros and cons. On the contra side for most of them is the problem that they use the same database or only a small own database. Only a few consider problems such as co-authorship and how to rate it, the duration of value that is created through a scientific publication or the number of publications. It is therefore our goal to develop an indicator that can overcome some of those problems and provide an even more realistic instrument to measure scientific prestige based on citations.

To do so, we first chose a different database, the SJR. This is based on a larger database than, for example, the Impact Factor uses, and utilizes additional English language journals and also journals from other countries (Falagas et al. 2008). Like most indicators, the SJR is based on the principle of citations per document. Only quotes that appeared within the last three years after publication from validated publications are included in the calculations. The special feature of the SJR is that the citations of individual journals are weighted, similar to the Google Page Rank for websites. This weighting is determined among other things by the total number of citations and the topic of a journal (González-Pereira et al. 2010). For each citation, the donating journal transfers a certain portion of its prestige to the cited journal. The amount of emitted prestige is thereby determined by the prestige of the journal, divided by the total number of citations. That means a journal of high prestige and a few quotes, transfers significantly more prestige to another journal per individual citation than a journal with low prestige and many citations. The possibility of self-citations to increase the SJR was severely limited by a maximum of 33 percent (González-Pereira et al. 2010). In addition, the intrinsic factor in the SJR's calculation is the total number of documents in a journal, whereas the Impact Factor considers only those documents that are most likely to be cited (Falagas et al. 2008).

Before an indicator can be created to rate the researchers, it is necessary to evaluate which items should be part of it and what speaks in favor or against these items to become part of the indicator. In regards to considering the total number of publications of a single author, there are arguments both for and against it. On the one hand, there is the presumption that if a researcher publishes more, his popularity is rising. This in turn increases the probability of a higher rate of citation, resulting in a higher level of prestige. In addition, a higher number of publications involving frequent examination by reviewers allow one to draw conclusions about the quality of the document. On the other hand, it would not be appropriate to say that every reviewed paper has the same level of quality. This results in the conflict ‘few good versus many bad publications’.

The consideration of the age of a publication is also worth discussion. First, the age of a publication does not necessarily mean that it has less influence on the scientific world or is cited less often after several years; however, this applies more for basic works or particularly significant research. These papers will continue to enjoy an oversized prestige in research and will be cited often. Thus, the age is not to be considered as a factor for the quality. However, this is only true for a few fundamental works; the mass of scientific publications will become insignificant or obsolete with age and will rarely be cited, a phenomenon known as the half-life of scientific publications. In the natural sciences, and thus also in the field of biotechnology, it is the prevailing opinion that the number of citations decreases on average exponentially in a range between five and six years (Hornbostel et al. 2009).

Further, co-authorship, when many authors are involved in a publication, allows various possibilities. On the one hand, co-authorship could be positive because more knowledge is accumulated by a variety of researchers and thereby a stronger research discourse arises. Through this, more and better outcomes are conceivable. Especially large projects, such as the research center European Organization for Nuclear Research (CERN) in Switzerland, have shown that ground-breaking research results can be achieved by many scientists and much participation. On the other hand, it can also be assumed that through a large number of involved researchers, other subjects are pursued. It is also possible that through the division of labor, there is less labor and output per person available. Furthermore, it is known that in practice, authors are often taken as co-authors rather than quoting them, or they are added because of loyalty or respect (Duncan 1980).

Due to the increasing number of publications with multiple authors (Weltzin et al. 2006), it is necessary to consider the input and prestige of the individual author differentiated. This view is based on the assumption that not all authors have contributed the same amount to a publication and do not benefit from the publication to the same extent. In the topic of biological science the "first-last-author-emphasis" is predominant (Tscharntke et al. 2007). In this model, the first named author will receive 100 percent of the journal review as an author review rating and the final listed author receives 50 percent of the journal review as an author review. All other authors obtain only a proportion based on their total number (Tscharntke et al. 2007). There are still other systems by which the authors are sorted. Other systems are either simply an alphabetical order ("equal contribution"), an order by exact proportion to the input ("sequence-determines-credit") or additional information of the actual workload of the authors possible ("percent-contribution-indicated") (Tscharntke et al. 2007). The problem is that while the "first-last-author-emphasis" applies in biotechnology, it does not apply for all publications, which could also be observed in our data input.

Based on the previous discussion, the indicator should therefore contain the following components: SJR, year of publication, number of publications, and the position of the author among other listed authors.

Figure 5: Prestige indicator

$$\sum SJR * 0.5^{\frac{2012-Jahr}{6}} * \begin{cases} pa_{1,10} = \frac{10}{pa} * 0.1 \\ pa_{11,n-1} = 0.05 \\ pa_{n} = 0.5 \end{cases} + \sum \overline{SJR} * 0.5^{\frac{2012-Jahr}{6}} * \begin{cases} pa_{1,10} = \frac{10}{pa} * 0.1 \\ pa_{11,n-1} = 0.05 \\ pa_{n} = 0.5 \end{cases}$$

pa	= position author
SJR	= Scimago Journal Rank
half-life	= 6 (years)
n	= last named author among authors

The indicator shows the prestige value an author who publishes in journals has reached. The indicator uses the journal's SJR. This value is weighted for each publication based on the age of the publication and the position of the author among other listed authors. For journals not ranked (before 1999), an average of the SJR value over the entire data set is formed. These publications should also be included and are weighted by the age of the publication and position of the author. The sum of these values then results in the prestige value. Through the summing, we take automatically account for the number of publications.

The weighting of the age of a publication is obtained by multiplying the SJR with the exponential function of the half-life. We use six years as a half-life, as existing research assumes a half-life of between five and six years in this field (Hornbostel et al. 2009).

To weight the position of the author, a case distinction is operated by the respective position of the author among the listed authors. Here, we merge two systems, after which the authors sort themselves in their papers. The first ten authors are rated proportionally from 100 percent to 10 percent of the SJR value as a prestige value. The final author will receive 50 percent of the SJR value as a prestige value. All other authors will receive 5 percent of the SJR value as a prestige value. Through this mechanism, we merge the "first-last-author-emphasis" and the sorting according to the individual performance.

6.3. Research, contacts and peers

In addition to the effect of prestige on the commercialization of research, there are some other influential factors. One of the most important is the type of research a scientist is doing. It is common to differentiate between basic and applied research in natural science (Ding 2005). While this differentiation may not have such a major impact in the appraisal of worth in the scientific community, for commercialization, applied research is typically far more valuable than basic research (Boardman 2009; Ponomariov 2008). This is for two main reasons. First, basic research results are, as the name implies, basic in nature, so while basic research is indispensable for scientific progress, it is not usually suitable for commercialization (Di Gregorio and Shane 2003; Tijssen 2006). Theoretical knowledge can be valuable in some scientific disciplines, but especially in natural and technological scientific fields, applied research can provide results that can be patented or implemented in prototypes. Following this argumentation, those scientists doing more applied research should have more and better opportunities to commercialize their research because it is more interesting and valuable for the economy (Boardman 2008).

A second argument as to why applied research is better suited for commercialization is that basic research is relatively easily copied by firms or competitors (Slaughter et al. 2002; Crespo and Dridi 2007). Even if theoretical knowledge is patented, the actual protection of this patented knowledge is difficult. Some research is so basic, such as the decoding of parts of the human genome for example, that depending on the interpretation, it could affect nearly every study or product in biotechnology. For practical reasons, some of those basic results cannot be under strict patent protection. The main reason why basic research is difficult to protect and relatively easy to copy, however, is that most results are so universalistic and theoretical useful that an effective control for patent protection is difficult to implement. If a product developed by a competitor uses this protected basic theoretical knowledge, it cannot usually be controlled. Further, patenting always means the publication of knowledge, which more or less provides a blueprint for copying, even if it is not legal.

Although there is a trend towards increased patenting of basic research, which theoretically offers the possibility to commercialize those results, applied research is still more valuable for industry (Bercovitz and Feldman 2008; Czarnitzki et al. 2009). As noted above, basic research is still needed for scientific process. That is why some firms started establishing R&D networks with universities (Audretsch et al. 2002; Lee 2000). Especially for the founding of spin-offs but also for other commercialization activities, applied research is still more promising. In addition to spin-offs, industry is also looking to cooperate with more applied-science oriented scholars and to license the results of applied science (Stern 2004; Toole and Czarnitzki 2009).

On the other hand, basic research is published more frequently. This is because basic research is more difficult to commercialize, and it is positively correlated with the internalization of Mertonian norms. Thus, if a researcher conducts basic research, he is likely to seek classical forms of exploitation of his research, such as the publication of his results in journals. As prestige in the scientific community is primarily based on publication, it can be assumed that there is a positive link between basic research and prestige. This combination would therefore suggest a negative impact of applied research.

However, the empirical results for this case are still controversial. While some studies show a relatively clear tendency for a connection between commercialization activities and applied research, other studies do not find this connection or show even antithetic results. Link et al. (2007), for example, analyzed data from 766 university scientists and showed a significant positive relationship between applied research and entrepreneurial outcomes. On the other hand, Bercovitz and Feldman (2008) examined 1,780 faculty members from 15 medical departments of US universities. They found a positive relationship between basic research and patenting activities, which are often interpreted as the weakest form of commercialization activity. Following their results, applied research shows even an oppositional effect on commercialization, although patenting does not necessarily lead to actual commercialization. Czarnitzki et al. (2009), for example, showed that the patenting activities of universities have increased in recent years. They also show, however, that this has not lead to a significantly higher rate of commercialization of university research. Lam (2010) also found no evidence that basic research could foster the commercialization of university research. In her analysis of 468 university scientists, including motivation and other variables as mediators, basic research shows no significant influence on commercial engagement. Following the theoretical considerations and the empirical results from the literature, we derive our second hypothesis:

H2: A focus on applied research leads to a higher probability of being involved in commercializing activities.

Another influential factor is pre-existing contacts with industry on either a personal or institutional level. Influenced by the former arguments, prestige and type of scientific output, university scholars can become more interesting for industry with respect to cooperation (Sætre et al. 2009). As the industry generally has no clear insight into academic research and the academic sphere as a whole, prestige in the scientific community is a strong indicator of a scientist's importance and status for the industry. Researchers with higher status and prestige tend to be considered more by the industry as cooperative partners and can thus make more contacts into the industry.

As noted above, industry, universities and scientists can benefit in some ways from those cooperations (Lee and Bozeman 2005; Dietz and Bozeman 2005). Industry has a clear interest in new, cutting-edge scientific results, mainly in applied research, while universities want to bolster research budgets and find prestigious partners in industry. Individual scientists can benefit in different ways from this cooperation. Some seem quite obvious, such as raising funds for research or creating income for themselves (Baldini et al. 2007). Certain other effects of cooperation are less direct. In some ways, cooperating with industry can open up new doors for scholars. Cooperation increases the number of contacts in a network and can create new opportunities for commercialization. Thus, cooperation often increases the social capital of scientists. For example, both firms and employees within those cooperating firms are potential partners for spin-offs or further corporate projects (Tijssen 2006). Contacts with investors for further commercialization can also be found in the economy, which especially helps boost spin-offs. Another important effect occurs in industry-science cooperation. University scientists gather a better understanding and knowledge of the mechanisms of the economic sector. This way, they can more easily identify commercial opportunities in their research and learn to act and think in an appropriate economic habitus (Wayne and College 2010).

Many authors highlight the importance of informal contacts between scientists and economy (e.g., Cohen et al. 2002; Thursby and Thursby 2004; Clark 2011). These informal channels are especially vital for the diffusion of newly created knowledge. This process is often performed via regional spillover effects (Audretsch et al. 2012). For example, Schiller and Diez (2010) highlight the significant influence of regional technological advancement on spillover effects. While most studies are only interested in spillovers from a macroeconomic, organizational or industrial perspective, those informal contacts can also be valuable for university scholars. A spillover per se is not well defined. Just because they are conducted through informal channels does not mean they are one sided and provide no returns. Wong and Sing (2013), for example, showed a significant effect of those informal spillovers and indirect pathways on the commercialization of knowledge via spin-offs. We therefore deduce our third hypothesis as follows:

H3: The stronger and more frequent the contacts with industry are, the higher the probability of being involved in commercializing activities.

At the beginning of the paper, the changes in the American legal context with regard to the Bayh-Doyle Act were briefly addressed. In fact, this act changed the self-concept of universities (Carlsson et al. 2013). Most universities changed their agendas from classical Mertonian norms to a more economically oriented set of norms (Etzkowitz 2003; Karlsson and Wigren 2012). The universities' scope of duties were expanded from two assignments, namely teaching and research, to a new field including the commercialization of knowledge to make the results of research useful and assessable to the public (Thursby and Thursby 2011). This trend also changed the function of scientists. Prior to the Bayh-Doyle Act, it would not meet the requirements of universities' research agendas to say that commercialization of universities research had not occurred. Scientists had commercial interests in their research prior to the passage of the act, but the institutionalization of those motives was something new (Henkel 2007; D'Este and Perkmann 2011). In this regard, the scientific environment for scholars at universities changed radically. On the one hand, they gain greater benefits from their own research, but on the other, they must pursue new objectives and expand their focus of activities. The change in the self-conception of universities has been and is still controversial. While the supporters of the new economically oriented modus argue that science should be for practical use and is not an end in itself, supporters of Mertonian norms argue that a strong commercial orientation would erode the scientific fundament and restrain future research

(Debackere and Veugelers 2005; Toole and Czarnitzki 2010; Murray and Stern 2007). In this still ongoing discussion, individual scientists must anchor the direction of their own research and career perspectives. While by today's standards, nearly every university engages in joint ventures with industry or the commercialization of knowledge as part of its official agenda, the actual habitus at a faculty or the university can differ from this official point of view (Göktepe-Hulten and Mahagaonkar 2010; Martinelli et al. 2008; Tijssen 2006).

In the context of prestige within the scientific community, this conflict is particularly interesting. Prestige, as measured by a scientist's published work, can have different effects. Following the star scientists thesis, researchers with higher prestige typically are interested in the commercial exploitation of their research and tend to follow the model of academic capitalism (Zucker and Darby 2007). However, there is also the thesis of the incompatibility of publication and commercialization to consider. Therefore, if a scientist adheres to the Mertonian model, he or she should be critically opposed to the commercialization of university research and thus would rather promote his or her findings in the form of publications (Karlsson and Wigren 2012). Whether a researcher with high prestige tends to commercialize his or her academic discoveries is probably also strongly influenced by the values in his working environment.

Especially for emergent scientists, the habitus at the faculty level or role model provided by colleagues is often more important than an abstract, far-off agenda. Peers have a major influence on the interpretation of a scientist's work for emergent and mid-career scientists (Haas and Park 2010; Bercovitz and Feldman 2008). If a scholar has peers who provide a positive role model for commercialization and entrepreneurial activities, it will affect their views on scientific work and goals and may shift them towards a positive evaluation of those activities (Stuart and Ding 2006; Huyghe and Knockaert 2015). Peer effects as an influential factor for spin-offs or commercialization are often discussed, but are rarely the focus of studies. Moog et al. (2015), for example, showed that peer effects are one of the most important influences on the decision to become an entrepreneur. It can therefore be argued that actual or former colleagues who have experience with cooperating or founding a spin-off could be positive role models in the case of the commercialization of scientific results. In addition, Aschoff and Grimpe (2014) used data from 355 German biotech scientists to analyze the importance of co-authorship. Their results show a positive influence of co-authorship with scientists from industry on their tendency to commercialize research. Their findings would also support the influence of peers. Following those considerations, our fourth hypothesis is as follows:

H4: If a scientist has peers who are involved in commercialization activities, they have a higher probability of being involved in commercialization activities themselves.

6.4. Dataset and methodology

The dataset comprises data for 1,046 Swiss and German university scientists. The data were collected in two waves in 2007 and 2013 via an online questionnaire that was mailed to 7,464 life scientists in Germany and Switzerland and the authors' own data collection. A total of 441 scientists answered all questions relevant to this empirical analysis. Comparing the sample with data from the German Federal Statistics Office and the Swiss Statistical Office as well as Life Science Federal organizations in both countries, we can find a high degree of similarity between the scientists within the sample used in this paper sample and the scientists within other data sources. Therefore, our dataset should include no relevant bias with regard to the empirical tests. As method for the empirical analysis, we have chosen an ordinary least squares (OLS) regression for the first regression on spin-offs and binary logistic regressions for the two regressions on consultancy and licensing and sales. The individual regressions are divided into seven models. The first model always includes only the control variables, while model 2 to model 6 include the central variables for each individual hypothesis and model 7 finally includes all variables.

The commercialization of scientific results is not an accurately defined term. It can range in meaning from simply applying for a patent to creating an actual spin-off. While commercialization is often measured by the number of patents an institution or scholar owns, in our study, we do not use patents as a benchmark for commercialization activities directly. As showed above, especially for basic research, patents are often simply gathering dust, not leading to commercial applications (Ito et al. 2016). Therefore, in this study, only actual commercialization activities, namely the creation of a spin-off or consulting and licensing and sales of research are taken into consideration. To measure the commercial activities of university scientists, we consider three dependent variables. First, we wish to examine university spin-offs as type of commercialization. To predict the propensity to start a spin-off, scholars were asked if they planned to start a spin-off based on their scientific results in the near future. The respondents could select an answer on a Likert scale ranging from 1 (very unlikely) to 5 (very likely). We are aware of the fact that intention based measures are not as precise as factual based measures, but as other studies showed, entrepreneurial intention is a very accurate predictor for actual future entrepreneurial activities (e.g., Krueger et al. 2000; Villanueva et al. 2005). Without the intention to become an entrepreneur, it is very unlikely for scientists to be involved with or start a spin-off. The distribution of the variable shows that 68 percent of the respondents think that it would be very unlikely to start a spin-off, while slightly above 1 percent are quite sure they will start a spin-off. When comparing the values in this sample with the nascent entrepreneur rate of the total population in Germany and assuming that scientists from the natural sciences at universities have less incentive to found a spin-off, we see that these values are quite common among nascent entrepreneurs (Sternberg et al. 2015). The second dependent variable to measure commercialization activities in academia is consultancy. Although consultancy can be considered as a weaker form of commercialization, scientists can provide their knowledge and experience as experts in a certain scientific field and this activity also meets the requirements for the commercialization of university research. In that case, a scientist does not convert their research into a product or found a firm, but transfers scientific expertise into industry and receives a financial reward in return (Bonardo et al. 2011). For this variable, interviewees were asked if they had ever used their research to consult for a firm. The third predictor considered for the commercial activities of scientists, licensing and sales of knowledge to firms, is included next. As discussed above, patenting is not a commercialization activity per se, but it is a requirement for the licensing and sale of research. While there are scenarios in which it is possible to engage in licensing or sales without patenting, a strong connection between these two can be expected (Ito et al. 2016). Here, the respondents were asked if they ever licensed or sold their research to a firm.

To test our hypotheses, we included variables related to the influential factors assumed in the hypotheses. As explained above, individual scientists' prestige is measured by an indicator based on their publications. While the complete indicator can be used for measuring the impact on the propensity to found a spin-off, we must modify the indicator for the other two analyses. Briefly, a central element of the indicator is the depreciation of older publications to find a value for their prestige at the present. For the creation of spin-offs, this is an absolutely accurate indicator because the interviewees were asked if they could imagine founding a spin-off from this point forward. With regard to consulting and the licensing and sale of knowledge, the respondents were asked if those events have ever taken place in the past. In the case of spin-offs, we take the publication index developed in our paper, while for consulting and licensing and sales, we use another similar indicator that is better suited to measure prestige in relation to those two variables. In those cases, the sum of the value of Scimago Journal Rank (SJR) ranked publications is taken as a predictor for the prestige of a scientist. This may create some problems because we know if but not when a scientist did consulting work or licensing and sales. Although those indicators are slightly different, the indicator and the sum of SJR ranked publications is strongly correlated (0.859), so there should not be a bias in the comparison between the results for spin-offs and the other two regressions.

To test the type of research a scientist does, they were asked to state on a Likert scale to what degree they think their research is applied. To identify the intensity of contacts in industry, we use several predictors to create a more complete and differentiated picture of those contacts. First, we asked about the extent to which the scientific results of a scholar depend on cooperation with industry or scientists outside a university. Second, we examined which and how frequently the respondents have contact into industry via (1) informal exchange of information about their research; (2) the use of infrastructure provided by industry, such as laboratories or special machines; and (3) short or (4) long term cooperative projects. Finally, there is a variable for working in secondary employment in an existing spin-off. Because those different contacts are analyzed individually, not only can contacts be examined, but they can also be differentiated by their individual effects on social capital and networks. For example, informal exchange with industry requires a different level of personal contacts than cooperative projects. While informal contacts often provide strong ties to each other, the use of infrastructure or cooperative projects are more formalized (Ubfal and Maffioli 2011). That does not mean that one of the two necessarily provides more support for commercialization, but it could be interesting to analyze if there are differences between formal and informal contacts regarding the three types of commercialization. For the last hypothesis, the peer effects are examined. Those effects are measured by questions about how many former colleagues have (1) founded a spin-off; do (2) work in big pharma or (3) in a biotech small medium-sized enterprises (SME) (Likert scale from 1 to 5). In addition to those individual peer effects, we also included the question of whether a scientist’s fellow faculty member has created a spin-off in the past. That way, we can also differentiate between personal and institutional peer effects.

In addition to these central variables, control variables are included in the regressions. We consider other indicators of prestige within the scientific community, such as whether a scientist has ever gotten a research scholarship or won a scientific award. Because we only have data if a scientist qualifies in one of those two categories without details regarding the specific award or scholarship, we can view both as less precise indicators for a certain level of prestige. For example, a scientific award could range from a global recognition, such as the Nobel Price, to a student award on the university level. Therefore, data concerning the scientific awards and research scholarships is clearly limited and cannot be included in our prestige index. However, especially for industry, with its limited insights into universities, both could also be indicators of prestige within the scientific community and should not be neglected in our analysis. Two variables related to networks and peer effects are the questions of whether a scholar has been abroad for a research project and to what extent their scientific results rely on international cooperation. A more internationalized network often provides a wider range of contacts into the industry and contacts to university scientists who exhibit a more positive attitude towards commercialization of research than is present at the scientist's university. Other control variables are targeted mainly on the founding of spin-offs. One argument for entrepreneurship is dissatisfaction in a current job. Thus, interviewees were asked if they are happy in their current job and if they can choose their research freely or must orientate their research to federal programs or the needs of the biotech industry. Because our dataset includes public universities and scientists from research facilities, the type of institution where a scientist works could prove influential. Hence, there is a variable specifying if a respondent is from a public university. Similarly, we must control for university affiliation a scientist works because the university systems in Switzerland and Germany are slightly different. Therefore, a variable is included to control possible effects conducted by the university system. There are also several common control variables such as gender, income, family status, if someone has children, and age included in the regressions.

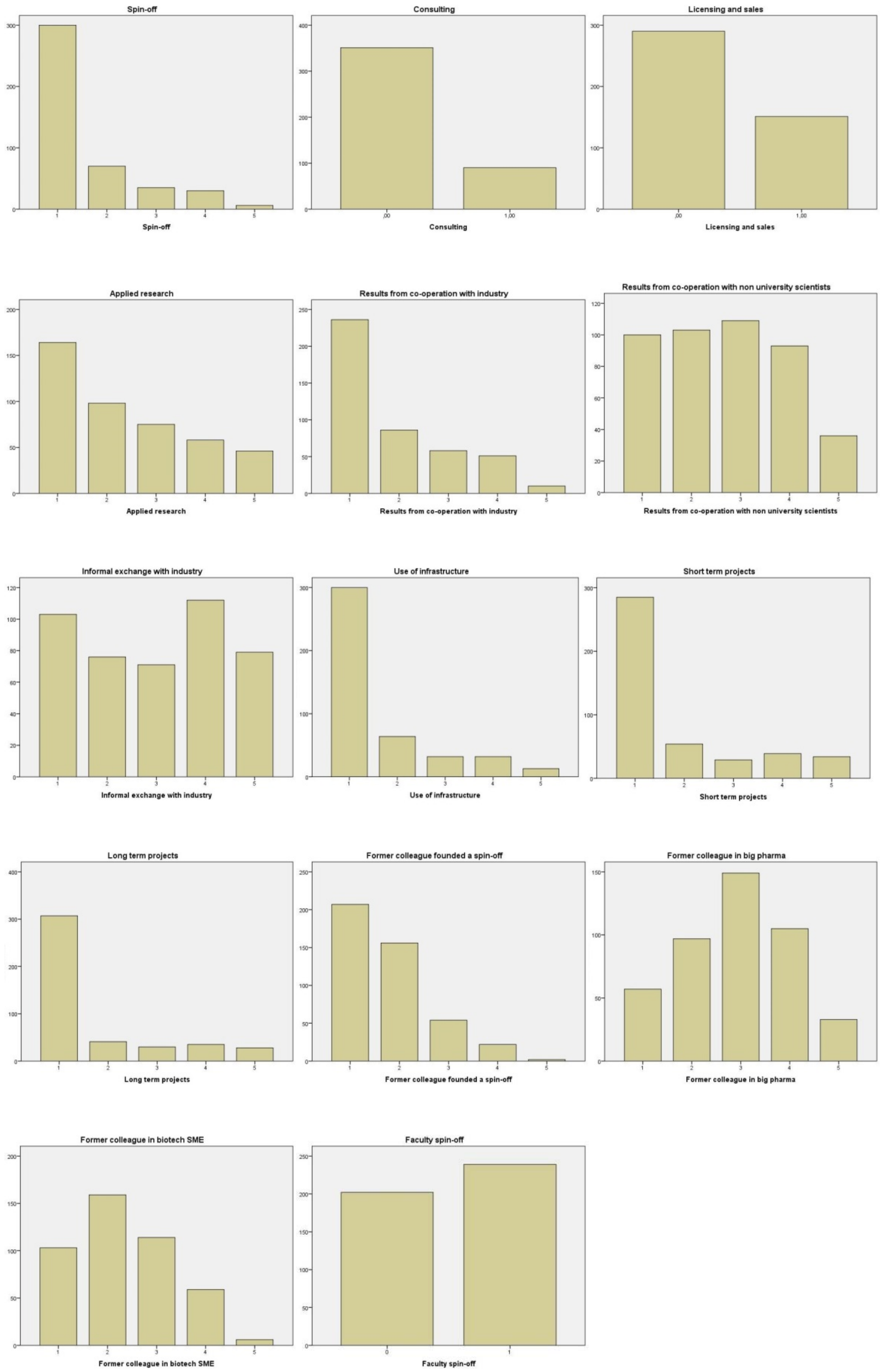
Concerning the dependent and central variables in the models, the descriptive statistics show the following results.

Table 8: Descriptives

		Mean	SD	Min	Max
1	Consulting	0.20	0.40	0.00	1.00
2	Licensing and sales	0.34	0.48	0.00	1.00
3	Spin-off	1.58	0.99	1.00	5.00
4	Publication index	5.46	6.51	0.02	41.67
5	Publication index (Sum)	26.56	39.81	0.00	315.34
6	Applied research	2.37	1.37	1.00	5.00
7	Results from cooperation with industry	1.90	1.15	1.00	5.00
8	Results from cooperation with non-university scientists	2.69	1.26	1.00	5.00
9	Informal exchange with industry	2.97	1.44	1.00	5.00
10	Use of infrastructure	1.63	1.08	1.00	5.00
11	Short term projects	1.83	1.32	1.00	5.00
12	Long term projects	1.72	1.26	1.00	5.00
13	Former colleague founded a spin-off	1.77	0.88	1.00	5.00
14	Former colleague in big pharma	2.91	1.13	1.00	5.00
15	Former colleague in biotech SME	2.33	1.02	1.00	5.00
16	Faculty spin-off	0.54	0.50	0.00	1.00
17	Secondary employment spin-off	0.09	0.28	0.00	1.00
18	Research scholarship	0.61	0.49	0.00	1.00
19	Scientific award	0.37	0.48	0.00	1.00
20	Research project abroad	0.86	0.34	0.00	1.00
21	International cooperation	3.41	1.10	1.00	5.00
22	Job satisfaction	3.37	0.92	1.00	5.00
23	Choose own research subjects	3.73	1.05	1.00	5.00
24	Demands from federal programs	2.56	1.23	1.00	5.00
25	Demands from industry	1.95	1.10	1.00	5.00
26	Public university	0.76	0.42	0.00	1.00
27	German	0.81	0.39	0.00	1.00
28	Gender (1=female)	0.29	0.45	0.00	1.00
29	Income	1.78	0.85	1.00	5.00
30	Family status (1=single)	0.15	0.35	0.00	1.00
31	Children	0.59	0.49	0.00	1.00
32	Age	50.89	9.22	34.00	89.00
N=441					

While the spin-off variable itself is not normally distributed, the chi-square test shows that the residuals of the variable are normally distributed. Following the assumption that the spin-off variable can be handled as quasi-metric, there should be no reason not to use an OLS-regression in regression 1.

Figure 6: Distribution of dependent and central variables



The results of the chi-square tests on the normal distribution of the residuals of variables show significant effects for all non-dichotomous dependent or central variables, except for the publication index and the prestige indicator. Because every value for the publication index and the prestige indicator appears only once (or in only four cases twice), a graphic presentation is not included in the above figure. Due to the fact that the publication index and the prestige indicator are not dependent variables, there should be no issues concerning the normal distribution of residuals in the regression models.

With regard to the tests for multicollinearity, neither the VIF-test nor the correlation-matrix indicated multicollinearity.

While heteroscedasticity should generally be no problem for the second and third regression, due to the nature of logistic regressions, the first linear regression must be tested for homoscedasticity. For the first regression, the white test for heteroscedasticity shows that there is no relevant bias due to the premise of homoscedasticity.

Table 9: Test for homoscedasticity

White’s test for H0: homoscedasticity; H1: unrestricted heteroscedasticity
Chi-square = 426.40
Prob >Chi-square = 0.4582
df = 424

Table 10: Pair-wise 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
1	Consulting																															
2	Licensing and sales	.168***																														
3	Spin-off	.206***	.058																													
4	Publication index	.042	.059	.007																												
5	Publication index (Sum)	.118*	.133**	-.007	.859***																											
6	Applied research	.191***	.047	.219***	-.119*	-.138**																										
7	Results from cooperation with industry	.276***	.182***	.195***	-.009	-.013	.406***																									
8	Results from cooperation with non-university scientists	.010	.085	.019	.000	-.025	-.045	.073																								
9	Informal exchange with industry	.275***	.246***	.218***	.086	.132**	.254***	.448***	.142**																							
10	Use of infrastructure	.196***	.091	.068	-.001	.006	.231***	.459***	.062	.381***																						
11	Short term projects	.263***	.247***	.178***	-.049	-.020	.293***	.517***	-.018	.389***	.342***																					
12	Long term projects	.301***	.237***	.228***	.086	.094*	.231***	.563***	.055	.383***	.383***	.529***																				
13	Former colleague founded a spin-off	.128**	.175***	.235***	.114*	.124**	.073	.128**	.147**	.190***	.082	.151**	.201***																			
14	Former colleague in big pharma	.046	.109*	.008	.039	.060	-.037	.079	.022	.116*	.090	.100*	.075	.155**																		
15	Former colleague in biotech SME	.083	.177***	.134**	.058	.063	.015	.061	.050	.134**	.033	.046	.113*	.400***	.319***																	
16	Faculty spin-off	.082	.126**	.135**	.106*	.089	-.025	.063	.097*	.049	.019	.032	.140**	.262***	.080	.113*																
17	Secondary employment spin-off	.286***	.136**	.148**	.046	.056	.082	.112*	.012	.124**	.046	.132**	.145**	.191***	.154**	.106*	.055															
18	Research scholarship	.013	-.040	-.019	.217***	.205***	-.189***	-.137**	.078	-.076	-.053	-.175***	-.096*	-.001	.055	.011	-.026	-.119*														
19	Scientific award	.163***	.114*	.046	.298***	.294***	-.081	-.021	.006	.047	-.006	-.025	.038	-.001	.049	.018	.002	.068	.156**													
20	Research project abroad	.070	.049	.031	.106*	.112*	-.080	.027	.096*	.038	.052	.003	.065	.015	.056	-.091	.007	.004	.212***	.069												
21	International cooperation	.058	-.011	.078	.130**	.155**	-.028	.072	.359***	.093	-.003	-.068	.014	.017	.032	.008	.052	.011	.175***	.102*	.075											
22	Job satisfaction	.001	.051	-.004	.285***	.277***	-.112*	-.024	.093	.073	.106*	-.076	.023	.069	.058	.023	-.046	.045	.151**	.148**	.093	.120*										
23	Choose own research subjects	.011	-.076	-.048	.245***	.248***	-.267***	-.160***	.016	-.044	.010	-.091	-.072	-.014	.041	-.061	-.070	-.022	.204***	.136**	.145**	.093	.280***									
24	Demands from federal programs	.079	.174***	.155**	-.053	-.055	.213***	.124**	.137**	.084	.005	.168***	.120*	.206***	-.024	.062	.197***	.043	-.068	-.048	.037	.078	-.209***	-.506***								
25	Demands from industry	.168***	.127**	.179***	-.030	-.025	.416***	.411***	.050	.245***	.263***	.239***	.317***	.164***	.113*	.162***	.128**	.118*	-.082	-.039	-.014	-.044	-.095*	-.248***	.192***							
26	Public university	.109*	-.106*	-.001	-.054	.025	-.016	.052	-.245***	.045	.010	.021	.004	.029	.031	.040	-.200***	.056	.038	-.064	-.049	-.076	-.029	.123**	-.162***	.055						
27	German	.074	-.064	-.004	-.111*	-.141**	.036	.001	-.024	-.045	-.088	-.015	.007	-.056	-.008	.062	-.087	.046	-.151**	-.062	-.108*	-.088	-.103*	-.074	-.045	-.087	.071					
28	Gender (1=female)	-.133**	-.107*	-.125**	-.125**	-.121*	-.052	-.095*	-.086	-.155**	.005	-.096*	-.107*	-.106*	.055	-.054	-.053	-.087	-.040	-.003	-.027	-.112*	-.033	-.073	-.095*	-.074	.020	.089				
29	Income	.196***	.084	.047	.296***	.331***	-.041	.100*	.017	.136**	.059	.114*	.107*	.129**	.013	.021	.000	.069	.140**	.162***	.108*	.054	.154**	.239***	-.080	.021	.115*	-.226***	-.245***			
30	Family status (1=single)	-.017	-.026	.007	-.089	-.087	.029	-.047	.026	-.028	-.036	.015	-.032	.014	-.001	-.015	-.073	.080	.026	-.060	-.024	-.018	-.052	-.024	.005	.044	-.014	-.030	.081	-.106*		
31	Children	.063	.042	.000	.056	.112*	-.017	.041	-.055	-.006	-.008	.004	.048	.142**	-.001	.107*	.056	.089	.002	.036	.063	.017	-.023	.014	.027	.014	.074	.069	-.234***	.185***	-.341***	
32	Age	.217***	.214***	-.037	.010	.086	-.057	.032	.042	.135**	-.002	.135**	.117*	.225***	.005	.082	-.005	.075	.100*	.021	.062	.020	.048	.114*	-.042	-.011	.082	-.063	-.201***	.434***	-.039	.266***

Significance levels *** p<0.01; ** p<0.05; * p<0.1
N= 441

6.5. Results

Table 11: Regression analysis on founding of spin-offs

Spin-off	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Central variables							
Publication index		-0.007 [0.008]					-0.014* [0.008]
Applied research			0.118*** [0.038]				0.095** [0.039]
Results from cooperation with industry				0.105** [0.045]			0.001 [0.056]
Results from co-operation with non university scientists				-0.038 [0.041]			-0.059 [0.040]
Informal exchange with industry					0.092** [0.037]		0.081** [0.037]
Use of infrastructure					-0.070 [0.049]		-0.075 [0.049]
Short term projects					0.033 [0.043]		0.022 [0.044]
Long term projects					0.104** [0.046]		0.090* [0.047]
Former colleague founded a spin-off						0.196*** [0.061]	0.184*** [0.061]
Former colleague in big pharma						-0.060 [0.043]	-0.063 [0.043]
Former colleague in biotech SME						0.053 [0.051]	0.057 [0.050]
Faculty spin-off						0.109 [0.098]	0.138 [0.097]
Control variables							
Secondary employment spin-off	0.410** [0.170]	0.415** [0.170]	0.398** [0.168]	0.394** [0.169]	0.336* [0.168]	0.336** [0.170]	0.282* [0.167]
Research scholarship	-0.020 [0.102]	-0.008 [0.103]	0.018 [0.102]	0.013 [0.102]	0.040 [0.102]	-0.015 [0.100]	0.088 [0.101]
Scientific award	0.075 [0.099]	0.093 [0.102]	0.085 [0.098]	0.072 [0.099]	0.048 [0.098]	0.085 [0.098]	0.099 [0.098]
Research project abroad	0.058 [0.140]	0.058 [0.140]	0.073 [0.138]	0.044 [0.139]	0.022 [0.138]	0.102 [0.138]	0.099 [0.136]
International cooperation	0.052 [0.044]	0.054 [0.044]	0.050 [0.043]	0.054 [0.046]	0.041 [0.043]	0.056 [0.043]	0.068 [0.045]
Job satisfaction	0.006 [0.054]	0.014 [0.055]	0.007 [0.053]	0.006 [0.053]	-0.002 [0.053]	-0.012 [0.053]	0.008 [0.053]
Choose own research subjects	0.035 [0.056]	0.041 [0.056]	0.050 [0.055]	0.048 [0.056]	0.039 [0.055]	0.019 [0.055]	0.051 [0.055]
Demands from federal programs	0.107** [0.045]	0.109** [0.045]	0.097** [0.045]	0.111** [0.045]	0.090** [0.045]	0.060 [0.046]	0.049 [0.046]
Demands from industry	0.132*** [0.044]	0.133*** [0.044]	0.079* [0.047]	0.094** [0.047]	0.081* [0.046]	0.106** [0.044]	0.031 [0.049]
Public university	0.029 [0.113]	0.022 [0.113]	0.033 [0.112]	-0.007 [0.115]	0.014 [0.111]	0.045 [0.113]	-0.011 [0.115]
German	0.094 [0.124]	0.095 [0.124]	0.074 [0.123]	0.086 [0.124]	0.060 [0.122]	0.105 [0.122]	0.070 [0.121]
Gender (1=female)	-0.211* [0.109]	-0.216** [0.110]	-0.197* [0.108]	-0.203* [0.109]	-0.155 [0.109]	-0.201* [0.108]	-0.155 [0.107]
Income	0.057 [0.065]	0.070 [0.067]	0.051 [0.064]	0.041 [0.065]	0.038 [0.064]	0.056 [0.064]	0.063 [0.065]
Family status (1=single)	-0.013 [0.141]	-0.019 [0.141]	-0.016 [0.139]	0.006 [0.140]	0.008 [0.139]	-0.026 [0.139]	-0.017 [0.136]
Children	-0.073 [0.106]	-0.071 [0.106]	-0.064 [0.105]	-0.074 [0.106]	-0.032 [0.105]	-0.119 [0.105]	-0.086 [0.104]
Age	-0.008 [0.006]	-0.009 [0.008]	-0.007 [0.006]	-0.008 [0.006]	-0.012** [0.006]	-0.012** [0.006]	-0.015*** [0.006]
R^2	0.086	0.088	0.107	0.100	0.127	0.125	0.138
F	2.503***	2.400***	2.971***	2.592***	3.047***	3.153***	3.304***
Observations	441	441	441	441	441	441	441

Unstandardized effect coefficients; standard errors in brackets. Significance levels *** p<0.01; ** p<0.05, * p<0.1.

Table 11 shows the estimation results for the regression models on the propensity to found a spin-off. In model 1, including only the control variables, there are four statistically significant variables. First, it is interesting to see that external demands seem to have an influence on the willingness to become an entrepreneur. Demands from federal programs show a positive effect on founding a spin-off (0.107). This could come with the specification of those programs, which often promote transferring knowledge into practice. The argumentation also stands for the positive effect of demands from industry (0.132). If practical useful knowledge is generated, transferring that knowledge into practice, e.g., via a university spin-off, is more likely. The third significant control variable is secondary employment in a spin-off (0.410). Here, a first indication of the importance of learning effects and peer effects, which will be specifically tested in later models, is already given. The last significant control variable in model 1 is the gender variable. Being female has a negative effect on founding a spin-off (-0.211). This effect is in line with the general literature on gender effects on entrepreneurship (e.g., Murray and Graham 2007; Giuliani et al. 2010). In model 2, testing for the effects of prestige on founding a spin-off, the prestige indicator shows no significant effect. This is especially interesting because in the seventh and final model, the indicator has a negative effect on founding a spin-off. It therefore seems that mediator variables are needed to completely understand the effect of prestige on founding a spin-off. While prestige shows no significant effect, the control variables mentioned earlier are also statistically significant in model 2 (demands from industry (0.133), demands from federal programs (0.109), secondary employment in a university spin-off (0.415) and the gender variable (-0.216)). Model 3 tests for the type of research a scientists does. As expected, doing applied research has a positive effect on founding a spin-off (0.118). This result is in line with H2. While the four control variables forming model 1 are still significant, the effect of demands from industry is noticeably reduced (0.079), which speaks to an overlay of the effect by the type of research a scientist does, which is only logical considering the need from industry for applied research. The effects of the other control variables stay relatively stable (demands from federal programs (0.097), secondary employment in a university spin-off (0.398) and the gender variable (-0.197)). In model 4, the effects of direct cooperation in scientists' research should be analyzed. While research cooperation with industry have a positive effect (0.105) on founding a spin-off, cooperation with other non-university scientists has no significant effect. It therefore appears that even if there is no economic cooperation between industry and university scientists, there are positive effects on the willingness to found a spin-off. In regard to the control variables, the coefficients stay relatively stable. Demands from federal programs (0.111), demands from industry (0.094) and secondary employment in a spin-off (0.398) show positive effects, while being female (-0.203) has a negative influence on spin-offs. In model 5, the effects of formal and informal industry contacts show a statistically significant effect on founding a spin-off. While informal contacts in general show a positive effect (0.092), the effects of formal contacts are slightly more diverse. Only long term projects show a significant effect (0.104), while short term projects have no significant effect. This could be explained by the fact that the learning effects to overcome the cognitive distance between the habitus of university and industry are more likely to be reduced the more intense and longer cooperation between scholars and firms continue. Hence, long term projects should have a stronger effect on the reduction of cognitive distance via learning effects (Meyer 2003). Regarding the control variables, there are some interesting mediator effects. While demands from industry (0.081) and federal programs (0.090) as well as secondary employment in a spin-off (0.336) are still statistically significant, the gender variable is not in this model. It appears that gender is less important when contacts into industry filter the effects of gender on founding a spin-off. One possible explanation could be that a scientist is reduced to his or her professional role in (formal) relationships with industry. That way, pure expertise is more important than other personal traits such as gender. Therefore, gender is less important when mediated by contacts in industry. A second interesting effect in this model regarding the control variables is the statistically significant effect of age. While not significant in previous models, in model 5, age has a negative effect (-0.012). In model 6, testing for peer effects, having a former colleague who founded his or her own university spin-off has a significant positive effect on founding a spin-off (0.196), while former colleagues working in a biotech SME or in big pharma has no significant effect. In this model, demands from federal programs show no statistically significant effect. All other control variables mentioned above show significant effects. While orientation to the demands of industry (0.106) and secondary employment in a spin-off (0.336) have positive effects, the gender variable (-0.201) and age (-0.012) show negative effects on founding a spin-off. The final seventh model includes all variables. As in model 3, applied research has a positive effect on founding a spin-off (0.095). The positive effects of informal contacts (0.081) and formal contacts via long term joint projects (0.090) also appear in model 7. The same goes for peer effects of former colleagues who founded their own spin-offs (0.184). As mentioned above, it is interesting that prestige requires the mediation of other central variables to have a statistically significant effect. In the final model, prestige has a somewhat surprising negative effect on founding a spin-off (-0.014). This is a result that will require more detailed discussion below. While the effects of secondary employment in a spin-off (0.282) and age (-0.015) are statistically significant in model 7, the gender variable, orientation to the demands of industry and federal programs are not significant. Especially for the last two control variables, this is surprising and can only be explained by the combined influence of the central variables on the effect of those control variables. As seen in the correlation matrix, there are some correlations between demands from industry and federal programs and certain central variables that could explain the non-significant effects in model 7.

Table 12: Logistic regression analysis on consulting

Consulting	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Central variables							
Publication index		0.003 [0.003]					0.003 [0.004]
Applied research			0.367*** [0.110]				0.276** [0.124]
Results from cooperation with industry				0.486*** [0.124]			0.099 [0.162]
Results from co-operation with non university scientists				-0.112 [0.122]			-0.078 [0.131]
Informal exchange with industry					0.241** [0.121]		0.201 [0.127]
Use of infrastructure					0.242* [0.137]		0.231 [0.142]
Short term projects					0.135 [0.119]		0.095 [0.126]
Long term projects					0.178 [0.119]		0.136 [0.130]
Former colleague founded a spin-off						-0.088 [0.178]	-0.194 [0.190]
Former colleague in big pharma						-0.033 [0.133]	-0.080 [0.140]
Former colleague in biotech SME						0.040 [0.151]	0.062 [0.158]
Faculty spin-off						0.515* [0.297]	0.578* [0.322]
Control variables							
Secondary employment spin-off	1.679*** [0.410]	1.681*** [0.412]	1.718*** [0.422]	1.715*** [0.422]	1.629*** [0.438]	1.672*** [0.422]	1.730*** [0.459]
Research scholarship	-0.077 [0.310]	-0.103 [0.312]	0.054 [0.320]	0.097 [0.323]	0.131 [0.335]	-0.085 [0.314]	0.177 [0.347]
Scientific award	0.907*** [0.286]	0.853*** [0.292]	0.968*** [0.293]	0.966*** [0.296]	0.919*** [0.305]	0.933*** [0.289]	0.955*** [0.322]
Research project abroad	0.570 [0.471]	0.561 [0.470]	0.636 [0.480]	0.518 [0.486]	0.474 [0.494]	0.604 [0.482]	0.566 [0.518]
International cooperation	0.144 [0.134]	0.134 [0.135]	0.133 [0.137]	0.109 [0.146]	0.119 [0.143]	0.137 [0.135]	0.115 [0.156]
Job satisfaction	-0.121 [0.158]	-0.154 [0.162]	-0.110 [0.161]	-0.113 [0.162]	-0.181 [0.168]	-0.088 [0.161]	-0.147 [0.178]
Choose own research subjects	0.058 [0.170]	0.039 [0.172]	0.133 [0.173]	0.103 [0.174]	0.025 [0.178]	0.043 [0.173]	0.073 [0.187]
Demands from federal programs	0.187 [0.138]	0.176 [0.139]	0.201 [0.141]	0.221 [0.143]	0.146 [0.148]	0.171 [0.143]	0.166 [0.157]
Demands from industry	0.352*** [0.125]	0.354*** [0.125]	0.190 [0.134]	0.163 [0.138]	0.135 [0.139]	0.347*** [0.129]	0.030 [0.151]
Public university	0.704* [0.371]	0.700* [0.371]	0.785** [0.384]	0.643* [0.388]	0.709* [0.385]	0.847** [0.383]	0.900** [0.414]
German	1.069*** [0.404]	1.100*** [0.408]	1.031** [0.409]	1.071** [0.415]	1.181*** [0.427]	1.092*** [0.408]	1.187*** [0.441]
Gender (1=female)	-0.501 [0.355]	-0.499 [0.356]	-0.457 [0.359]	-0.374 [0.362]	-0.395 [0.372]	-0.506 [0.358]	-0.323 [0.383]
Income	0.323* [0.179]	0.300* [0.181]	0.322* [0.182]	0.241 [0.185]	0.258 [0.190]	0.328* [0.180]	0.248 [0.195]
Family status (1=single)	-0.220 [0.419]	-0.218 [0.420]	-0.211 [0.434]	-0.124 [0.430]	-0.087 [0.438]	-0.137 [0.424]	0.019 [0.456]
Children	-0.493 [0.310]	-0.522* [0.312]	-0.448 [0.318]	-0.492 [0.319]	-0.345 [0.327]	-0.534* [0.314]	-0.430 [0.341]
Age	0.051*** [0.016]	0.053*** [0.016]	0.053*** [0.016]	0.056*** [0.017]	0.045*** [0.017]	0.054*** [0.017]	0.057*** [0.018]
Nagelkerke R^2	0.287	0.289	0.320	0.333	0.362	0.296	0.393
Log-Likelihood	357.392	356.483	345.976	341.090	330.756	354.204	319.398
Observations	441	441	441	441	441	441	441

Unstandardized effect coefficients; standard errors in brackets. Significance levels *** p<0.01; ** p<0.05, * p<0.1.

The results for the logistic regressions for consulting are shown in table 12. In model 1, only the control variables are included. In regard to consulting, an orientation toward the demands from industry has a positive effect (0.352), which appears to be logical because firms are interested in knowledge and expertise matching their needs. Hence, research oriented towards industry demands is better suited for commercialization. In addition, having a second position at a university spin-off increases the chance of doing consulting for firms (1.679), which could be explained by the overlapping of interests and tasks during secondary employment. The borders between consulting and second employment could become blurred and this could explain the positive effect. Third, to have won a scientific prize increases the probability of consulting (0.907), and fourth, being employed at a public university also increases the probability of consulting (0.704). Additionally, German scientists are more often involved in consulting than their Swiss counterparts (1.069), which could be explained by the greater number of firms located in Germany in comparison to Switzerland. Income (0.323) and age (0.051) also show a positive influence on consulting. Both are related and could come in line with certain social capital and network effects, which are important for consulting (Haeussler and Colyvas 2011; Landry et al. 2006). Model 2 tests for the prestige indicator. Contrary to the assumptions of the second hypothesis, the prestige indicator shows no statistically significant effect, although several control variables show significant effects. In addition to the variables, which are significant in model 1 (demands from industry (0.354), secondary employment at a spin-off (1.681), scientific prize (0.853), being employed at a public university (0.700), affiliation with a German institution (1.100), income (0.300) and age (0.053)), having children has a negative effect on consulting (-0.522), which could be explained by the fact that consulting is not only time consuming but also requires flexibility that may be more difficult to arrange around a family. In the third model, applied research has a positive significant effect on consulting (0.367). As in model 3 of the first regression on spin-offs, the significant effect of the orientation on the demands from industry disappears. The effects for secondary employment at a spin-off (1.718), having won a scientific prize (0.968), being employed at a public university

(0.785), affiliation with a German institution (1.031), income (0.322) and age (0.053) still stand true in this model. In the fourth model, the results from cooperating with industry have a positive effect (0.486) while cooperation with non-university scientists has no significant effect. Secondary employment at a spin-off (1.715) has a positive effect on consulting, as does having won a scientific award (0.966), being employed at a public university (0.643), affiliation with a German institution (1.071) and age (0.056). In model 5, testing for contacts in industry, informal contacts show a significant positive effect on consulting (0.241). Additionally, the use of private sector equipment and infrastructure shows a positive influence on consulting (0.242). This is a hybrid sort of contact. While there is not necessarily formal cooperation between a scientist and a firm, the more or less frequent use of private sector infrastructure is probably not purely informal. Actual formal contacts, however, have no statistically significant effect. Regarding the control variables, again, there are significant effects for secondary employment at a spin-off (1.629), being awarded a prize (0.919), being employed at a public university (0.709), affiliation with a German institution (1.181) and age (0.045). Due to moderation effects, neither demands from industry nor income are statistically significant in this model. In model 6, no statistically significant effects from direct peer effects occur; however, there is an indirect peer effect. If the faculty a scientist belongs to has created a spin-off, the chance for consulting by that scientist is increased (0.515). Thus, there may be no direct peer effect, but the commercialization activities of the faculty seem to provide a role model for scholars. Additionally, some control variables are again significant. An orientation towards industry demands shows a positive effect (0.347) on consulting as well as secondary employment at a spin-off (1.672), being awarded a scientific prize (0.933), being employed at a public university (0.847), affiliation with a German institution (1.092), income (0.328) and age (0.054). Having children shows a negative effect on consulting (-0.534). In the final seventh model, including all variables, there is a positive effect of applied research on consulting (0.276) as well as a positive influence on consulting, if the faculty a scientist belongs to has founded a university spin-off (0.578). All other central variables show no statistically significant effects. With regard to the control variables, secondary employment at a university spin-off (1.730), being awarded a scientific prize (0.955), being employed at a public university (0.900), affiliation with a German institution (1.187) and age (0.057) show statistically significant effects. Orientation to the demands of industry, however, shows no significant effects, probably due to the mediator effects mentioned above.

Table 13: Logistic regression analysis on licensing and sales

Licensing and sales	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Central variables							
Publication index		0.007** [0.003]					0.006* [0.003]
Applied research			-0.037 [0.090]				-0.112 [0.103]
Results from cooperation with industry				0.280*** [0.104]			0.117 [0.141]
Results from co-operation with non university scientists				0.086 [0.097]			0.087 [0.104]
Informal exchange with industry					0.254*** [0.093]		0.219** [0.098]
Use of infrastructure					-0.128 [0.118]		-0.119 [0.125]
Short term projects					0.182* [0.100]		0.219** [0.107]
Long term projects					0.142 [0.106]		0.080 [0.115]
Former colleague founded a spin-off						-0.009 [0.147]	-0.107 [0.155]
Former colleague in big pharma						0.128 [0.106]	0.070 [0.112]
Former colleague in biotech SME						0.291** [0.126]	0.315** [0.132]
Faculty spin-off						0.290 [0.240]	0.249 [0.251]
Control variables							
Secondary employment spin-off	0.737* [0.378]	0.732* [0.383]	0.741* [0.378]	0.715* [0.381]	0.592 [0.389]	0.588 [0.391]	0.520 [0.405]
Research scholarship	-0.284 [0.242]	-0.339 [0.245]	-0.295 [0.244]	-0.203 [0.247]	-0.122 [0.254]	-0.344 [0.247]	-0.248 [0.262]
Scientific award	0.574** [0.232]	0.463* [0.238]	0.572** [0.232]	0.590** [0.235]	0.535** [0.240]	0.588** [0.236]	0.461* [0.250]
Research project abroad	0.234 [0.347]	0.235 [0.348]	0.230 [0.347]	0.161 [0.352]	0.144 [0.360]	0.340 [0.357]	0.248 [0.374]
International cooperation	-0.110 [0.104]	-0.132 [0.105]	-0.109 [0.104]	-0.181 [0.113]	-0.140 [0.109]	-0.120 [0.106]	-0.205* [0.121]
Job satisfaction	0.178 [0.127]	0.127 [0.130]	0.177 [0.128]	0.172 [0.129]	0.172 [0.133]	0.169 [0.131]	0.129 [0.138]
Choose own research subjects	-0.020 [0.131]	-0.056 [0.132]	-0.026 [0.132]	0.004 [0.132]	-0.004 [0.134]	-0.030 [0.134]	-0.038 [0.141]
Demands from federal programs	0.300*** [0.107]	0.290*** [0.107]	0.303*** [0.107]	0.299*** [0.108]	0.267** [0.111]	0.285** [0.112]	0.259** [0.117]
Demands from industry	0.196* [0.102]	0.194* [0.103]	0.213* [0.110]	0.080 [0.111]	0.068 [0.112]	0.131 [0.105]	0.040 [0.123]
Public university	-0.480* [0.260]	-0.494* [0.261]	-0.482* [0.260]	-0.472* [0.269]	-0.573** [0.269]	-0.443 [0.271]	-0.506* [0.288]
German	-0.213 [0.281]	-0.193 [0.284]	-0.207 [0.281]	-0.274 [0.284]	-0.285 [0.290]	-0.246 [0.288]	-0.332 [0.303]
Gender (1=female)	-0.280 [0.267]	-0.273 [0.269]	-0.283 [0.268]	-0.252 [0.270]	-0.139 [0.279]	-0.310 [0.272]	-0.158 [0.285]
Income	-0.117 [0.152]	-0.195 [0.159]	-0.116 [0.152]	-0.160 [0.154]	-0.176 [0.156]	-0.121 [0.156]	-0.268 [0.168]
Family status (1=single)	-0.253 [0.341]	-0.233 [0.341]	-0.251 [0.341]	-0.208 [0.344]	-0.214 [0.353]	-0.200 [0.347]	-0.162 [0.361]
Children	-0.237 [0.253]	-0.285 [0.256]	-0.238 [0.253]	-0.207 [0.256]	-0.102 [0.262]	-0.297 [0.258]	-0.172 [0.271]
Age	0.059*** [0.014]	0.063*** [0.014]	0.059*** [0.014]	0.060*** [0.014]	0.053*** [0.014]	0.061*** [0.014]	0.058*** [0.015]
Nagelkerke R^2	0.184	0.198	0.184	0.206	0.244	0.217	0.284
Log-Likelihood	503,842	498.498	503.670	495.739	481.281	491.587	465.504
Observations	441	441	441	441	441	441	441

Unstandardized effect coefficients; standard errors in brackets. Significance levels *** p<0.01; ** p<0.05, * p<0.1.

For licensing and sales, as in the first two regressions, contacts with industry, peers or role models and the type of research should be important, as should prestige. Table 13 shows the results for the binary logistic regression on licensing and sales. Model 1 again includes the control variables. Here it can be seen that orientation towards the demands of industry (0.196) and federal programs (0.300) shows a positive significant influence on the probability for licensing and sales, which is again not very surprising because industry and other practically oriented organizations are most interested in buying licenses or knowledge from universities. Thus, an orientation towards the needs of those private sector organizations should have a positive influence. Likewise, secondary employment in a spin-off has a positive influence on the licensing and sales of research (0.737) as well as being awarded a scientific prize (0.574). Age also shows a significant positive effect (0.059), which could again be explained by a greater stock of social capital but also by the probably higher awareness of senior researchers (Landry et al. 2006). Being employed at a public university, however, shows a significant negative effect on licensing and sales (-0.494). This effect could occur because of the often more professional technology transfer management of federal research labs, which see technology transfer as one of their mayor goals, while universities are often less focused and must follow several missions with equal dedication. While consulting is not necessarily managed by the university and informal knowledge and experience is often transferred via consulting, university involvement in licensing and sales is more formalized and has a greater impact. In model 2, a scientist’s prestige shows a significant positive effect on licensing and sales (0.007), which is in line with H1. With regard to the control variables, all variables from model 1 stay statistically significant (demands of industry (0.194), demands of federal programs (0.290), secondary employment at a spin-off (0.732), being awarded a scientific prize (0.463), being employed at a public university (-0.494) and age (0.063)). Surprisingly, in model 3, conducting applied research has no significant effect on licensing and sales. Contrary to H2, an applied research orientation does not increase the probability of licensing or selling research. Although it seems logical at first glance that firms are seeking applied research results, our finding seem to support the division-of-labor thesis that firms do applied research themselves or cooperate with university scientists to do applied research because they are more interested in upgrading their own products or creating new products that can be sold to a consumer, but still need some basic research, which is performed by university scholars and then bought by industry (Fukugawa 2013). While applied research shows no significant effect, the control variables mentioned in model 1 are all statistically significant (demands of industry (0.213), demands of federal programs (0.303), secondary employment at a spin-off (0.741), being awarded a scientific prize (0.572), being employed at a public university (-0.482) and age (0.059)). In the fourth model, getting a significant share of scientific results from cooperation with scientists in industry has a positive effect (0.208) on licensing and sales, while the scientific results from cooperation with other non-university scientists have no significant effect. With regard to the control variables, secondary employment in a spin-off (0.715), scientific awards (0.590), an orientation towards the demands of federal programs (0.299) and age (0.060) show positive influences, while being employed at a public university (-0.472) has a negative effect. Interestingly, considering the cooperation variables, an orientation towards the demands of industry has no significant effect in model 4. In model 5, testing for the effects of industry contacts industry, informal contacts (0.254) and involvement in short term cooperative ventures (0.182) both show significant positive effects on licensing and sales, underlining the importance of social capital and networks for the commercial activities of university scientists. While informal contacts on a personal level are significant, as in the regression on spin-offs, in regard to licensing and sales, short term but not long term cooperative ventures have a significant influence. This may be because of the nature of licensing and sales; that is, they are more or less a singular event without long term effects. Knowledge may flow via more informal mechanisms in long term relationships. With regard to the control variables, it is interesting that an orientation towards the demands of industry is not significant in a model including variables concerning industry contacts. Likewise, the effect of secondary employment at a university spin-off has no effect due to the mediation effects of the central variables in this model. The other control variables, however, remain significant (demands of federal programs (0.267), being awarded a scientific prize (0.535), being employed at a public university (-0.573) and age (0.053)). In model 6, we wanted to test for peer effects. We could identify a statistically significant effect of former colleagues who now work in small biotech SMEs (0.291), which can not only be interpreted as a role model for the commercialization of university research but also provide some important network contacts. As in model 5, orientation towards the demands of industry and secondary employment in a university spin-off are not significant in model 6. This is another indication of the mediation effect of personal network contacts and peer effects on those two control variables. Further, the effect of being employed at a public university does not occur in this model. The other control variables remain statistically significant (demands of federal programs (0.285), being awarded a scientific prize (0.588) and age (0.061)). In the seventh and final model including all variables, prestige shows a significant positive effect on licensing and sales (0.006) as well as informal exchange with industry (0.219), short term cooperative ventures with industry (0.219) and former colleagues now working in a biotech SME (0.315). The type of research a scientist does still has no significant effect. With regard to the control variables, due to the mediator effects of the central variables, orientation towards the demands of industry and secondary employment at a university spin-off are not statistically significant in the final model. Being employed at a public university, however, is statistically significant and has a negative influence on licensing and sales (-0.506). Interestingly, international cooperation (-0.205), which was not significant in previous models, shows a significant effect in model 7. In addition, the demands of federal programs (0.259), being awarded a scientific prize (0.461) and age (0.058) show significant positive effects on licensing and sales.

6.6. Discussion and concluding remarks

As quoted previously, star scientists had a great impact on the development of the biotech industry. Nevertheless the question of whether those stars have an outstanding position in today's mature industry is mostly unexamined in previous studies. As our analysis shows, prestige in the scientific community has an impact on commercialization activities; however, the impact is indeterminate in its direction. If different types of commercialization taken into consideration, prestige shows diverse effects. While there is no effect for consulting, there is a significant positive effect for licensing and sales of knowledge, while on the other hand, there is a significant negative effect on the founding of spin-offs. Thus, H1 can neither be confirmed nor rejected as a whole but must be seen in a more differentiated way. One possible explanation for the negative effect on spin-offs could originate from the German and Swiss systems for university professorship. Tenured professors gain special privileges that could come in conflict with a possible spin-off. While a spin-off is an entrepreneurial activity that consumes time and resources and requires risk-taking, the licensing or sale of knowledge is a way to commercialize research with less investment and risk: a spin-off could force a university scientist to decide between focusing on his or her nascent firm or scientific career in a way that licensing and sales do not (Abreu and Grinevich 2013). In this way, senior researchers in particular, who normally have a higher prestige in the scientific community, could be prevented from using their research to found spin-offs and instead opt to license or sell their results to industry. In the case of consulting, the non-significant effect of the prestige indicator remains somewhat ambiguous. As the results show, existing spin-offs owned by faculty or secondary employment in an existing spin-off have significant effects. This could hint at the importance of institutional contacts and social capital for consulting, which is based less on scientific results and more on experience.

As expected, applied research has a significant positive effect on spin-offs and consulting. Surprisingly, it shows no significant effect on licensing and sales of knowledge. A possible explanation is the upward trend by industry to sign cooperative agreements with universities. While firms concentrate their research on applied research and commercial products, they still need the products of basic research. Alliances with universities can provide firms with basic research results, which are more often patented by universities, while allowing them to maintain their R&D focus on applied research (Tijssen 2012; Mansfield and Lee 1996). Sivadas and Dwyer (2000), for example, show that because of the complexity of knowledge in high-tech industries, firms tend to invest in networks with science to get timely access to new basic knowledge. That way, they can focus resources on applied research and the development of new products.

With regard to contacts with industry, spin-offs and licensing and sales show the expected results. In both cases, informal contacts play an important role. This is in line with other studies (e.g., Ponomariov and Boardman 2008; Mueller 2006; Arundel and Geuna 2004). Moreover, involvement in cooperative projects in the case of long term project spin-offs and short term licensing and sales shows significant positive impacts. This can be interpreted as learning effects for scientists via involvement in the economic sphere (Wayne and College 2010; Bruneel et al. 2010). Additionally, role models provided by former colleagues in spin-offs or biotech SMEs increase the propensity for founding spin-offs or licensing and sales. H3 can thus be confirmed for spin-offs and licensing and sales, but not for consulting. One possible explanation is that knowledge, normally transferred by consulting, is already absorbed by contacts within industry. In a formal cooperative venture, it is inevitable that knowledge and results are exchanged. This can be both an integral part of the contractually agreed upon cooperation agreement or occur more informally through the everyday cooperation. As a result, a formal consultancy agreement would be needless, which would explain the lack of statistically significant results for formal contacts through consultancy. The same could be suggested for informal contacts. At a regular informal exchange between researchers from academia and industry, knowledge and expertise is always transferred. Especially with informal contacts, personal relationships always play a large role, so that information that would otherwise have to be purchased by companies through consulting will be divulged.

As expected, peer effects had significant positive effects in all three cases of commercialization. In case of consulting, however, contacts with former colleagues seem to have effects on an institutional level but not a personal one. Institutional contacts are somewhat opaque from the outside. We can only observe those contacts on a macro level. On a micro level, relationships between involved individuals cannot be observed. Nevertheless, peer effects, whether institutionalized or at a personal level, have significant impacts on the observed dependent variables. This result is in agreement with H4 and recent literature. For example, Moog et al. (2015) show a positive impact of peer effects on the economic activity of university scholars in their empirical study.

With regard to the control variables, there are some interesting observations. The first remarkable variable is clearly age. While age has a significant positive impact on consulting and licensing and sales, it shows a significant negative effect on spin-offs. The question of whether scientists should pursue commercialization activities at a younger or older age is still debated and remains unanswered (e.g. Boardman and Ponomariov 2009; Giuliani et al. 2010). Our data show a more diverse picture. While younger scientists seem to prefer founding of spin-offs, older scientists tend to do consulting and licensing and sales. This can be interpreted through the generally increasing risk adversity that manifests as people age (Brush and Hisrich 1991; Bates 1995; Jain et al. 2009). Therefore, older scientists do not want to endanger their positions or prestige in the scientific community with a start-up. The risk of failing at consulting or licensing and sales is smaller and a failure would not be directly connected to the individual scholar. In addition, the tendency of younger researchers to found spin-offs could also be explained through network effects. While senior researchers typically have larger networks in the scientific community and beyond, younger researchers do not have the opportunity to take advantage of such established networks. As networks not only transport information but are also reciprocal constructs, it is probably easier for older researchers to use such contacts for commercialization activities. Younger researchers, who lack the necessary contacts to get research contracts from industry or sell their research to industry, must move into the creation of university spin-offs to transfer their research into practice. Additionally, the results for public universities are somewhat diverse. While there is no effect on spin-offs, there is a positive effect on consulting and a negative effect on licensing and sales. This may also be seen with respect to the German university system. While consulting is a mostly individual process and does not necessarily require a transfer of formal knowledge, licensing and sales are more formal ways of commercialization. While consulting can occur largely without university involvement, licensing and sales are often handled by a technology transfer office. Thus, to evade closer university involvement or administrative barriers, university scientists tend to consult. On the other hand, research institutes have often more experience in handling patents, which are mostly needed for licensing or sales of knowledge. Licensing and sales can be easier and more profitable for scientists at those facilities. Thus, if universities want to promote the licensing and sales of research findings by their scientists, administrative barriers should be broken down and stronger or more appropriate incentives should be set. In model 7 of the 2nd and 3rd regressions, scientific prizes had a positive effect. Although in the case of licensing and sales, this only bolsters the positive influence of our indicator, a closer examination is necessary in the case of consulting. Winning a scientific prize is certainly a boost for prestige in the scientific community. The magnitude of those prizes is uncertain, however, due to some data limitations. We cannot see if someone won a Nobel Prize or a minor scientific prize, which means this variable is far less accurate to measure prestige and should not have been the focus of our models. Besides this effect, however, it must also be asked whether scientific prizes and prestige generated by publications may send different signals that are interpreted differently by different target groups. Here, further research is needed to explain the effect of different types of prestige effects.

Ultimately, there are two variables influencing the propensity for licensing and sales. First, the requirements of federal programs have a significant positive influence on licensing and sales. This can be explained by the nature of those programs. While there are programs supporting purely theoretical research, the goal of politically motivated programs is often application oriented with the demand to produce something practical that can be accessed by the public (Ambos et al. 2008). Thus, there should be a clear tendency towards licensing and sales where there is a stronger influence of federal programs. International cooperation in research shows a significant negative effect on licensing and sales. This is somewhat surprising but is possibly due to regional knowledge spillovers. Other studies have shown that knowledge spillovers, e.g., via licensing or sales, takes place primarily in a regional environment (Audretsch and Lehmann 2005). International cooperation is not necessarily located in a regional environment, and in this way, knowledge spillovers could be restrained by international cooperative research projects.

7. The importance of peer effects

In papers 1 and 2, the effect of peers was shown to be an influential factor. Therefore, in paper 3, peers will be the main objective. While previous studies mostly focused on a mechanistic view of the commercialization of research, we understand that scientists, as social beings, are not free from the influence of others. Their opinions about the behavior of an individual are important for social acceptance. Non-confirmative behavior can be sanctioned negatively, whereas compliance with social norms in general or in a specific sector leads to social acceptance. Accordingly, the normative framework in a work environment should have a measurable impact on an individual scholar's decision to commercialize his or her research. If the founding of spin-offs and the commercialization of academic research were widely accepted and positive role models were provided by peers, scientists would be more likely to commercialize their research. However, if there are no positive role models and commercialization is socially sanctioned, it also should have an effect on founding university spin-offs. Therefore, the effects of peers will be in the focus of paper 3.

In addition to peer effects there are other variables that could influence the creation of university spin-offs. Hence, we wanted to shed some light on not only the personal contacts and role models of scientists in their work environments but also other factors that are influenced by the work environment. We did not want to analyze the organizational structures in depth. The effect of organizational structures has been discussed by several authors (e.g., Phan and Siegel 2006; Siegel et al. 2007; Rothermael et al. 2007). Our intention in this paper is to focus on the direct effects of the work environment on the individual scientist.

First, we identify the effects of a diverse set of skills. It is often stated that generalists are more likely to become entrepreneurs than specialists are (Lazear 2005). Therefore, we include a variable that measures the skill diversity of scientists. Therefore, scholars that are involved in a diverse set of activities in their research are likely to have a generalist set of skills, which should have a positive influence on founding spin-offs. Second, diverse activities in the daily work routine should contribute to a diverse set of activities, which would have a positive influence on the founding of a university spin-off.

Paper 3: The Impact of Skills, Working Time Allocation and Peer Effects on the Entrepreneurial Intentions of Scientists

Abstract

Little is currently known about the effects of skill composition on academic entrepreneurship. Therefore, in this paper, following Lazear's (2005) jack-of-all-trades approach, we study how the composition of a scientist's skills affects his or her intention to become an entrepreneur. Extending Lazear, we examine how the effect of balanced skills is moderated by a balance in working time and peer effects. Using unique data collected from 480 life sciences researchers in Switzerland and Germany, we provide first evidence that scientists with more diverse and balanced skills are more likely to have higher entrepreneurial intentions, but only if they also balance their working time and are in contact with entrepreneurial peers. Therefore, to encourage the entrepreneurial intentions of life scientists, it must be ensured that scientists are exposed to several types of work experience, have balanced working time allocations across different activities, and work with entrepreneurial peers; e.g., collaborating with colleagues or academic scientists who have started new ventures in the past.

Keywords: Jack-of-all-Trades; Entrepreneurial intentions; Academic entrepreneurship; Peer effects

7.1. Introduction

Recent developments in university policies and governance structures are intended to foster an entrepreneurial climate in the university environment to facilitate technology transfer from the ivory tower, i.e. fostering technology development and making academic scientists more entrepreneurial (Shane 2004). In becoming entrepreneurial, academic scientists may improve their prestige, earn more income and gain more satisfaction (Lam 2010a). Along this line, a continuously increasing number of academic scientists have founded university spin-offs in the last decade by using their acquired knowledge as well as patents and licenses from universities (e.g., Stuart and Ding 2006). However, compared to the general population, fewer academic scientists consider starting their own businesses: they tend to concentrate their occupational choices on being employees (Thurik 2003). Nevertheless, empirical evidence relating the background of scientist's skills and specific environmental factors such as work time allocation and peer effects to these scientists' entrepreneurial activities remains scarce (Nicolaou and Birley 2003).

Our paper tries to fill this research gap by studying how a life scientist's skill composition affects their intention of becoming an entrepreneur, moderated by work time and peer effects. Specifically, we follow Lazear's (2005) jack-of-all-trades approach and examine the effects of balanced entrepreneurial skills on scientists' propensity to become entrepreneurs. The fact that scientists – compared to non-scientists – are characterized by relatively homogeneous human capital at the beginning of their careers underlines the influence that balanced skill sets – acquired through more diverse work experience when working in academia in different academic settings – have on scientists' occupational choices. At the beginning of their careers, scientists know how to conduct research, teach and write academic studies, but on average, they do not know how to patent, license results or start up a business with their research results (Horlings and Gurney 2013). In line with Lazear's (2005) key idea, we argue that, all else being equal, researchers who have a more balanced portfolio of skills are also more willing to transition into entrepreneurship in the near future.

Balance in the sense of Lazear (2005) means that people specialized in one aspect are ‘unbalanced’. An individual is balanced in their skills and human capital when they have a broad skill set. The limiting factor in starting a business or becoming an entrepreneur is an individual's weakest skill, which results from a gap in a person’s experience. Lazear (2005) discusses roles in former jobs, such as administration, technical experience, and project management. He then adds these different roles to produce a balance variable, which is measured by the total number of roles that the individual has had. We adopt this concept to measure the skills achieved during an academic career. By doing so, we screened the literature on academics and their different work tasks and experiences and came up with a list of thirteen different work fields mentioned in the recent scientific discussion (e.g. Ding 2011; Louis et al. 1989). Those are the traditional work fields of publishing research results, teaching and advising students and PhDs, contribution to committees, boards, and commissions, informal meetings and contacts as well as free sharing of research results. Moreover, scientists do contract research and share equipment, do collaborative research with academic and non-academic third parties, exhibit patent and licensing activities as well as consultancy activities. To get an impression of how much time was spend on different tasks; we followed the approach of Colbeck (1998). That is, we measured how much work time was spent on teaching, academic administration, research, non-commercial use of research findings, commercial use of research findings, setting up new research projects and other fields of activity. In particular, we study the experiences of researchers in different academic work activities and analyze the extent to which these (combined) activities affect their entrepreneurial intentions. In addition, we analyze how balanced working time and experience with peers moderate the effect of the portfolio of skills, arguing that these aspects deliver a) additional experience in managing time and organizing a scientist’s work day and b) additional skills and experiences through contact with peers with different backgrounds. Moreover, following the peer literature (Falck et al. 2010; Nanda and Sorensen 2010) we argue that peer groups with entrepreneurial background influence the decision to become an entrepreneur assuming that networks and peer groups may provide role models and thus, fostering the partial skill effects.

Recent work in the entrepreneurship literature has begun to shed light on the effects of skills on the propensity of scientists to become entrepreneurs; however, most studies in this field of research focus on specialized experiences and thus neglect multifaceted experiences (e.g., Allen et al. 2007; Ding 2011). Most authors just analyze the impact of general human capital on the probability to become an entrepreneur and find especially industry experience and higher qualifications trigger the intention (e.g. Davidson and Honig 2003). Very few authors provide evidence of a difference between a more balanced or specialized human capital with regard to academic entrepreneurship and that broader skills are more helpful (e.g. Roach and Sauermann 2012). Moreover, studies focus on the general environment, such as institutional settings and networks (e.g. Colombo et al. 2010), but they rarely address more immediate environmental factors affecting scientists, such as their work time, organization or work peers (e.g. Lam 2010a). Our contribution lies in the connection of these three aspects that have in the past been more or less neglected, even when they are considered important in the general personnel economics or start-up literatures (e.g. Acs et al. 2009; Nanda and Sorensen 2010). We shed the focus on peers because we believe first that the literature results show that the peer effect in academia may be stronger than in a general work environment (Merton 1957; Göktepe-Hulten and Mahagaonkar 2010). Scientists are much more highly dependent on peer opinions, interactions and relations due to peer reviews in journals or conferences and peer evaluations when applying for an academic position. Therefore, peers' entrepreneurial behavior represents a signal that this type of behavior is acceptable for the community or, in some cases, even individually rewarding (Lam 2007). We focus on the connection to work time because if people concentrate on one or two roles in their work time, they can neither develop nor use new experiences in other fields. We contribute to the entrepreneurship literature by focusing on two new aspects: the combination of skills as a trigger for entrepreneurial intention and the combination of individual aspects related to the work environment such as work time and peers.

Using unique data collected from 480 Swiss and German life sciences researchers, we find that having a balanced skill set positively affects the intention to become an entrepreneur in cases where organizational peers have entrepreneurial ideas and where the working time is balanced between different academic activities. Thus, our main finding is that only if the environmental factors – and here especially the peer group effects – support an entrepreneurial climate, a more diverse set of skills together with a balanced working time will lead to higher entrepreneurial intentions of scientists.

The paper is organized as follows. In the next section, we discuss how the jack-off-all-trades perspective may help explain the propensity of scientists to become entrepreneurs. Section three explains our empirical method and shows our results. Finally, in section four, we discuss our results, indicate the limitations of our study and make some concluding remarks.

7.2. Theory and hypotheses

7.2.1. General developments in academia

Recent changes and developments in university policies and governance structures aimed to foster an entrepreneurial climate in the university environment to facilitate technology transfer from the ivory tower to industry and thus to foster technological development, improve countries' competitive advantage and make academic scientists more entrepreneurial (OECD 2005). In particular, the Bayh-Dole Act in 1980 in the USA may be considered the starting point of such changes in university policies (Karlsson and Wigren 2012). Many other countries have adopted similar changes in law since this act, such as Germany in 2001/2002 and Switzerland beginning in the new millennium. The main idea of these enactments was that scientists and universities would generate more research that could be commercialized if they could benefit from their inventions in a direct way through, for example, spin-offs, licensing rewards or other income sources (Klofsten and Jones-Evans 2000). Affected by the new law, many universities have changed their policies from a Mertonian norms-influenced policy to an entrepreneurial-oriented approach. These changes did occur not only because of the chances to participate in the commercialization of scientific knowledge. Diminishing state funds are another reason why universities and scientists were pushed to generate more third-party funds. To gain these third-party funds, universities and scientists were forced to build another type of prestige: an entrepreneurial one (Henkel 2007). Nevertheless, many scientists continue not to have entrepreneurial intentions, and not all universities have become 'entrepreneurial universities'. Consequently, several studies address the question of why some scientists decide to start new ventures while others completely avoid moving towards self-employment (e.g., Lam 2010a). In sum, the results of these studies indicate that the factors motivating university scientists to transition into entrepreneurship may be very specific.

7.2.2. Antecedents of academic entrepreneurship and hypotheses building

Skill approach — One of the main factors related to general entrepreneurial success is human capital (Allen et al. 2007). Especially in innovative start-ups, such as life sciences spin-offs, entrepreneurs are said to require a set of skills to transform their ideas into profitable ventures (Bygrave and Hofer 1991). Prior knowledge is regarded as a key factor in enabling a spin-off to exploit new market opportunities (Ardichvili et al. 2003), and a certain level of knowledge is a prerequisite for successfully recognizing and processing new external information. Consequently, the success of a new spin-off depends strongly on the founder's skills, knowledge and their educational background. Following Boeker and Fleming (2010), we argue in this study that these competencies are mostly related to what the founder has learned and observed during his or her previous academic job career. Put differently, past work experience and skills gained in specific working environments are considered key factors of the founder's knowledge base and their ability to manage the specific challenges related to entrepreneurship. Knowing about this relationship between human capital, skills and entrepreneurial success and being rational, people who currently have these skills should develop stronger intentions to become entrepreneurs. This learning may occur by undertaking different tasks with different degrees of time spent in these activities as well as through peers and interactions with them. Therefore, we focus on these three issues. Hills et al. (1999) support this view, demonstrating that 50-90 percent of start-up ideas are derived from previous work experience. Following this general idea, Kakati (2003) identified a broad range of skills that a diversified management team or a single entrepreneur should possess, i.e., both managerial and technical skills. Moreover, many studies show that employees should be exposed to working conditions that provide a specific type of job variety or diversity to develop a broad knowledge base about how businesses are run and organized and to learn how to act with great flexibility (Baron and Markman 2003). Therefore, we focus on the specific work environment and conditions of scientists.

To address this problem, Lazear (2005) developed the jack-of-all-trades approach, which differentiates between different types of skills. This approach ascertains that a specific mixture of human capital is essential for the founding of a start-up because an entrepreneur needs not only specific human capital but also a generally broader set of skills. This broad set of skills is required because of the several challenges faced by entrepreneurs, such as the acquisition of capital or human resource management. In our paper, we assume that scientists may also acquire a variety of specific skills by being exposed to specific working conditions which are, in sum, conducive to entrepreneurship.

Whereas several empirical findings relating to start-ups in general (for an overview, see Unger et al. 2011) support the idea that human capital increases the willingness to transition into entrepreneurship as well as the success of start-ups, few studies investigate the relation of human capital and university spin-offs, and even fewer examine the jack-of-all-trades approach in the context of academic entrepreneurship (Shane 2004). Some general studies have found evidence that a more balanced, respectively diverse skill set supports entrepreneurial intentions as well as the success of new start-ups. Wagner (2004), for example, finds evidence that the probability of being self-employed in regular professions depends on the number of different types of professional training and changes in profession. Baumol (2005) demonstrates that the human capital of independent inventors who found their own business differs from that of inventors hired by large firms. Whereas large firms seek highly specialized human capital, independent inventors require a generalized human capital stock – in Lazear's terms: a balanced stock. Contrary to these findings, Silva (2007) finds no evidence for the jack-of-all-trades approach. Finally, the study of Stuetzer et al. (2013) reveals a positive relationship between a balanced set of skills or human capital portfolio and (general) entrepreneurial intentions, represented by the progress of a nascent entrepreneurial venture. We thus believe that it may be reasonable to replicate this test for a specific group of scientists as well. Moog and Backes-Gellner (2013) find evidence that students with more diverse sets of skills have stronger intentions of starting a business than other students and that this effect is stronger for male than for female students. However, none of these studies focuses specifically on scientists nor analyses how balanced skills influence this group.

Meanwhile, empirical research on the skills, experience or professional education (human capital: PhD, tenure, research productivity, publishing and patenting activities) of academic entrepreneurs is mostly conducted from an ex-post perspective (e.g., Ding 2011; Roach and Sauermann 2012). Moreover, these studies generally do not integrate multifaceted experiences. For example, in an analysis of 400 scientists from US universities, Allen et al. (2007) present first evidence that human capital indicators are directly linked to the extent of science-industry relations and patenting rates by scientists. They find that specific human capital indicators, such as tenure, academic status, PhD experience, and discipline indicators, among others, are directly linked to the extent of science-industry relations and patenting rates by scientists. The authors argue that (faculty) patenting behavior may serve as an indicator of entrepreneurial activities; this finding provides a first hint of peer effects. However, this study does not focus on entrepreneurial activities such as start-ups or university spin-offs. Karlsson and Wigren (2012) focus on human and social capital as well as legitimacy and find first evidence that one specific type of human capital investment, such as supporting colleagues to start a business, increases academics' propensity to start a business on their own. This finding represents another hint of peer effects and in addition learning, but again neglects other academic activities. Boehm and Hogan's (2014) study finds that principal investigators - when organizing collaborative industry-academic research projects with multiple stakeholders – must act like jacks-of-all-trades following role models such as negotiators, project managers, resource developers and PhD supervisors and mentors to make their project successful. Comparing the effect of the prior activities of researchers on becoming a consultant or entrepreneur, Ding and Choi (2011) show that publication output, patent experience, co-authorships and networking are positively related to both scientific consulting activities for companies and becoming an entrepreneur. Therefore, this latter study suggests that some specific individual skill sets support entrepreneurial intentions as well as spin-offs.

Nevertheless, a combined effect in the sense of Lazear remains to be found. Moreover, two important issues in the context of academic scientists are peer groups and work time, which may moderate the effect of balanced skills. Consequently, our contribution is to apply Lazear's jack-of-all-trades theory to the special case of the entrepreneurial intentions of scientists to demonstrate that the effect of a more balanced skill set is moderated by peer group and working time effects.

Work time and peers — The fact that scientists – compared to non-scientists – are characterized by relatively homogeneous human capital at the beginning of their careers underlines the influence that broader skill sets – acquired through more diverse work experience – have on their occupational choices. However, we argue that specific environmental and motivational aspects will also affect a scientist's propensity to become an entrepreneur. In other words, we believe that these specific environmental and motivational factors are the main reasons that scientists with more diverse portfolios of skills have higher propensities towards entrepreneurship. Moreover, we believe that scientists must also invest a reasonable amount of working time in the activities necessary to acquire these skills. In line with this reasoning, we believe that more balanced working time should also help to build a more diverse set of skills affecting the propensity of scientists under specific organizational circumstances to become entrepreneurs.

For instance, personal relationships and a peer-group orientation are vital for shaping individual behaviors and ambitions (Lam 2007). Young scholars are especially likely to orient themselves according to existing norms or leadership behaviors. These norms, often provided by leaders in the academic context (e.g., chair of the department or faculty), create the organizational culture. If the chair of the department is highly involved in entrepreneurial activities, they send a strong positive signal to other scientists in the department regarding these activities, whereas a chair avoiding entrepreneurial activities negatively influences the other scientists' entrepreneurial development (Bercovitz and Feldman 2008). However, organizational norms cannot be implemented solely by leaders because members of an organization could merely symbolically abide by these norms. In fact, the organizational culture is only truly able to implement behavioral norms if the majority of faculty members comply with them. According to Stuart and Ding (2006), personal relations, networks and interactions are one of the most important factors driving individual behavior and internalized norms. Peers may support entrepreneurial ideas and create pressure on individuals to internalize norms to conform to the peer group. The closeness and especially the frequency of interactions strengthen the induced learning effects. Individuals compare themselves and their behaviors to those of other individuals who are similar to them. Therefore, peers must have similar social statuses, personal skills and interests (Ellison and Fudenberg

1993). For scientists, colleagues are the relevant peer group relating to professional norms. Therefore, the level of collegial support is considered one of the most important factors related to the entrepreneurial activities of scientists (Link and Ruhm 2011). Therefore, group leaders, department chairs or PhD or post-doc colleagues who have been entrepreneurs or who are involved in university-industry cooperation are able to provide other faculty members with contacts in the economic sector. Scientists may also acquire entrepreneurial knowledge from experienced faculty members via spill-over effects (Acs et al. 2009). As Nanda and Sorensen (2010) show for employees in different industries, even peers with negative entrepreneurial experience may influence the general thinking about entrepreneurship positively and change the motivation of co-workers, thereby facilitating their transition into entrepreneurship. Therefore, the learning effect of peers with entrepreneurial experiences should be considered when analyzing scientists' intentions to become entrepreneurs. Moreover, as previously mentioned, the environment for academic scholars has changed in the past two decades, and long-established Mertonian norms have given way to more entrepreneurial approaches (e.g., Thursby and Thursby 2002). Individuals often perceive this changing environment as creating pressure on them to change their individual attitudes, i.e., to comply with the newly established norms. Consequently, the implementation of these new organizational norms should also foster the previously discussed peer effects and, consequently, the scientists' propensity to become entrepreneurs (Thursby and Thursby 2002).

Therefore, in sum, we hypothesize the following:

H1: If organizational peers support entrepreneurial ideas, then a more diverse set of skills and working time will positively affect the propensity to become an entrepreneur.

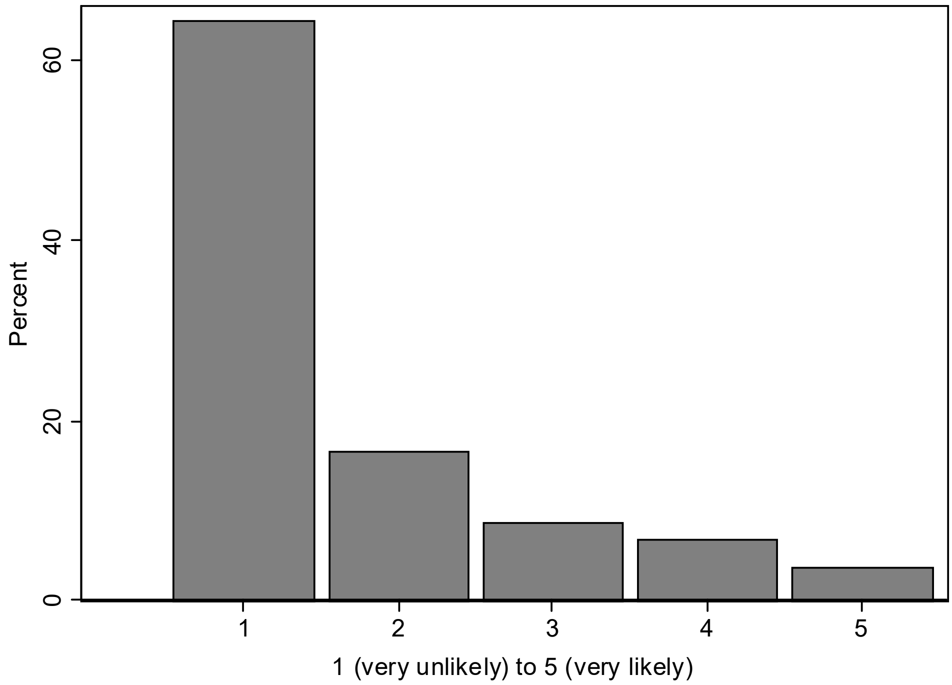
7.3. Data and variables

We collected data on Swiss and German scientists in 2007. A total of 1,760 scientists responded to our online survey, and 480 answered all of the questions relevant to our empirical analysis, yielding a completion rate of 23.58 percent. Acknowledging that our sample is one of convenience, we compared it to data from the German Federal Statistical Office and the Swiss Statistical Office as well as from Life Sciences Federal organizations in both countries regarding gender or age. We find a high degree of similarity between the scientists within our sample and the scientists within other data sources and are thus confident that our sample is not seriously biased.

7.3.1. Dependent variable

Propensity to become self-employed — For the composition of our dependent variable, we rely on the answers regarding the future career choices of the responding scientists. They were asked whether they planned on becoming entrepreneurs in the near future and to estimate the probability of such an occupational change in the near future on a Likert scale ranging from 1 (very unlikely) to 5 (very likely). We realize that intention-based measures represent only the first step towards becoming an entrepreneur and acknowledge that not all of the researchers who have the intention to become entrepreneurs will actually do so. However, many empirical studies have shown that actual entrepreneurs are a sub-sample of so-called latent entrepreneurs (e.g., people who in the past have wished to become entrepreneurs). Moreover, early entrepreneurial intentions have been shown to be the single best predictors of starting a business later (e.g. Krueger et al. 2000; Villanueva et al. 2005) and represent the best measure of capturing the idea of preparing for an occupational choice. Figure 7 shows the distribution of the dependent variable.

Figure 7: Distribution of the propensity to become self-employed



7.3.2. Independent variables

More diverse *set of skills* — Our sample includes information on a variety of specific skills that have been acquired by the scientists through exposure to specific working conditions. Following Lazear's (2005) jack-of-all-trades theory, the sum of these experiences should be conducive to entrepreneurship. In particular, we collected data on (1) patent activities; (2) licensing activities; (3) collaborative research activities with academic and non-academic third parties; (4) consultancy; (5) publications; (6) contract research; (7) free sharing of research results; (8) shared usage of equipment; (9) education of students and PhD candidates; (10) advising for master and PhD theses; (11) staff outflow; (12) contribution to committees, boards, and commissions; and (13) informal meetings and contacts. Following Lazear's (2005) number of roles measure, we have constructed an additive index of up to 13 different researcher experiences to construct a balanced skill set drawn from these activities.

Figure 8: Balanced set of skills

$$\text{Balanced Set of Skills} = \sum_{i=1}^{13} Xi$$

In accordance with Schmoch (2003) as well as Karlsson and Wigren (2012), we condensed the information on the different activities, i.e., the quantity of these experiences (e.g., how long, how much), by creating a set of binary variables (i.e., one indicator per activity). Each of these dummy variables takes on the value "0" if the researcher never acquired the skill and "1" otherwise. A higher index value indicates a greater balance and diversity of the skills of the responding scientist; this configuration is in line with the approach of Lazears (2005). Descriptive statistics reveal that the average scientist in our study is engaged in approximately 8.1 activities with a standard deviation of 2 of the 13 activities. Therefore, the average scientist is highly balanced (or diversified) in his or her activities and thus experiences.

Working Time Balance — As an indicator of balanced working time, we use the distribution of the individual scientist's working time (as a percentage) with respect to the sum of his or her fields of activities and responsibilities. The seven possible categories underlying this variable include (1) teaching; (2) academic administration; (3) research; (4) non-commercial utilization of research findings; (5) commercial utilization of research findings; (6) procurement of new research projects; and (7) other fields of activity. If a scientist's working time is perfectly balanced, he or she should spend exactly 1/7 of his or her total working time on each of these activities (i.e., 14.3 percent). Not surprisingly, the observed values deviate from this balanced value. We thus constructed a balance score for each scientist based on the sum of his or her individual deviations from the perfectly balanced value. High negative values of this variable indicate a more unbalanced distribution of working time with respect to the previously mentioned fields of activity. Low negative values indicate a relatively well-balanced distribution of working time. Descriptive statistics show that, on average, scientists are characterized by a deviation of approximately 38.5 percentage points from the perfectly balanced value, with a standard deviation of 11.2 percentage points.

Peer Effects — With regard to the entrepreneurial peer groups, we include a binary variable in our regression models for whether colleagues in the department have already started a new venture. A majority of 55.2 percent of the scientists in our sample stated that at least one person among their group leaders, department chairs, PhD or post-doc colleagues had at some point been an entrepreneur.

7.3.3. Control variables

To control for department-specific effects and financial capital endowments, the regressions include a (standardized) *faculty size* variable, reflecting the number of employees and budgets of the responding scientists' departments. Moreover, past research has also shown that socio-demographic factors may affect the propensity to become self-employed (Parker 2004). In Switzerland and Germany, as in many other countries, fewer *women* than men start new businesses. Ding and Choi (2011), for example, show that female scientists are about one fifth less likely than male scientists to become academic entrepreneurs. In addition, *older* employees are considered to be more risk-averse than younger ones and are less likely to work the long hours often required of entrepreneurs (Jain et al. 2009). We also control for the type of research a scientist is involved. In the life sciences, it is common to differentiate between basic, *applied* and *applied-oriented* research. Basic research, for example, is often considered non-commercializable because of its primarily basic and theoretical nature. Finally, we include one variable that denotes whether the university has a formal *technology transfer office* (TTO) and control for *country effects* using a country dummy variable (1=Switzerland, 0=Germany).

7.3.4. Analytical approach

In our empirical models we regress scientists' propensity to leave paid employment for self-employment on more diverse skills, balanced working time, peer effects and the control variables. In addition to the diverse skill variable (additive index), we have also included the set of binary skill variables (one indicator for each activity) to control for specific activity effects so that any intervening effects on our diverse skill variable, the dependent variable, may be ruled out in this respect. Three different specifications of the empirical model are estimated. First, we examine the role played by the set of binary skill variables and control variables discussed above, ceteris paribus (model 1). Second, we include the variables representing a broader range of skills, balanced working time and peer effects (model 2). Third, to test H1, we include a three-way interaction consisting of our three central variables: diverse set of skills, balanced working time and peer effects (model 3). Because three-way interaction models with continuous variables are prone to multicollinearity, which may lead to numerical instability and inflated standard errors, we followed the recommendation of Aiken and West (1991) and mean centered the skill diversity and the work-time balance variables. Moreover, because our dependent variable is a five-item ordinal scale variable, the appropriate econometric model is a regression model for ordinal outcome variables. When we illustrate our results, we display the predictive probabilities that the likelihood of becoming an entrepreneur is "very likely" (Likert scale value = 5). Moreover, the empirical models presented here have robust standard errors with correction for heteroskedasticity. Table 14 provides descriptive statistics for all variables and the correlations of key variables used in our empirical analysis.

Table 14: Pair-wise correlation and descriptives

		Mean	S.D.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
(1)	Entr	1.68	1.10	1.00	5.00	1																						
(2)	FacSize	0.07	1.15	-0.68	14.52	0.06	1																					
(3)	Female	0.25	0.43	0.00	1.00	-0.12	-0.14	1																				
(4)	Age	45.81	8.85	29.00	68.00	-0.02	0.23	-0.19	1																			
(5)	Country	0.14	0.35	0.00	1.00	0.02	0.15	-0.11	0.10	1																		
(6)	BasicR	0.69	0.46	0.00	1.00	-0.17	-0.08	-0.04	-0.01	0.03	1																	
(7)	AplR	0.42	0.49	0.00	1.00	0.17	0.05	-0.07	-0.04	-0.04	-0.32	1																
(8)	TTO	0.61	0.49	0.00	1.00	0.01	0.05	-0.06	0.11	-0.04	0.00	0.04	1															
(9)	Patent	0.44	0.50	0.00	1.00	0.16	0.20	-0.10	0.18	0.04	-0.04	0.17	0.06	1														
(10)	Licensing	0.40	0.49	0.00	1.00	0.14	0.09	-0.12	0.23	0.03	-0.07	0.08	0.02	0.33	1													
(11)	Collaboration	0.79	0.41	0.00	1.00	0.07	-0.03	-0.09	0.01	-0.00	-0.08	0.06	-0.02	0.02	0.01	1												
(12)	Consultancy	0.23	0.42	0.00	1.00	0.24	0.22	-0.13	0.23	0.08	-0.13	0.13	0.08	0.18	0.22	0.08	1											
(13)	Publication	0.97	0.16	0.00	1.00	-0.06	0.06	-0.05	0.10	-0.00	-0.03	0.01	0.05	0.10	0.08	0.07	0.03	1										
(14)	ContractR	0.25	0.43	0.00	1.00	0.21	0.10	-0.06	0.10	0.06	-0.27	0.25	0.07	0.15	0.24	0.14	0.22	0.10	1									
(15)	FreeSharing	0.94	0.24	0.00	1.00	0.05	0.04	-0.09	0.13	0.01	0.07	0.05	0.13	0.11	0.12	0.03	0.06	0.12	0.07	1								
(16)	SharedUsage	0.11	0.32	0.00	1.00	0.10	0.09	0.02	0.04	0.17	-0.12	0.14	-0.05	0.06	0.10	0.11	0.14	0.06	0.33	-0.07	1							
(17)	Education	0.96	0.19	0.00	1.00	-0.04	0.06	-0.12	0.09	0.02	0.03	-0.05	0.05	0.02	0.00	-0.05	0.08	-0.03	-0.04	0.08	-0.17	1						
(18)	CoachingPhD	0.96	0.20	0.00	1.00	0.04	0.02	0.00	0.01	-0.06	-0.06	0.08	0.02	0.03	-0.03	-0.01	0.07	0.03	0.05	0.03	-0.02	0.12	1					
(19)	Committees	0.73	0.44	0.00	1.00	0.02	0.18	-0.25	0.29	0.14	0.05	-0.02	0.02	0.17	0.16	0.03	0.08	0.19	0.09	0.12	0.03	0.10	0.15	1				
(20)	InformalCont	0.62	0.49	0.00	1.00	0.14	0.04	-0.05	0.01	0.09	-0.09	0.16	0.03	0.11	0.13	0.14	0.21	0.11	0.29	0.10	0.25	-0.06	0.11	0.05	1			
(21)	SkillDiversity	0.00	2.01	-6.14	4.86	0.26	0.22	-0.21	0.28	0.14	-0.13	0.22	0.06	0.51	0.54	0.34	0.49	0.25	0.55	0.30	0.38	0.12	0.21	0.42	0.54	1		
(22)	WorkTimeB	-0.00	11.18	-37.21	29.22	0.09	0.11	-0.07	0.06	-0.03	-0.09	0.12	0.05	0.17	0.18	0.03	0.19	0.13	0.20	0.13	0.09	0.25	0.21	0.35	0.05	0.36	1	
(23)	Peers	0.55	0.50	0.00	1.00	0.11	0.09	-0.06	0.02	0.06	-0.04	0.03	0.08	0.20	0.16	0.07	0.10	0.11	0.05	0.17	0.02	-0.02	0.01	0.06	0.07	0.21	0.06	1

7.4. Results

Table 15 presents the estimation results. As displayed in model 3, the three-way interaction effect of p*eers*skill diversity*working time balance* is statistically significantly different from zero at any conventional level (β=.010; p<.05). The predictive probabilities are displayed in Figure 9. The results show that scientists with a broader range of skill scores and high degrees of working time balance have a higher propensity to become entrepreneurs if they work with entrepreneurial peer groups in their departments. Therefore, H1 is supported by the data.

Figure 9: Three-way interaction: skill diversity, time balance and peers

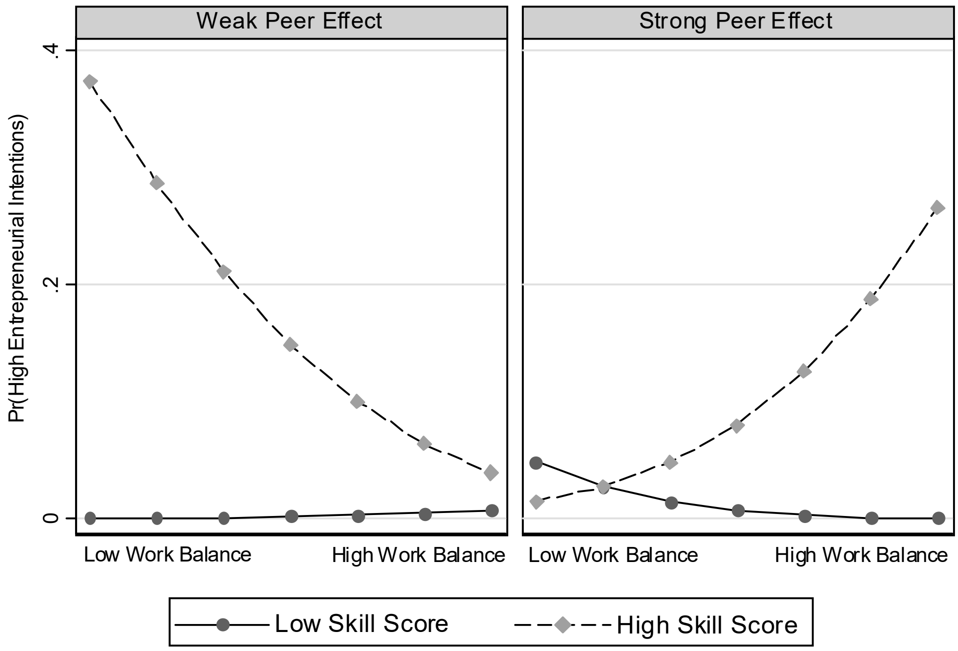


Table 15: Ordered probit estimation results

DV: Entrepreneurial intentions (5-item-Likert scale)	Model 1 Coef.	Model 2 Coef.	Model 3 Coef.
Controls			
Faculty size	-0.003	-0.004	-0.001
	[0.037]	[0.038]	[0.038]
Gender (1=female)	-0.327**	-0.321**	-0.281**
	[0.139]	[0.140]	[0.142]
Age (in years)	-0.022***	-0.021***	-0.022***
	[0.007]	[0.007]	[0.008]
Country (1 = Switzerland)	0.044	0.025	0.003
	[0.160]	[0.162]	[0.163]
Basic research[1]	-0.294**	-0.307**	-0.284**
	[0.136]	[0.138]	[0.138]
Applied-oriented research[1]	0.163	0.169	0.178
	[0.122]	[0.123]	[0.124]
TTO	-0.008	0.002	0.002
	[0.119]	[0.119]	[0.119]
Skill Dummy Variables			
Patent activity	0.257**	0.064	0.076
	[0.124]	[0.182]	[0.184]
Licensing activities	0.150	-0.034	-0.024
	[0.122]	[0.187]	[0.187]
Collaborative research activities	0.027	-0.157	-0.140
	[0.143]	[0.209]	[0.210]
Consultancy	0.540***	0.377**	0.350*
	[0.136]	[0.189]	[0.188]
Publications	-0.753**	-0.932**	-0.930**
	[0.380]	[0.397]	[0.413]
Contract research	0.236	0.078	0.096
	[0.149]	[0.194]	[0.195]
Free sharing of research results	0.333	0.111	0.137
	[0.280]	[0.334]	[0.347]
Shared usage of equipment	-0.006	-0.171	-0.168
	[0.196]	[0.254]	[0.255]
Education of students and PhDs	-0.397	-0.583	-0.522
	[0.289]	[0.348]	[0.349]
Coaching of Master and PhD Thesis	0.094	-0.082	-0.007
	[0.356]	[0.403]	[0.428]
Contribution to committees etc.	0.090	-0.064	-0.032
	[0.144]	[0.192]	[0.194]
Informal meetings and contacts	0.090	-0.101	-0.100
	[0.126]	[0.119]	[0.195]
Central variables			
Skill diversity		0.166	0.166
		[0.131]	[0.137]
Work time balance		-0.001	-0.006
		[0.006]	[0.008]
Skill diversity*work time balance			-0.004
			[0.004]
Peers		0.136	0.061
		[0.119]	[0.127]
Peers*skill diversity			-0.013
			[0.065]
Peers*work time balance			0.007
			[0.011]
Peers*skill diversity*work time balance			0.010**
			[0.005]
Log likelihood	-487.4	-485.9	-483.6
Observations	480	480	480

[1]Reference: Applied Research. Robust standard errors in brackets. ***, **, * indicate significance at 1%, 5%, and 10% level, respectively.

Regarding our control variables, in line with prior research (Murray and Graham 2007), we find that *female* scientists are much less willing to spin off or start a business compared to their male counterparts, all else being equal. We find stronger differences in the context of scientific entrepreneurship, where even fewer women plan becoming founders of spin-offs. This finding might be due to the working conditions in the life sciences, where it is difficult to balance family concerns and careers due to long working hours and time spent in the lab (e.g., night shifts). Moreover, with regard to *age*, we find evidence for the idea that younger scientists have a higher propensity to become entrepreneurs relative to their older counterparts. This might be caused by the specific characteristics of the life sciences, in which spin-offs often require long periods of time before generating real profits and thus, the cash-in effect will occur much later than in non-academic start-ups. Following the idea of human capital, older individuals will not invest in this "risky" occupational choice because the investment will deliver no short-term rewards. In addition, if the department falls into the category of *basic* rather than *applied research*, then the scientists in that department have a lower propensity to become entrepreneurs. Finally, with regard to the *specific skill variables*, we find a significant positive effect of consultancy and a significant negative effect of publication. In other words, scientists who are involved in consulting activities in the private sector have a higher intention of switching into entrepreneurship. Meanwhile, scientists who invest in publishing their research papers are less likely to leave the university and switch into entrepreneurship. This result implies that successful scientific publication somewhat crowds out entrepreneurial behavior from an academic scientist's perspective. Put differently, scientists who are successfully publishing research papers appear to remain in academia because of their better career prospects in that field (Ndonzuau et al. 2002).

7.5. Discussion and outlook

Despite the importance of academic entrepreneurship, empirical evidence relating scientists' backgrounds to their intentions of becoming entrepreneurs remains scant (Nicolaou and Birley 2003). Our paper has contributed to filling this research gap by studying how a scientist's human capital, as well as their work time and peers affect the intention to become an entrepreneur in the near future. By analyzing the standard working conditions to which scientists are exposed at their workplace, we find that those who are engaged in more diverse activities are also significantly more likely to have higher start-up intentions when working in an entrepreneurial environment. Thus, our results are in line with those of Ding and Choi (2011), who show that publication flow, patent experience, co-authorships and networking have a positive influence on scientists' becoming entrepreneurs, even when testing singular effects. The interesting point here is that for scientists, the effect of a more diverse skill set holds, especially when the set occurs in a peer environment that is positively related to entrepreneurship and when work time is balanced. This relation between entrepreneurial intention and peer effects may occur because of the special environment these scientists work in. Whereas some universities have adopted the entrepreneurial university approach, other universities continue to follow an approach highly influenced by Mertonian norms. Consequently, scientists are under high peer pressure. If universities want to produce more entrepreneurial scientists, they need to foster an entrepreneurial environment. Universities' policies often focus on monetary incentives to motivate scientists to create spin-offs or on institutional measurements like TTOs and patent strategies with the aim to support university spin-offs. In this context, our main results become of high interest: we find that in this setting the jack-of-all-trades effect (balanced skill set) works more like a latent capacity for entrepreneurship that can only be activated under specific conditions like being influenced by entrepreneurial peers. So, if university policies are already in place focusing on creating scientists with balanced work skills and allocating their work time on different activities, our findings outline the importance of looking at entrepreneurial experience when hiring new key employees at universities. According to our results, this strategy should help to create a more entrepreneurial environment and complement universities entrepreneurial strategies.

Peer-related results for more diverse human capital for the general population of other studies support our findings (e.g., Bercovitz and Feldman 2008; Acs et al. 2009). Therefore, our results add one more contribution to the discussion of academic entrepreneurship in terms of considering the three-way interaction. These results provide significant support for our hypothesis, which proposes that the positive moderating effect of entrepreneurial peers and more diverse skills is significantly stronger when scientists balance their working time across different activities. Technically speaking, this finding implies that these scientists are perfectly established in the new scientific mode described by Etzkowitz (e.g., 2003a): they 'live' according to the entrepreneurial university. Surprisingly, the three-way interaction also shows that a high skill score (together with a low working time balance) only result in high entrepreneurial intention under weak peer effects. We have two explanations for this effect. First, we follow Campell et al. (2012) and Werner and Moog (2009), explaining that quite often highly skilled individuals who do not find support in their work environment may be pushed into entrepreneurship to generate more satisfying career or working conditions. In this specific case of researchers with even low work balance, not only the peer group but also the work environment might frustrate the individual. A second explanation may be that some scientists who feature a broader set of skills but a low work-time balance and a weak peer effect have non-job-related learning settings where they diversify their skill sets. These scientists are able and willing to become entrepreneurs, but because of the lack of peer support, they concentrate on specific working areas, such as cooperation with industry, where they may find personal contacts with experienced entrepreneurs and firms. Those contacts may later help the scientists become entrepreneurs themselves.

Another interesting issue is the changing environment in academia. If universities in Switzerland and Germany develop as expected and transition to the US model, which features teaching and research universities, we will observe both effects on work-time balance and peer effects. At teaching universities, it might become increasingly difficult to generate a positive intention due to bad conditions – or, as mentioned previously, scientists will escape this environment and start their own company. In research universities that are highly interrelated with industry, we may find stronger positive effects.

However, future research could analyze each working condition in greater detail, by, for example, examining the length, extent, scope or range of the experience or how specific activity sets interact and differ in quality. Moreover, in our paper, we analyzed how individuals engaging in the generation of the previously mentioned skill combinations develop stronger intentions to become self-employed by viewing this type of occupational choice as a chance to earn higher income or utility in later stages of their careers – either outside academia or in combination with an academic career. In contrast to this approach, Åstebro and Thompson (2011:1) claim that the relation of varied work histories to entrepreneurship can also be explained by "[…] the simple story that individuals with a taste for variety prefer to become entrepreneurs because doing so provides utility.". Ghiselli (1974) defined this as 'hobo syndrome.' Both theoretical approaches positively relate work or experience variety to entrepreneurship. In our paper, we do not discuss or analyze this aspect due to data restrictions. Therefore, further research could explore these two approaches and attempt to discriminate between them in the academic field by relating variety to income data. However, this phenomenon again would require testing using different data, particularly longitudinal data.

With regard to the controls our data do not enable us to support previous findings that *TTOs* and entrepreneurship courses for scientists have a positive impact on the entrepreneurial intentions of researchers. Therefore, even though most of the literature supports the notion that the presence of a TTO supports the entrepreneurial activities of scientists (e.g. Nosella and Grimaldi 2009), this effect appears to depend on the quality of the TTO (e.g., size, age, specialization of the TTO employees, incentives).

In conclusion, we believe that our work on the entrepreneurial intentions of scientists provides a useful starting point for more comprehensive studies on the occupational choices of researchers. Despite some limitations, we believe that our study provides novel insights into the career decisions of scientists. We provide first evidence that researchers with broader experience through diverse academic working conditions develop stronger intentions of becoming academic entrepreneurs when working in a peer-supported entrepreneurial environment. This finding, in turn, highlights the importance of recognizing that researchers' experiences in different academic tasks (teaching, research and transfer) represent the most important factors determining entrepreneurial intentions. Therefore, the notion supported in life science faculties - and in other faculties - of focusing increasingly on publications in journals in making career decisions could be detrimental to the entrepreneurial initiatives of scientists; in contrast, it would be helpful to also foster or honor collaboration with industry or when young scientists are applying for a research group leading position or a professorship. However, our analysis is only a first step. Future research should provide more in-depth analyses of the human capital of scientists, the quality and quantity of different skill combinations related to different peer or institutional environments and the resulting synergy effects. This future research should help researchers more explicitly examine how the experience and skill profiles of scientists relate to their entrepreneurial intentions, their founding of start-ups and the success of their entrepreneurial activities.

8. The impact of federal programs

The start-up financing is generally one of the biggest hurdles for entrepreneurs. Although other forms of commercialization also incur costs, the establishment of a new, more or less independent entity has a much greater requirement for financing. Especially in the early stages of the development of a spin-off, when the success is difficult to predict, many investors are cautious with their investments (Volkmann and Tokarski 2006). Although university spin-offs have the advantage of support by their parent organization, capital requirements often cannot be met by the founder or the university, especially in technology-intensive start-ups. In addition to the previously examined cooperation with industry as a way of financing of start-ups, the state as the third player in the triple helix model implements mechanisms to support the transfer of technology from universities into practice. This support is usually provided as part of governmental or federal programs.

In addition to providing financial support, such programs also support other areas, such as in the production of network contacts or in dealing with authoritative bureaucracies (Hayter 2016). However, the effectiveness and importance of federal support programs is controversial. Although some studies have concluded that public funding leads to a higher rate of spin-offs from universities, others concluded that federal programs support does not work and produces only windfall profits. Therefore, the effect of federal programs, provided by the state as third actor in the triple helix model, in terms of financial, network and social support will be the main topic in paper 4.

Probably, the most prominent attempt to foster knowledge transfer from university to industry was the implementation of Bayh-Dole Act in the US. Henderson et al. (1998) showed that the increase in patenting because of the Bayh-Dole Act did not increase the number of important and valuable patents. Only the number of patents, not the commercialization rate, was affected significantly. In the German case, Czarnitzki et al. (2011) showed that because of structural reforms and the abolishment of the professors’ privilege, the patenting rates increased significantly. However, this increase did not lead to a higher degree of commercialization, mainly because the increasing number of patents was accompanied by a decrease in the quality of patents. In contrast, there is evidence of successful government programs. Cumming and Johan (2016) analyzed government-subsidized innovation investment funds in Australia. Their results showed that government programs fostered innovativeness and technology transfer in the economy.

Paper 4: The Impact of Federal Programs on University Spin-offs

Abstract

Academic entrepreneurship has become an important driver of economic development. Therefore, governments try to foster university spin-offs by implementing federal support programs. Although these programs have the potential to foster academic entrepreneurship, their impact on individual scientists, especially their motivation, is controversial. Using data collected from 337 life science researchers in Switzerland and Germany, this paper provides evidence for the positive effects of federal programs on scholars' decisions to commercialize their knowledge through founding university spin-offs. The effect that government-supported scientists showed a higher tendency to found spin-offs than their non-supported counterparts did can be identified in the analyses. Nevertheless, the results also showed that the motivational effects of such incentives might be inefficient. Although younger scientists seem to be more interested in founding a spin-off, they are less supported by federal programs. Older and more prestigious scientists have better access to federal funds, even though, they are often less interested in founding a spin-off and might not need and often do not want support from federal programs. In addition to this effect, this paper also provides evidence for the influence of peer effects on applications for programs and on the founding of university spin-offs.

Keywords: Academic entrepreneurship; Federal programs; Peer effects

8.1. Introduction

There have been some radical changes in university environments in recent decades (Shane 2004). Since the implementation of the Bayh-Dole-Act in 1980 in the US, the direction of university policies and university scientists' research has changed (Carlsson et al. 2013). Thus, following the environmental development, there has been an increase in the commercial activities of university scientists (Stuart and Ding 2006). In addition, since the original act was passed in the US, policy makers around the world have begun to identify the importance of university technology, and they have fostered federal programs to enhance the volume and quality of technology transfers and university spin-offs. However, the effectiveness and efficiency of such programs are controversial. The programs share two main objectives. First, they are intended to motivate scientists who do research that can be commercialized in order to transfer their knowledge into the commercial arena. Second, they try to support scientists who are willing to found a spin-off in order to increase their chances for success. This paper aims to answer the questions of whether these programs have a motivation effect and whether they address the right target group. Therefore, on one hand, there should be a motivation effect; on the other hand, support should be available for scientists who need it.

Although these effects are discussed in the literature, the author of this paper aims to shed light on the broad context of the changes in university environments and their impact on the motivation to commercialize research and the influence of federal programs on this context. In addition, although governmental support programs exist in nearly every country around the world, little research has been conducted on this topic. Most studies dealing with federal programs are interested in the institutional context by considering the function of support for the cooperation between industry and science or the effectiveness of technology transfer (e.g. Link and Scott 2010; Toole and Turvey 2006). Only a few empirical studies have analyzed the individual effects of those programs on the motivation and capability of an individual scientist in the case of commercialization, particularly university spin-offs.

Therefore, regression analyses are performed to identify the factors that influence the application and receipt of federal support for spin-offs and the impact of the latter on commercializing research. The rest of this paper is organized as follows. Hypotheses will be derived from the theoretical framework. The data collection will be introduced briefly, and the results of the regression analyses will be described. The paper will conclude with a discussion of the results.

8.2. Bayh-Dole policies and their implications

Since the 1980s, nearly every government in the world, or at least in the West, has passed acts similar to the Bayh-Dole Act in the US (e.g., the EU's "New Deal"). Although the influences of these acts vary, generally there has been a positive effect on the quantity of commercialization and technology transfer at universities (Thursby et al. 2001; Henkel 2007). In the context of these acts and legal changes, the biotechnology industry for example was created mostly by university spin-offs. In particular, the legal changes in the ownership of patents derived from university research and the commercial exploitation of research are major motivations for scholars to commercialize their knowledge (Klofsten and Jones-Evans 2000).

Although there are new opportunities for the commercialization of university research, there is also another trend in university environments. In addition to policy changes, the function of universities has expanded. The so-called third mission is now part of the demands of universities (Rasmussen et al. 2006; Etzkowitz 2003a). The traditional tasks in academic research and teaching have expanded by the commercialization of research. Following Etzkowitz and Leydesdorff's (2000) triple helix model, the borders between the traditional domains of university, industry, and government have become blurred. Each partner in this model adopts the tasks and habitual norms of the other spheres, which results in the fusion of activities and the creation of hybrid organizational structures. Hence, the commercial activities of university scientists are not only more possible and potentially more rewarding but also there is greater pressure on scholars to create commercial useful research and be involved in spin-offs or technology transfer (Davis et al. 2011).

In addition to the expansion of the mission of universities, another trend in this environment has increased the pressure on scholars. Although governments and politicians have emphasized the importance of university research for the economy and society, university budgets have been lowered or stagnated despite the expansion of their mission. This has led to a situation in which university scientists have better chances to use their research for economic success, but they are also forced to find new sources of funding (Ambos et al. 2008). This situation has led to the need for third-party funds and other alternative sources of income to finance research projects. There is a general discussion of whether the commercialization of university research should be part of a university's mission. For followers of Mertonian norms, the concentration on commercialization is generally undesirable (e.g. Thursby and Thursby 2011; D'Este and Perkmann 2011). Because the commercialization of research takes time, effort, and money, most scholars need external funding. Private investors such as business angels, venture capital organizations, and universities are important sources of financial support. However, the resources provided by universities are limited, and private investors often show no interest in investing in very early research, or they demand high profits or rates of interest, which could discourage scientists and create a gap in early financing (Stiglitz and Weiss 1981). Therefore, governments have established federal programs to foster commercialization and the founding of university spin-offs. These programs vary in volume and importance in different countries. In the US, for example, federal programs play a minor role, whereas in Germany they are more important. Similar programs exist in nearly every information-driven economy worldwide.

To overcome the early finance gap and to motivate scientists to found spin-offs, many programs were implemented. In periods when research funds are lacking or are insufficient, federal programs that support commercialization have a high attractiveness for scientists in universities. An important question concerns the design of these programs. To foster the creation of spin-offs, programs have to be effective and efficient. Most previous studies on this topic have taken a macro perspective, examining only the governments' perspective or the effects on national or regional economic development (e.g. Clarysse et al. 2005; Powers and McDougall 2005; Degroof and Roberts 2004). Link and Scott (2010) showed that the SBIR program, launched in 1982 by the US government, had a positive effect on R&D in small- and medium-sized firms by lessening some investment barriers to their funding. In a study that analyzed data collected from 44 projects sponsored by the US Department of Defense, Audretsch et al. (2002) found that the SBIR stimulated R&D in firms. In their study on early-stage technology, Toole and Turvey (2006) showed that initial public investment had positive effects on subsequent private investment and financial returns. However, most previous studies on federal programs were located in the US. Although, this limitation is not generally problematic especially in the US, government programs play a minor role in university spin-offs. The only widely recognized program is the SBIR, which was not designed for university spin-offs but for existing firms. Nevertheless, a few previous studies focused on federal programs and their influence on individual scientists. Harman (2010) analyzed Australian government-funded programs, comparing scientists who were specialists in technology transfer with industry-funded scientists. He focused mainly on their opinions about the effectiveness of such programs. The findings showed that although they used the programs, the scholars were unsatisfied, especially with the financial capacity of the programs. Based on the findings, he concluded that third stream funding provides returns that are lower than the costs of commercialization. In an analysis of the effectiveness of the SBIR, Toole and Czarnitzki (2007) showed that the program was used as a support for commercialization and that supported spin-offs performed significantly better than other SBIR-funded firms did. Only Audretsch et al. (2002a) analyzed the motivational effects of programs on individual scientists. Using 12 case studies of SBIR-funded scientists they showed that because programs influenced the career trajectories of scientists, they had a motivational effect. Nevertheless, to the best of the author's knowledge, no previous study has focused on individual scientists and compared them with non-entrepreneurial scientists, which is the objective of the present paper. The topic of federal programs is not only widely discussed in literature but also is included in a general and often emotional political dispute about freedom of research, the economy, and governmental influence. Therefore, the following hypotheses are stated:

H1: Lower basic budgets granted by the university generally raise the interests of individual scientists in federal programs and university spin-offs.

H2: The granting of aid from federal programs actively fosters the founding of university spin-offs.

8.3. Other influential variables

Support from programs can be a mayor driver of scientists' motivation to create a spin-off. However, other factors influence the decision to found a spin-off and might affect the interest in federal programs. Neglecting these variables would distort the results of the analyses performed in this paper. Therefore, the following influences should be considered.

The type of research a scholar does is an influential factor. Some research can be commercialized more easily and more profitably than other kinds of research. In the field of biotechnology, it is common to differentiate between basic research and applied research (Henderson and Cockburn 1994). Basic research is mainly theoretical in nature. Although it is viewed as enhancing prestige in the scientific community, it is often seen as less valuable in commercialization (Di Gregorio and Shane 2003; Tijssen 2006). The results of basic research are often highly complex and abstract and because of the nature of such results, they are often difficult to implement in industry. In addition, it is easily copied by existing firms or other scientists and often rather publicized then commercialized (Crespo and Dridi 2007). However, Ding and Choi (2011) showed a positive relationship between publication and managerial outputs. Although there is a trend toward the patenting of basic research, it is often a complex and time-consuming process. One example of the problems involved in the patenting of basic research is the discussion about if and under which conditions parts of the human genome could be patented. Even if basic research were patented, it could be easily copied by competitors. In contrast, application-oriented research produces results that are suitable for commercialization (Bekkers and Bodas Freitas 2008; Boardman 2009). Patenting of applied research is relatively uncomplicated, and results cannot be copied easily by firms or other scientists. In addition, the results of application-oriented research are practicable, often resulting in patents, prototypes, and knowledge that are appropriate to commercialization (Rosenberg 1990). Although basic research is needed for scientific progress, industry is interested in applied research. Because firms still need basic research, R&D networks between universities or individual university scientists and firms are established frequently (Stuart et al. 2007; Lee 2000). Thus, basic research can be commercialized through the technology transfer to firms, but is less likely to be the basis of a university spin-off. In the case of federal programs, basic research is also less likely to be funded. Especially programs that foster spin-offs are more likely to grant aid to scientists who do applied-oriented research because of the better chances of creating a successful spin-off.

The empirical evidence for the type of research in spin-offs is still controversial. Empirical studies have shown diverse results. Bercovitz and Feldman (2008) used data gathered from 1,780 scientists in 15 medical departments of universities in the US. Their results showed a positive influence of basic research on patenting, whereas applied-oriented research showed a negative effect. Their results underlined the tendency to the increased patenting of basic research. However, patenting is a relatively weak indicator of commercialization. Czarnitzki et al. (2009) confirmed the trend of increased patenting at universities, but they found that it did not lead to a greater number of commercialization activities. Other studies found a positive influence of applied-oriented research. Link et al. (2007) found a positive effect of application-oriented research on entrepreneurial activities in their analysis of the data collected from 766 university scholars. In contrast, Lam (2010a) found no effect of the type of research conducted by a scientist on the commercialization of knowledge. Therefore, the following hypothesis is stated:

H3: A focus on basic research lowers the interest in federal programs to foster commercialization and spin-offs.

Another interesting point is the willingness or interest of scientists to commercialize their research. Over the last decades, the mission of universities has constantly expanded and now includes the so-called third mission. In addition to research and teaching, commercialization has become part of universities' activities. Those changes did of course come along with incentives from governments, including federal programs and allocation of basic funds in dependence of commercial success (Slaughter and Leslie 1997; Henkel 2007). There is an ongoing debate about whether the commercialization of university research is even desirable (Baumol 2005; Debackere and Veugelers 2005). There is a conflict between followers of the so-called old mode of universities habitus, the Mertonian norms, and the followers of the so-called new mode of academic capitalism (Pratt and Foreman 2000; Hackett 2005). The followers of Mertonian norms fear the diffusion of scientific progress because of its focus on applied research and commercialization (Huang and Murray 2009; Mendoza 2007; Cooper 2009), whereas the followers of the new mode hold that only by commercialization can knowledge be made accessible by the public, and without commercialization, universities are ivory towers where research is done for its own sake (Karlsson and Wigren 2012). Nearly every university in the West and worldwide has adopted a mission statement that includes commercialization and the third mission, the social habitus however has not changed at every university or faculty. For young scientists in particular, the habitus of their working environment has much stronger impact on their behavior than an abstract mission statement has. Peer effects are important in deciding which kind of research is done or whether to commercialize research or not (Jain et al. 2009; Haas and Park 2010). In commercialization or university spin-offs, a supervisor or former or present colleague who founded a spin-off or was involved in commercialization could provide a positive role model (Bercovitz and Feldman 2008; Huyghe and Knockaert 2015).

Scientists may also acquire entrepreneurial knowledge from experienced faculty members through spillover effects (Acs et al. 2009). To influence an individual scientist, peers must have similar social status, personal skills, and interests (Ellison and Fudenberg 1993). In the case of scientists, colleagues are a relatively homogenous peer group that shares similar goals, habitual expressions, and professional norms (Moog et al. 2015). Nanda and Sorensen (2010) showed that even peers with negative entrepreneurial experience could positively affect the attitudes of employees in different industries toward entrepreneurship and influence the motivation of their colleagues, thereby facilitating their transition to entrepreneurship. Moog et al. (2015) analyzed the data on 480 scientists in the biotechnology field and found a positive effect of peer effects on economic activity of university scientists. Considering the strong impact that peers have on other scientists, it can be assumed that their influence also has an impact on the interest in founding a spin-off and in federal programs aimed at commercialization and technology transfer. Therefore, the following hypothesis is stated:

H4: Peers involved in the founding of spin-offs lead to a higher degree of interest in federal programs and university-spin-offs.

In addition to the changes in the ethos of universities, there is another interesting point concerning the commercialization of universities research. Regardless of whether scholars and universities want their research to be commercialized, there is still the question of their ability to do so. It is often said that there is a cognitive distance between universities and industry (Wayne and College 2010). Their objectives and structures are different and if, following the triple helix model, the spheres of universities and industries become blurred; universities need to learn and adopt economic approaches. To understand the functions and habitus of the economic sphere, scientists need to deal with those objectives and structures. The possibly best way of learning those norms of the economic sphere is to interact with it (Meyer 2003;

Aschoff and Grimpe 2014; Bruneel et al. 2010). Those interactions can be formalized through cooperation in research or on an informal and individual level. Both alternatives can foster the learning process and affect positive attitudes toward commercialization (Wayne and College 2010; D'Este and Patel 2007). In addition, contacts can improve the social capital of an individual scientist and provide valuable information about raising third-party funds or the aid provided by federal funds. Through networks, programs can become known by scholars, and they could obtain information about the application process. Therefore, the following hypothesis is stated:

H5: A stronger interaction with industry leads to a higher interest in federal programs and university spin-offs.

The last important influence factor considered in this paper is the scientist's prestige in the scientific community. The effects of prestige are important in achieving successful career paths and receiving funding from universities (Bollen et al. 2009). A high level of prestige can open doors, not only in the academic world but also in the economic sphere. Creating a spin-off needs support by third-party members. A scientist with a high prestige can gain the attention of investors more easily than an unknown scientist who maybe has a better suited idea for commercialization (Cassia et al. 2014). In addition to the interest of investors, the application for support by a federal program could be influenced by the prestige of the candidate. Although prestige per se can have many sources, scholars' prestige is most often linked to publications (Teixeira 2011). The greater the number of highly-rated publications that scientists produce, the higher their prestige is.

Although commercialization normally depends on a decent level of scientist's prestige, there are some conflicts between publication and commercialization. There is an ongoing discussion regarding whether they are exclusive or complementary (e.g. Ambos et al. 2008; Lam 2010a), particularly in the natural sciences where publication means the disclosure of data and methods. Hence, patenting can be problematic because the results can be used by already existing firms (Crespo and Dridi 2007). Therefore, it could be wise for a scientist to hide the knowledge he or she wants to commercialize. However, the majority of the literature, including the ‘star scientist’ thesis, shows evidence for the complementary effects of publication and commercialization (e.g. Stern 2004; Darby and Zucker 2001). Those previous studies showed no problematic effects of publishing with regard to commercialization. Indeed, some findings emphasized the positive effects of publication and commercialization. With regard to the star scientist thesis, Darby and Zucker (2001; 2006) showed that scientists who have the most publications are the most often involved in spin-offs. In the biotechnological industry, they showed that firms with star scientists had a higher survival rate (Darby and Zucker 2001) and that they were more successful than were firms without star scientists’ involvement (Zucker et al. 1998). In addition, Wong and Singh (2013) showed that scientists with a higher degree of co-publication with industry had a generally stronger affinity for commercialization activities. Considering this complementary effect, a higher publication rate and the concomitant higher prestige in the scientific community should have a positive influence on university spin-offs and the granting of support by federal programs.

Closely linked to prestige is the income of scientists. Support by universities and wages is often linked to the prestige of a scientist in the scientific community and in the university itself (Göktepe-Hulten and Mahagaonkar 2010). Prestigious scientists often have higher incomes and have higher budgets for their research (Franklin et al. 2001). Hence, they often do not have the need to raise third-party funds from alternative sources of income. Therefore, scientists with higher incomes should be less interested in university spin-offs and the support of federal programs. In their analysis of the data on 478 Swedish university scientists, Åstebro et al. (2013) showed that, despite some fluctuation, the earnings of scientists did not increase significantly when they became entrepreneurs. However, the risk to income tripled. Therefore, scientists with already high incomes are not likely to take that risk and prefer to stay in their secure jobs.

Therefore, the following hypothesis is stated:

H6: The higher the prestige in the scientific community of an individual scientist, the more likely it is that federal programs will grant aid and they will found spin-offs.

8.4. Dataset and methodology

The dataset includes data on 1,046 Swiss and German university scientists. The questionnaire was mailed to 7,464 life scientists in Germany and Switzerland. The data collection took place in from 2007 to 2013 and is complemented by own data collection. A total of 337 scientists answered all questions relevant to this empirical analysis. The data within our sample is in accordance with data from the German Federal Statistics Office and the Swiss Statistical Office. Furthermore, the data from the scientists in our sample is similar to the data of Life Science Federal organizations in Germany and Switzerland. Therefore, the dataset should not bias results of the empirical tests.

To test the hypotheses, four regression analyses will be conducted. The first three regressions will each be divided into seven models. In each first model, only the control variables will be taken into account. In the next five models, each variable is tested in association with a hypothesis. In the last model, all variables are included. The last regression will include eight models instead of seven; otherwise, the structure remains the same.

Three indices were created to measure the knowledge of programs, the application for programs, and the granting of aid by programs. To generate the indices, questions were asked about the general knowledge of assorted federal programs, as well as whether a scientist had already applied to one or more of the ten programs and if they had been granted aid from one or more of the programs. From these variables, the first three dependent variables were created. To measure the propensity to start a spin-off, the scientists had been asked whether they planned to start a spin-off based on their scientific results in the near future. The variable was measured on a Likert scale ranging from 1 (very unlikely) to 5 (very likely). Although intention-based measures are not as valid as fact-based measures are, entrepreneurial intention is an accurate predictor for actual future entrepreneurial activities (e.g. Krueger et al. 2000; Villanueva et al. 2005).

To test the hypotheses, certain variables were chosen to measure the impact of the influence factors described in the hypotheses. First, the variable of basic budget is linked to H1 and H2 to measure the extent of the budgets granted by the home-university. Regarding H3, to test the influence of basic research, the scholars were asked to indicate the extent to which their works could be described as basic research. Three variables are used to test H5: (1) the extent of informal contacts of scientists or managers in industry; (2) the number of short term projects; (3) the number of long-term projects in cooperation with industry. Hence, both formal and informal contacts could be considered. To test H4 regarding peer effects, the participants were asked whether a former colleague had ever started a university spin-off. To test H6, an indicator was created to measure prestige. Because of the limitations of the existing indicators, such as the Impact Factor or the Eigen Factor (for an overview see Vanclay 2012), a new indicator based on the SJR was generated.

The SJR is based on the ratio of citations per document, which is common in most other databases of publication indicators. Although it covers only the most recent three years, the SJR overcomes some of the shortcomings of other databases. First, it has an international database that includes journals in languages other than English. Hence, journals from the English-speaking world are not overrepresented (Falagas et al. 2008). In addition to the database, the special weighting of the citations of the individual journals is an advantage of the SJR. This weighting process is similar to the Google Page Rank for websites. The journals are weighted according to the total number of citations and the topic of a journal (González-Pereira et al. 2010). For each citation, the cited journal receives a certain portion of prestige from the donating journal. The amount of prestige is thereby determined by the prestige of the journal, divided by the total number of citations. To avoid a bias resulting from self-citations, the SJR allows a maximum of 33 percent of self-references (González-Pereira et al. 2010). If there are more self-citations, they do not raise the indicator of a journal. Furthermore, as the intrinsic factor in its calculation, the SJR considers the total number of documents in a journal. For example, the Impact Factor is considered in only documents that are most likely to be cited (Falagas et al. 2008). Because the SJR was chosen as the database for ranking the publications in our dataset, books and other forms of publishing could not be included. The exclusion of other forms of publishing should not create a serious bias because journals are the most dominant form of publishing in the scientific community, and other forms of publications are marginalized.

In addition to the SJR value of each citation of an author, other values are included in an accurate prestige indicator. In the scientific community, prestige is often measured according to the number of articles a scientist has published. However, although the number of published articles is not an accurate indicator mainly because of the conflict between a few good publications of high quality and a high quantity of publications of poor quality, it still has some significance with regard to prestige. The more publications a scholar has, the better known their name is in the scientific community, which normally goes hand in hand with higher prestige. Furthermore, frequent publication in peer-reviewed journals could signal at least a basic level of quality in the publications. Therefore, the number of publications is included in the indicator.

Even though an old publication does not necessarily lose its importance, most publications, excluding the basic literature, become out of date and are less frequently cited. Hence, importance decreases, and the publication becomes obsolete. This half-life time of scientific studies varies significantly between different disciplines. In biotechnology, the half-life time is five to six years (Hornbostel et al. 2009).

The position of an author is included as the last element in the index. Co-authorship has become increasingly common (Weltzin et al. 2006). In the natural sciences, the number of authors is particularly high. Therefore, a publication does not result in the same amount of prestige to every author. Predominant in biological science, for example, is the ‘first-last-author-emphasis’, which means that the first author has the most prestige, 100 percent in our case, while the last author has 50 percent of the prestige. All other authors have a proportion based on the total number of authors (Tscharntke et al. 2007). Although there are other systems, such as alphabetical order, the ‘first-last-author-emphasis’ is also predominant in biotechnology.

Figure 10: Prestige indicator

$$\sum SJR * 0.5^{\frac{2012-Jahr}{6}} * \begin{cases} pa_{1,10} & = \frac{10}{pa} * 0.1 \\ pa_{11,n-1} & = 0.05 \\ pa_{n} & = 0.5 \end{cases} + \sum \overline{SJR} * 0.5^{\frac{2012-Jahr}{6}} * \begin{cases} pa_{1,10} & = \frac{10}{pa} * 0.1 \\ pa_{11,n-1} & = 0.05 \\ pa_{n} & = 0.5 \end{cases}$$

pa	= position author
SJR	= Scimago Journal Rank
half-life	= 6 (years)
n	= last named author among authors

The value of the indicator shows the prestige of an individual scientist. Derived from using the SJR values of the individual journals, the publications are published in. The index value is weighted for each publication based on the age of the publication and the position of the author among all authors. Because the SJR does not rank journal articles published earlier than 1999, an average of the SJR value over the entire data set is formed to include publications before 1999. These publications are also weighted by the age of the publication and position of the author. By incorporating the prestige value of all published articles, the number of publications is automatically obtained. The prestige value is obtained by summing the individual values. The weighting of the age of a publication is obtained by multiplying the SJR by the exponential function of the half-life of six years (Hornbostel et al. 2009). The position of an author is respected by two different systems. The first ten authors are rated proportionally from 100 to 10 percent of the SJR value as a prestige value. The latter author receives 50 percent of the SJR value as the prestige value. All other authors receive five percent of the SJR value as the prestige value.

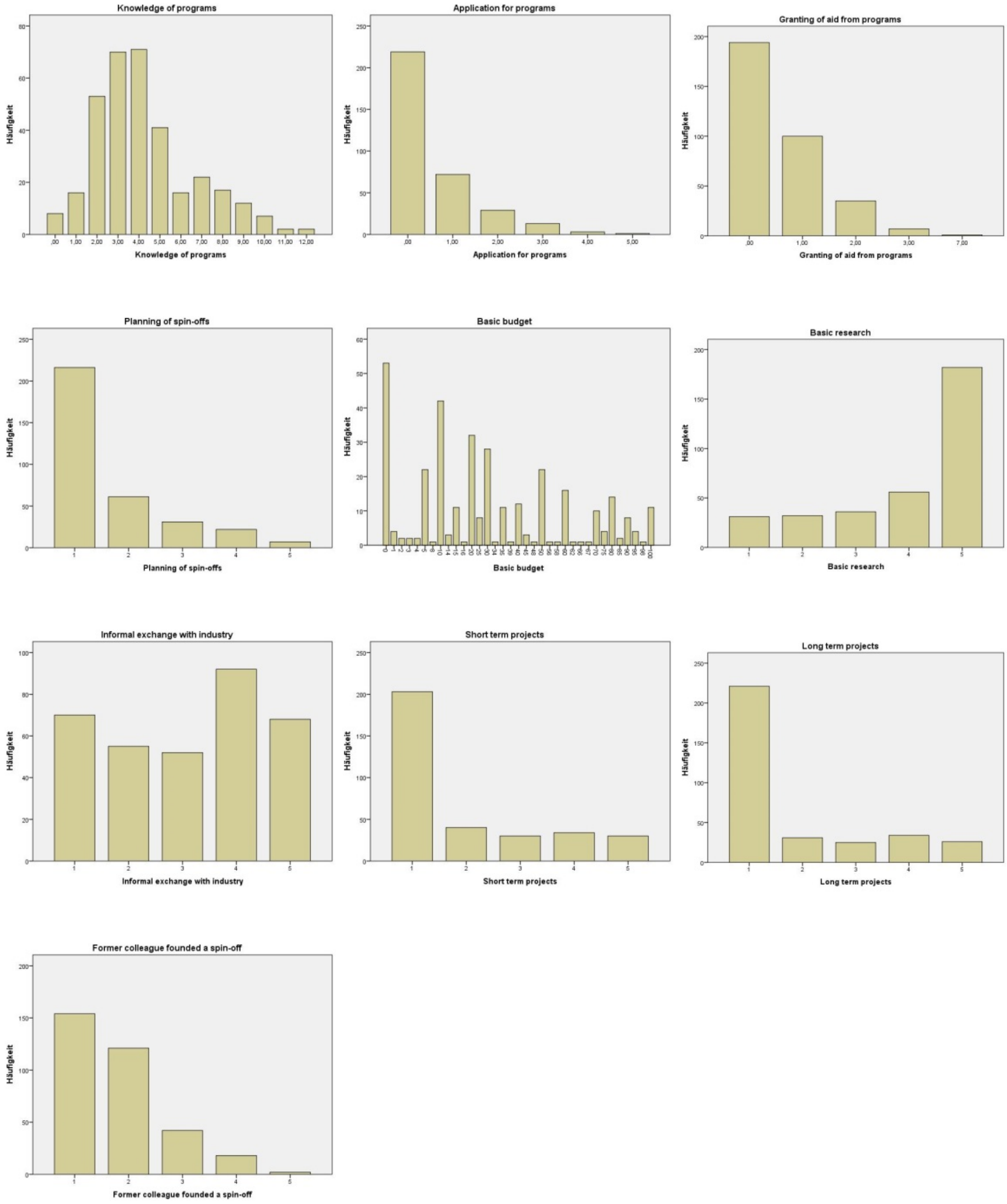
In addition to the central variables, some control variables are included in the regression analyses. First, it is controlled according to whether a respondent is a professor or not and whether he or she works at a public university or a research institute. Second, a variable, if the institution, a respondent works at, maintains a TTO, is included. For this variable, the data only show whether a TTO is active at the institution, but not how effective and efficient it is. To see if patenting influenced the behavior with regard to federal programs or spin-offs, two variables are included to measure whether a scientist has applied for a patent and if he or she thinks that patenting could foster his or her career. Because both Swiss and German scientists are included in the dataset, a variable measuring the affiliation of a scholar is included. Last some very common control variables are included in the regression: gender, income, family status, if the respondent has children, and age.

Table 16: Descriptives

		Mean	SD	Min	Max
1	Spin-off	1.64	1.03	1.00	5.00
2	Knowledge of programs	4.25	2.37	0.00	12.00
3	Application for programs	0.55	0.91	0.00	5.00
4	Granting aid from programs	0.59	0.84	0.00	7.00
5	Basic budget	2.03	1.31	1.00	5.00
6	Basic research	3.97	1.36	1.00	5.00
7	Informal exchange with industry	3.10	1.44	1.00	5.00
8	Short term projects	1.96	1.38	1.00	5.00
9	Long term projects	1.85	1.35	1.00	5.00
10	Former colleague founded a spin-off	1.79	0.90	1.00	5.00
11	Prestige indicator	5.66	6.55	0.05	41.67
12	Professorship	0.31	0.47	0.00	1.00
13	Public university	0.75	0.43	0.00	1.00
14	TTO	0.61	0.49	0.00	1.00
15	Patents	0.49	0.50	0.00	1.00
16	Patenting positive career influence	3.32	1.44	1.00	5.00
17	German	0.81	0.39	0.00	1.00
18	Gender (1=female)	0.23	0.42	0.00	1.00
19	Income	58281.80	28819.56	10000.00	190000.00
20	Family status (1=single)	0.12	0.32	0.00	1.00
21	Children	0.65	0.48	0.00	1.00
22	Age	53.17	8.91	37.00	75.00
N=337					

While some variables are not normally distributed, the chi-square test shows that the residuals of the variable are normally distributed. Following the assumption that the dependent variables can be handled as quasi-metric, there should be no reason not to use an OLS-regression.

Figure 11: Distribution of dependent and central variables



Because every value for the prestige indicator variable appears only once, a graphic presentation of the prestige indicator is not included in the above figure. There should be no heteroscedasticity in the data for the variables included in regression models. Therefore, all regressions were tested for heteroscedasticity. Although the white test for heteroscedasticity showed no relevant bias in models 1, 2, and 4, there was significant heteroscedasticity in model 3. To deal with this issue, robust estimators were used in the third regression model.

Table 17: Test for homoscedasticity

White's test for H0: homoscedasticity; H1: unrestricted heteroscedasticity	
Regression1:	Regression 2:
Chi-square = 155.22	Chi-suare = 200.85
Prob >Chi-square = 0.9177	Prob>Chi-square = 0.1486
df = 181	df = 181
Regression3:	Regression 4:
Chi-square = 231.91	Chi-suare = 264.61
Prob >Chi-square = 0.0063	Prob>Chi-square = 0.1741
df = 181	df = 244

Table 18 shows the correlations of all variables used in the empirical analysis. With regard to the tests for multicollinearity, neither the VIF-test nor the correlation-matrix indicated relevant multicollinearity.

Table 18: Pair-wise correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
(1)	1																					
(2)	.164***	1																				
(3)	.177***	.319***	1																			
(4)	.213***	.257***	.172***	1																		
(5)	-.119**	-.164***	-.118**	-.131**	1																	
(6)	-.174***	.059	-.132**	-.033	-.044	1																
(7)	.183***	.165***	.155***	.246***	-.003	-.244***	1															
(8)	.253***	.139**	.084	.211***	-.093	-.237***	.427***	1														
(9)	.256***	.116**	.119**	.202***	-.114**	-.236***	.389***	.527***	1													
(10)	.293***	.257***	.171***	.115**	-.122**	.011	.119**	.134**	.213***	1												
(11)	-.084	.087	.046	.214***	.083	.228***	.032	-.066	.024	.041	1											
(12)	.023	.143***	.060	.212***	.064	.134**	.012	.064	.037	.057	.177***	1										
(13)	-.017	.060	.105	.015	-.194***	.047	.068	.052	.034	.083	.004	.254***	1									
(14)	.014	.178***	.016	-.029	-.044	.012	-.001	.054	.021	.100	-.073	.094	-.004	1								
(15)	.122**	.239***	.035	.181***	.043	-.059	.152***	.161***	.166***	.089	.060	.074	-.029	.006	1							
(16)	.048	-.036	.098	.099	.100	-.211***	.221***	.072	.076	.089	.035	-.019	-.054	.002	.179***	1						
(17)	.083	.188***	-.048	-.148***	-.164***	-.056	-.083	-.060	.003	-.053	-.087	-.096	-.013	.173***	-.037	-.197***	1					
(18)	-.117**	-.092	-.007	-.116**	-.092	-.024	-.141**	-.117**	-.057	-.097	-.095	-.106	-.038	-.021	-.134**	-.102	.062	1				
(19)	.060	.066	.021	.340***	.196***	.075	.150***	.200***	.100	.144***	.282***	.512***	.164***	.013	.142***	.198***	-.301***	-.210***	1			
(20)	.056	-.019	.040	.005	-.036	-.072	-.051	.025	.020	.003	-.089	-.051	-.024	.048	.024	.103	.061	.087	-.124**	1		
(21)	-.039	.043	.012	.029	.058	.032	-.058	.008	-.003	.126**	.068	.193***	.082	.060	.119**	.045	-.057	-.300***	.196***	-.305***	1	
(22)	-.032	.053	-.051	.184***	.139**	.034	.050	.141**	.065	.191***	-.045	.376***	.112**	.081	.108**	.070	-.137**	-.156***	.379***	.028	.253***	1

Significance levels *** p<0.01; ** p<0.05; * p<0.1
N= 337

(1) Spin-off; (2) Knowledge of programs; (3) Application for programs; (4) Aid from programs; (5) Basic budget; (6) Basic research; (7) Informal exchange with industry; (8) Short term projects; (9) Long term projects; (10) Former colleague founded a spin-off; (11) Prestige indicator; (12) Professorship; (13) Public university; (14) TTO; (15) Patents; (16) Patenting positive career influence; (17) German; (18) Gender (1=female); (19) Income; (20) Family status (1=single); (21) Children; (22) Age

8.5. Results

Table 19: Regression analysis on knowledge of programs

Dependent Variable	Knowledge of programs						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Central variables							
Basic budget		-0.161*** [0.097]					-0.116** [0.097]
Basic research			0.056 [0.093]				0.066 [0.096]
Informal exchange with industry				0.133** [0.099]			0.139** [0.097]
Short term projects				0.044 [0.110]			0.056 [0.108]
Long term projects				0.000 [0.109]			-0.049 [0.107]
Former colleague founded a spin-off					0.240*** [0.136]		0.211*** [0.138]
Prestige indicator						0.076 [0.020]	0.064 [0.020]
Control variables							
Professorship	0.108* [0.324]	0.108* [0.321]	0.103 [0.326]	0.120* [0.323]	0.129** [0.315]	0.100 [0.325]	0.124** [0.313]
Public university	0.036 [0.293]	-0.001 [0.298]	0.036 [0.293]	0.023 [0.292]	0.019 [0.285]	0.040 [0.293]	-0.015 [0.289]
TTO	0.138** [0.256]	0.131** [0.253]	0.136** [0.256]	0.133** [0.255]	0.115** [0.250]	0.143*** [0.257]	0.112** [0.247]
Patents	0.240*** [0.251]	0.238*** [0.248]	0.242*** [0.252]	0.219*** [0.253]	0.228*** [0.244]	0.238*** [0.251]	0.213*** [0.244]
Patenting positive career influence	-0.044 [0.091]	-0.040 [0.090]	-0.032 [0.093]	-0.069 [0.092]	-0.055 [0.088]	-0.043 [0.091]	-0.058 [0.090]
German	0.186*** [0.336]	0.171*** [0.333]	0.191*** [0.337]	0.188*** [0.333]	0.190*** [0.325]	0.186*** [0.335]	0.188*** [0.324]
Gender (1=female)	-0.065 [0.311]	-0.072 [0.307]	-0.063 [0.331]	-0.044 [0.311]	-0.057 [0.302]	-0.061 [0.311]	-0.038 [0.301]
Income	0.028 [0.000]	0.053 [0.000]	0.025 [0.000]	0.007 [0.000]	0.008 [0.000]	0.006 [0.000]	-0.013 [0.000]
Family status (1=single)	-0.034 [0.406]	-0.036 [0.401]	-0.032 [0.406]	-0.021 [0.406]	-0.039 [0.394]	-0.032 [0.405]	-0.023 [0.391]
Children	-0.038 [0.290]	-0.037 [0.287]	-0.038 [0.290]	-0.012 [0.291]	-0.054 [0.282]	-0.040 [0.290]	-0.028 [0.282]
Age	-0.010 [0.016]	0.004 [0.015]	-0.009 [0.016]	-0.017 [0.016]	-0.044 [0.015]	0.005 [0.016]	-0.023 [0.015]
R^2	0.142	0.165	0.145	0.164	0.196	0.147	0.234
F	4.89***	5.335***	4.58***	5.50***	6.58***	4.66***	5.39***
Observations	337	337	337	337	337	337	337

Standardized effect coefficients; standard errors in brackets. Significance levels *** p<0.01; ** p<0.05, * p<0.1.

Table 19 shows the regression results for the knowledge of federal programs. Model 1 shows the results for the control variables. The findings showed that the existence of a TTO had a positive effect on knowledge of programs (0.138). If a researcher had already applied for a patent, he or she had a higher general interest in the topic of federal programs (0.240), and there was a positive effect of professorship (0.108) on the knowledge of programs. In addition, German scientists seemed to have a greater knowledge of federal programs than their Swiss counterparts did (0.186). In model 2, the effect of basic budgets on the knowledge of programs was tested. A higher basic budget was associated with a lower knowledge of programs (-0.161); in other words, a lower basic budget increased the general interest in support from federal programs. In this model, the effects of the control variables were similar to those in the first model (TTO (0.138), patents (0.238), professorship (0.108) and affiliation with a German institution (0.171)). In model 3, the effects of the kind of research were tested. A focus on basic research showed no significant effect on the knowledge of programs, and the results for the control variables were relatively stable (TTO (0.136), patents (0.242) and affiliation with a German institution (0.191)). Only the effect of professorship did not occur in model 3. In model 4, three variables were included to measure the effects of contacts with industry. Interestingly, there was a significant positive effect of informal contacts with industry (0.133), whereas the two variables used to measure the formal contacts with industry showed no significant results. Although the effects of the four control variables in model 3 were relatively constant (TTO (0.133), patents (0.219), and affiliation with a German institution (0.188)), when contacts with industry were added to the regression, professorship was significant again. In this model, professorship had a positive effect (0.120) on the knowledge of programs, which could indicate the importance of scientific prestige or industry's interest in academic titles. Considering the importance of informal contacts on the knowledge of programs, professorship seems to open a door to contacts in industry, perhaps by longstanding contacts with former students (Genua and Muscio 2009). In model 5, the peer effect variable was tested. Former colleagues who founded a spin-off showed a noticeably positive effect (0.240) on knowledge of programs. Interestingly, the positive effect of professorship (0.129), in addition to the other effects of the above-mentioned variables (TTO (0.115), patents (0.228) and affiliation with a German institution (0.190)), also showed in this model. However, in model 6, which was used to test prestige in the scientific community, the effect of professorship was not significant. In addition, there was no significant effect of the prestige indicator. However, the effects of the three control variables TTO (0.143), patents (0.238), and affiliation with a German institution (0.186) were found. In the final model 7, which integrated all variables, the effects shown in the previous models were relatively stable. Basic budget had a negative effect (-0.116) on the general interest in federal programs, whereas informal contacts (0.139), former colleagues who founded a spin-off (0.211), the existence of a TTO (0.112), patents (0.213), and affiliation with a German institution (0.188) had positive effects. Additional professorship also showed a positive effect on knowledge of programs (0.124). This finding indicated that professorship had a significant effect only when it was influenced by mediator variables. Mainly when network variables or the budget variable were included in the model, professorship showed a significant effect.

Table 20: Regression analysis on application for programs

Dependent Variable	Application for programs						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Central variables							
Basic budget		-0.111* [0.040]					-0.090 [0.040]
Basic research			-0.130** [0.037]				-0.127** [0.040]
Informal exchange with industry				0.120* [0.040]			0.101 [0.040]
Short term projects				0.002 [0.044]			-0.013 [0.045]
Long term projects				0.071 [0.044]			0.015 [0.044]
Former colleague founded a spin-off					0.176*** [0.056]		0.151*** [0.057]
Prestige indicator						0.035 [0.008]	0.060 [0.008]
Control variables							
Professorship	0.082 [0.131]	0.082 [0.131]	0.095 [0.131]	0.092 [0.131]	0.097 [0.130]	0.078 [0.132]	0.107 [0.130]
Public university	0.107* [0.119]	0.081 [0.122]	0.107* [0.118]	0.094* [0.118]	0.094* [0.117]	0.109* [0.119]	0.070 [0.120]
TTO	0.022 [0.104]	0.017 [0.103]	0.024 [0.103]	0.019 [0.103]	0.005 [0.103]	0.024 [0.104]	0.010 [0.102]
Patents	0.025 [0.102]	0.024 [0.101]	0.021 [0.101]	0.001 [0.102]	0.017 [0.101]	0.024 [0.102]	-0.001 [0.101]
Patenting positive career influence	0.101* [0.037]	0.104* [0.037]	0.071 [0.037]	0.076 [0.037]	0.093 [0.036]	0.101* [0.037]	0.050 [0.037]
German	-0.048 [0.136]	-0.058 [0.136]	-0.058 [0.135]	-0.049 [0.135]	-0.045 [0.134]	-0.048 [0.136]	-0.063 [0.134]
Gender (1=female)	0.001 [0.126]	-0.004 [0.125]	-0.002 [0.125]	0.019 [0.126]	0.007 [0.124]	0.003 [0.126]	0.014 [0.125]
Income	-0.036 [0.000]	-0.018 [0.000]	-0.030 [0.000]	-0.053 [0.000]	-0.050 [0.000]	-0.046 [0.000]	-0.054 [0.000]
Family status (1=single)	0.043 [0.164]	0.041 [0.164]	0.039 [0.163]	0.055 [0.164]	0.039 [0.162]	0.044 [0.165]	0.047 [0.162]
Children	0.022 [0.117]	0.023 [0.117]	0.022 [0.117]	0.047 [0.118]	0.011 [0.116]	0.022 [0.118]	0.028 [0.117]
Age	-0.105* [0.006]	-0.096 [0.006]	-0.108* [0.006]	-0.111* [0.006]	-0.130** [0.006]	-0.098 [0.006]	-0.111* [0.006]
R^2	0.036	0.047	0.052	0.060	0.065	0.037	0.101
F	1.11	1.33	1.47	1.46	1.87**	1.04	1.98**
Observations	337	337	337	337	337	337	337

Standardized effect coefficients; standard errors in brackets. Significance levels *** p<0.01; ** p<0.05, * p<0.1.

In model 1 in the second regression, employment at a public university and the opinion that patenting has a positive effect on career and age showed significant effects. Being a scholar at a public university (0.107) and the opinion that patenting has a positive effect on career (0.101) had positive effects on the application to federal programs, whereas age had a negative effect (-0.105). Other control variables showed no significant effects in model 1. In model 2, a higher basic budget showed an expected negative effect on the application to programs (-0.111). Although the effects of the public university variable and age disappeared, the variable used to measure whether a scientist thought that patenting could help fostering his or her career had a positive effect (0.104). In model 3, basic research had a negative effect on the application to programs (-0.130), which supports H3. In addition to the effect of the public university variable, which was similar to model 1 (0.107), age showed a negative effect (-0.108) in model 3. In model 4, with regard to the effects of contacts with industry, again only informal contacts had a significant effect (0.120). Public university (0.094) and age (-0.111) again showed significant effects in this model. In model 5, the effects of public university (0.094) and age (-0.130) remained the same. In addition, the central variable for peer effects showed a positive effect (0.176) on the application to federal programs. In model 6, the central variable of prestige in the scientific community showed no significant effect. Only some control variables showed significant effects on application to federal programs. Employment at a public university had a positive effect (0.109) as well as the opinion that patenting had a positive effect on career (0.101). In interpreting the results of model 1 to model 6, it must be kept in mind that, except for model 5, including the peer variable, all models were not statistically significant. Hence, the results can only indicate the occurrence of the effects. However, the final model 7 was statistically significant, and it concretized some findings in the other models. Although the effects of basic research (-0.127) and former colleagues who funded a spin-off (0.151) still were significant, basic budget, employment at a public university, the opinion that patenting has a positive effect on career, and informal contacts were not significant in model 7. This result could be explained by the mediation through the kind of research. Basic research and informal contacts had a mutually negative influence. Therefore, basic research could have influenced the relatively weak significance of informal contacts. In addition to the effects of the central variables, age had a negative effect on application to federal programs (-0.111). This result indicates that older scientists are less interested in applying to funding programs, whereas younger scientists have a higher interest in or need for support by federal programs.

Table 21: Regression analysis on granting of aid from programs

Dependent Variable	Granting aid from programs						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Central variables							
Basic budget		-0.246*** [0.032]					-0.238*** [0.035]
Basic research			-0.056 [0.033]				-0.053 [0.034]
Informal exchange with industry				0.149** [0.043]			0.147** [0.043]
Short term projects				0.028 [0.042]			0.019 [0.041]
Long term projects				0.086 [0.039]			0.047 [0.034]
Former colleague founded a spin-off					0.064 [0.054]		-0.002 [0.051]
Prestige indicator						0.135*** [0.006]	0.157*** [0.006]
Control variables							
Professorship	0.065 [0.126]	0.065 [0.124]	0.070 [0.126]	0.078 [0.123]	0.070 [0.125]	0.050 [0.125]	0.064 [0.119]
Public university	-0.044 [0.097]	-0.101** [0.093]	-0.044 [0.096]	-0.061 [0.095]	-0.049 [0.098]	-0.037 [0.097]	-0.105** [0.092]
TTO	-0.034 [0.089]	-0.044 [0.088]	-0.033 [0.090]	-0.040 [0.087]	-0.040 [0.089]	-0.025 [0.088]	-0.035 [0.085]
Patents	0.130** [0.089]	0.128** [0.087]	0.128** [0.090]	0.096* [0.088]	0.127** [0.090]	0.127** [0.089]	0.095* [0.086]
Patenting positive career influence	0.005 [0.033]	0.012 [0.031]	-0.008 [0.034]	-0.026 [0.036]	0.002 [0.032]	0.007 [0.033]	-0.026 [0.034]
German	-0.046 [0.149]	-0.068 [0.148]	-0.050 [0.149]	-0.047 [0.147]	-0.045 [0.150]	-0.046 [0.147]	-0.071 [0.147]
Gender (1=female)	-0.049 [0.090]	-0.060 [0.088]	-0.051 [0.091]	-0.026 [0.089]	-0.047 [0.090]	-0.043 [0.090]	-0.033 [0.087]
Income	0.266*** [0.000]	0.305** [0.000]	0.269*** [0.000]	0.240*** [0.000]	0.261*** [0.000]	0.227*** [0.000]	0.239*** [0.000]
Family status (1=single)	0.023 [0.134]	0.019 [0.124]	0.021 [0.135]	0.037 [0.133]	0.021 [0.136]	0.026 [0.135]	0.036 [0.124]
Children	-0.070 [0.098]	-0.070 [0.093]	-0.070 [0.098]	-0.038 [0.098]	-0.075 [0.098]	-0.074 [0.098]	-0.045 [0.094]
Age	0.056 [0.005]	0.078 [0.005]	0.055 [0.005]	0.047 [0.005]	0.047 [0.005]	0.083 [0.005]	0.101* [0.005]
R^2	0.149	0.203	0.152	0.190	0.153	0.165	0.257
F	4.44***	6.85***	4.13***	5.11***	4.34***	5.55***	7.77***
Observations	337	337	337	337	337	337	337

Standardized effect coefficients; robust standard errors in brackets. Significance levels *** p<0.01; ** p<0.05, * p<0.1.

In the third regression, model 1, including only the control variables, holding a patent (0.130) and income (0.266) had significant effects on the approval of aid from federal programs. All other control variables showed no significant effects. In model 2, the central variable of higher basic budget had an expected significant negative effect on approval of aid from programs (-0.246), as well as employment at a public university (-0.101). The effects for patents (0.128) and income (0.305) were relatively stable in model 2. In model 3, basic research had no significant effect on approval of aid. Although the effects of patents (0.128) and income (0.269) were found again, employment at a public university had no significant effect in model 3. In model 4, only informal contacts with industry had a significant effect (0.149), whereas the variables used to test for formal contacts had no statistically significant effect. In addition, the effects of patents (0.096) and income (0.240) were found in this model. No peer effect was found in model 5, but holding patents (0.127) and income (0.261) showed the already noted effects. More interestingly, the effect of prestige in the scientific community was found in model 6. Although the effect was not significant for knowledge of programs and application to programs, it was positive in getting aid from those programs (0.135). In addition, the effects of patents (0.127) and income (0.227) were also found in model 6. In the final model 7, some interesting mediation effects were found. With regard to the central variables, basic budget showed the expected negative effect on approval of support (-0.238). However, informal contacts (0.147) and prestige (0.157) had a positive effect on the approval of support from federal programs. The results for patents (0.095) and income (0.239) were also found in model 7, whereas two other control variables were significant. The significant negative influence of employment at a public university (-0.105) could be explained by the mediator effect of the negative effect of basic budget, as in model 2. However, the positive effect of age (0.101) appeared to be dependent on a mix of influences by the central variables.

Table 22: Regression analysis on spin-off

Dependent Variable	Spin-off									
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Central variables										
Knowledge of programs		0.127**								-0.017
		[0.025]								[0.026]
Application for programs			0.176***							0.084
			[0.062]							[0.062]
Aid from programs				0.205***						0.152***
				[0.071]						[0.072]
Basic budget					-0.142**					-0.027
					[0.045]					[0.044]
Basic research						-0.172***				-0.084
						[0.042]				[0.042]
Informal exchange with industry							0.047			0.005
							[0.044]			[0.043]
Short term projects							0.143**			0.109*
							[0.049]			[0.047]
Long term projects							0.146**			0.074
							[0.048]			[0.047]
Former colleague founded a spin-off								0.308***		0.266***
								[0.061]		[0.062]
Prestige indicator									-0.132**	-0.133**
									[0.009]	[0.009]
Control variables										
Professorship	0.015	0.001	0.001	0.002	0.015	0.032	0.033	0.041	0.030	0.057
	[0.148]	[0.148]	[0.146]	[0.146]	[0.147]	[0.147]	[0.143]	[0.142]	[0.148]	[0.137]
Public university	-0.020	-0.024	-0.039	-0.011	-0.053	-0.020	-0.035	-0.042	-0.027	-0.061
	[0.134]	[0.133]	[0.133]	[0.132]	[0.136]	[0.132]	[0.130]	[0.128]	[0.133]	[0.127]
TTO	-0.004	-0.021	-0.007	0.003	-0.009	0.000	-0.014	-0.032	-0.013	-0.039
	[0.117]	[0.117]	[0.115]	[0.115]	[0.116]	[0.115]	[0.113]	[0.112]	[0.117]	[0.108]
Patents	0.106*	0.075	0.101*	0.079	0.104*	0.100*	0.060	0.091*	0.109*	0.049
	[0.115]	[0.118]	[0.113]	[0.114]	[0.114]	[0.113]	[0.113]	[0.110]	[0.114]	[0.109]
Patenting positive career influence	0.023	0.029	0.005	0.022	0.027	-0.016	0.009	0.009	0.021	-0.023
	[0.041]	[0.041]	[0.041]	[0.041]	[0.041]	[0.042]	[0.041]	[0.040]	[0.041]	[0.039]
German	0.111*	0.088	0.120	0.121**	0.098*	0.097*	0.107*	0.116**	0.111*	0.118**
	[0.153]	[0.155]	[0.151]	[0.151]	[0.153]	[0.152]	[0.148]	[0.146]	[0.152]	[0.145]
Gender (1=female)	-0.124**	-0.116**	-0.124**	-0.114**	-0.130**	-0.128**	-0.102*	-0.114**	-0.130**	-0.108**
	[0.142]	[0.141]	[0.140]	[0.140]	[0.141]	[0.140]	[0.138]	[0.135]	[0.141]	[0.131]
Income	0.090	0.086	0.096	0.035	0.112	0.098	0.047	0.065	0.129*	0.051
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Family status (1=single)	0.047	0.052	0.040	0.043	0.045	0.042	0.048	0.041	0.044	0.025
	[0.185]	[0.184]	[0.183]	[0.182]	[0.184]	[0.183]	[0.180]	[0.177]	[0.184]	[0.170]
Children	-0.069	-0.065	-0.073	-0.055	-0.069	-0.069	-0.044	-0.090	-0.066	-0.063
	[0.132]	[0.132]	[0.131]	[0.130]	[0.131]	[0.131]	[0.130]	[0.127]	[0.132]	[0.123]
Age	-0.070	-0.069	-0.052	-0.082	-0.058	-0.073	-0.088	-0.114*	-0.096	-0.145**
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
R^2	0.051	0.065	0.081	0.087	0.069	0.079	0.122	0.139	0.067	0.239
F	1.598*	1.882**	2.386***	2.576***	2.008**	2.307***	3.197***	4.370***	1.927**	4.716***
Observations	337	337	337	337	337	337	337	337	337	337

Standardized effect coefficients; standard errors in brackets. Significance levels *** p<0.01; ** p<0.05, * p<0.1.

Table 22 shows the results of the regression analysis of university spin-offs. In model 1, only the control variables were included, of which three were statistically significant. Although female scientists showed a lower affinity for spin-offs (-0.124) than their male counterparts did, scholars in Germany

(0.111) and those holding patents (0.106) showed a higher affinity for spin-offs than their Swiss counterparts and scholars without patents. In model 2, regarding the control variables, only the effect of the gender variable (-0.116) was significant. The knowledge of federal programs (0.127) showed a positive effect on spin-offs. These results indicate that the examination of programs opens up new perspectives for scientists and may have a positive influence on the probability of creating a university spin-off. In model 3, there was a positive effect of application to programs (0.176), which could be interpreted as a motivation effect by examining the topic of entrepreneurship through federal programs. In addition, holding patents (0.101) and the gender variable (-0.124) showed significant effects on the planning of spin-offs in model 3. Although the positive effects of knowledge of programs and application to programs were not expected, the positive effect of granting aid from programs (0.205) in model 4 supports H2. Furthermore, affiliation with a German institution (0.121) and the gender variable (-0.114) were significant in model 4. In model 5, basic budget showed a negative effect (-0.142) on the tendency to found a spin-off, which supports H1. In addition, the already mentioned effects of the control variables were found in this model (gender variable (-0.130), affiliation with a German institution (0.198) and patents (0.104)). In model 6, a focus on basic research lowered the affinity for founding a spin-off (-0.172). In addition to the positive effects of affiliation with a German institution (0.097) and holding one or more patents (0.104), the negative effect of the gender variable (-0.128) was found in model 6. The finding that a mediator effect of basic research led to a significant result for patenting may indicate the important connection between the type of research and its patentability. Although there is a trend toward the increased patenting of basic research (Crespo and Dridi 2007), applied research is still better suited for commercialization and patenting (Tijssen 2006), so it is logical to assume that the type of research is a mediator for patenting with regard to spin-offs. The results of model 7 are interesting in comparison to the results of the previous regressions. The previous regressions showed that informal contacts with industry were statistically significant but formal contacts were not statistically significant. With regard to spin-offs, however, informal contacts were not significant whereas formal contacts were significant. Both short term (0.143), and long-term cooperation with industry (0.146) had positive effects on founding a spin-off. In addition, the effects of the gender variable (-0.102) and affiliation with a German institution (0.107) were found again. In model 8, which was used to measure the influence of peer effects, peers showed a significant effect on the propensity to found a spin-off (0.308), which was the strongest of all variables, which held in model 8. In addition to the control variable which had been significant in the previous models of this regression, (gender variable (-0.114)), affiliation with a German institution (0.116) and holding a patent (0.091) were statistically significant again. The variable of age was also significant (-0.114) in model 8. The age effect, mediated by peer effects, could be explained by the type of networks held by younger and older scientists. Older scientists are deeply rooted in the scientific community and consider other academic scholars their main peer group, whereas younger scientists view experienced scholars as professional role models. However, they do not focus only on their scientific careers, and they have fresh and perhaps intense contacts with former fellow students who started their own spin-offs. In addition, the opportunity costs of leaving their present career path are lower, so that the peer effects of former colleagues who founded their own spin-offs could have a greater influence on their personal behavior. In model 9, the prestige indicator showed a negative influence on founding spin-offs (-0.132). This effect could also be explained by the opportunity costs that have to be paid in leaving a certain career path. An interesting finding is the positive effect of income on founding a spin-off (0.129). Another effect that was mediated by prestige was holding a patent. (0.109). In addition to those effects, the already seen effects of the gender variable (-0.130) and affiliation with a German institution (0.111) occur. The results of the final model 10 were interesting compared to those of the previous models. The peer effect had the greatest impact on the propensity to found a spin-off (0.266), which indicates the importance of peers and role models for the motivation to start a spin-off. These results are interesting because some of the previous effects did not occur in the final model that integrated all variables. An important finding was that the application for support from a federal program and the knowledge of programs were not significant in model 10. Only the granting of support by programs showed a significant effect (0.152), which was an indicator of the motivational effect and the positive effect of support from programs in founding a spin-off. Moreover, only short-term cooperation (0.109), not long-term cooperation, was significant in this model. The effect of long-term contracts could have been attenuated by the influence of the peer variable. Prestige showed a negative effect similar to that found in model 9 (-0.133). With regard to the control variables, the results of the gender variable (-0.108) and affiliation with a German institution (0.118) were similar to all other models. An interesting finding was that age was statistically significant in model 10. As in model 8, age had a negative effect on the tendency to found a spin-off (-0.145).

8.6. Discussion and concluding remarks

The main premise of this paper is that the insufficient budgets of universities have led to the growing pressure to find alternative sources to bolster the research funding for scientists. One source of such funding is the commercialization of research results, especially through a university spin-off. Although spin-offs have the potential to raise alternative funds for research, they are risky and expensive (Abreu and Grinevich 2013). Therefore, it is argued that scientists need support in founding a spin-off, which can be granted by federal programs. Based on the empirical results showed, some arguments are confirmed, while others should be rejected. With regard to basic budgets, the empirical results showed a diverse picture. Although lower basic budgets led to a higher general interest in federal programs and a higher rate of granting of aid from those programs, applications to programs and the founding of university spin-offs were not (directly) affected. Nevertheless, the granting of aid from programs showed a significant positive effect on spin-offs, so an indirect effect of basic budgets on spin-offs can be assumed. Therefore, H1 is not fully supported, but it must not be rejected.

Regarding the effect of aid from federal programs on university spin-offs, a clear positive effect was identified. Aid from those programs showed a positive significant effect on spin-offs. Therefore, H2 is confirmed.

Basic research showed a mainly insignificant effect. Although basic research had no effect on knowledge or granting of aid from programs or university spin-offs, there was only a negative effect on the application for programs. Although previous studies showed that basic research had a negative effect on spin-offs (e.g. Bercovitz and Feldman 2008; Czarnitzki et al. 2009), the findings in this paper did not show this effect. This negative effect in regression 2 could indicate the indirect negative effect of basic research. The findings indicate that applying for programs is less attractive to scientists who do this kind of research. Although the attractiveness is lower, the granting of aid was not affected by the type of research. Therefore, H3 is rejected.

With regard to federal programs, contacts with industry generally had a positive influence. Certainly, the type of contact played a major role. Although formal contacts showed no effect, informal effects had a positive effect on knowledge and granting of aid from federal programs. One explanation for the effect on knowledge is that programs often are provided and financed under the cooperation between government and industry. Hence, contacts with industry can provide information and increase the chances of receiving aid from those programs. Regarding spin-offs, the findings on contacts with industry were surprising. The non-significant effect could be explained by the possibilities of other forms of commercialization contacts to industry can foster. An example is a technology transfer via licensing or consulting that is a less risky and often faster means of commercialization. Hence, contacts with industry could be counterproductive for spin-offs but have positive effects on programs. Therefore, H4 is confirmed with regard to programs, but it is rejected with regard to spin-offs.

Previous studies showed the importance of peer effects for spin-offs and commercialization (e.g. Falck et al. 2010; Nanda and Sorensen 2010). These effects were also found in the present study. If a former colleague founded a university spin-off, scientists knew more about programs and were generally more interested in applying to them for funding. Although role models showed positive effects on knowledge of and application for programs, they had no significant effect on the success of applications for funding. However, peers showed a significant positive effect on the propensity for founding a spin-off. Therefore, H5 is confirmed.

The effects of prestige were diverse. Although prestige showed the expected effect on the granting of aid from programs, there was a negative effect on spin-offs. A possible explanation for the negative effect on spin-offs is that a spin-off is a risky venture. High prestige in the scientific community increased the expectations for success of a spin-off. The higher the prestige is, the further the fall. In failure, the loss of face is worse for a scholar with high prestige than for scientists with little prestige. Another factor could be the German system of university professorship. Tenured professors have privileges that they could be forced to relinquish if they found a spin-off. Professors who normally have high prestige in the scientific community could be prevented from using their research to found spin-offs, so they could seek other types of commercialization. These findings are in line with the literature on the effects of programs on individual scientists. Toole and Czarnitzki (2007) showed that star scientists had a lower affinity for founding spin-offs that are supported by programs. Nevertheless, high prestige in the scientific community certainly helps in obtaining funds from federal programs. Therefore, H6 can be confirmed with regard to programs, but it is rejected with regard to spin-offs.

With regard to the control variables, there were some interesting effects. Professorship had a positive effect on the knowledge of programs, which could be explained by the higher stock of social capital accumulated by senior researchers (Haeussler and Colyvas 2011; Giuliani et al. 2010). Information from the scientific community can be gathered more easily in broad networks than in narrow networks of other scientists. In addition to knowledge of funding programs, professorship had no significant effect on application for or granting of aid by those programs. There was a similar effect on TTOs. The existence of a TTO fostered the knowledge of federal programs, while it did not support the application for or funding by programs. The finding indicates that TTOs can provide general information about those programs, but do not motivate researchers to apply for federal programs and are not helpful in being granted support from federal programs. Even though, one function of TTOs is to foster technology transfer of any kind (Siegel et al. 2004; O'Gorman et al. 2008), the findings showed no significant effect on spin-offs. In addition to this finding, the problem of the heterogeneity of TTOs should be kept in mind. Although some universities employ twenty or more full-time staff members to deal with their TTOs, TTOs at other universities exist only on paper. As in this papers empirical analyses there are only data, if there is a TTO, but not how many employees in the TTO work or whether technology transfer is a central point in the mission of the university, the results concerning TTOs can only be considered as an indication of the identified effects and must be verified with in-depth data. For general technology transfer activities, the impact of TTOs has been analyzed by some authors. Hülsbeck et al. (2013) used a dataset of 73 TTOs at German universities. They showed that TTO performance was mainly influenced by the labor division of the TTO. In their study on the influence of TTOs on the career outputs of 33,000 scientists in nanotechnology, Lee and Stuen (2016) showed that the level of a TTO's staffing increased the number of patents as well as other commercial activities of universities researchers.

A surprising result was that patents showed no direct effect on spin-offs. However, there was a positive effect on knowledge of programs and the granting of aid from programs. Holding a patent on which a spin-off could be built had a positive effect on receiving aid from programs. Another control variable that should be examined in future research is affiliation. In the present study, the affiliation with a German institution had a positive influence on the knowledge of programs and, surprisingly, on spin-offs. The better knowledge of federal programs was not necessarily surprising because most of the ten reviewed programs were in Germany. However, it was surprising that German scientists seemed to be more willing to found a spin-off than their Swiss counterparts were. In most of the literature, the German university system and culture are viewed as very rigid with regard to entrepreneurial actions. Nevertheless, this study found a positive effect. Age showed a negative effect on application to programs and founding university spin-offs, whereas it had a positive effect on receiving aid from programs. The first effect can be explained by the generally more conservative lifestyle and worldviews, as well as more conservative reactions on alterations in personal environments and life planning (Brush and Hisrich 1991; Bates 1995; Jain et al. 2009).

Senior researchers have often achieved a status in the strongly hierarchically dominated German university system. They reluctantly risk their status by the possibility of failure in external projects such as the establishment of a university spin-off. In addition, the status of professors in the German university system endows them with extensive social protection. The creation of a university spin-off, however, not only entails the risk of failure but also consumes time needed for research, teaching, and administrative tasks. Sufficient time is not available, or it conflicts with the time needed to found a spin-off. Because of the complex process of the development of a university spin-off, a senior researcher might not be willing to give up his or her academic career, the security of a guaranteed income, and a pre-determined career path (Åstebro et al. 2013). However, young researchers might be more adventuresome. They do not have secure status in the university system, yet they would have to leave an already established career path. Hence, the opportunity cost would be relatively lower if they left this path. These are reasons that young researchers would be more interested in founding a university spin-off (Bercovitz and Feldman 2008).

However, while the interest in spin-offs is higher in young researchers, the conditions of a spin-off creation for older researchers are, measured objectively, better. Moreover, prestige in the scientific community supports the acquisition of investments and income. Thus, equity capital is higher among older researchers and prestigious researchers (Göktepe-Hulten and Mahagaonkar 2010). This could explain why younger researchers have a greater interest in the state subsidization of their start-up projects. Because of the shortage of financial capital for a spin-off, they show a growing interest applying for public funding. Interestingly, despite the great interest and the higher demand by young researchers for state funding, senior researchers are more likely to be granted aid. However, the positive effect on the granting of aid by programs could be explained by the amount of experience in raising funds. If an older scientist decides to apply for aid from programs, their prospects of success are higher. Although this effect is explainable, it raises the question of whether there is an aberration in public funding. The stakeholder group that has a particularly strong interest and a higher demand for funding will be promoted less frequently than the group that has less interest and a lower demand. At this point, the funders should certainly ask the question of whether changes need to be made to the funding structures and the assessment procedures.

The findings showed the effect of gender on the founding of university spin-offs. Female scientists were less likely to found a spin-off than their male counterparts were. This effect is well known in the entrepreneurship literature, and it has been discussed widely (e.g. Boardman 2008; Murray and Graham 2007). Although there was no significant effect of public university on the knowledge of or application for programs, there was a negative effect on being granted aid from programs. This effect could be explained by the lesser experience or focus in universities in raising additional third-party funds. Although private institutes need to rely on these additional funds, the need for third-party funds in universities is relatively new. Similarly, private institutes have cooperated more frequently and have stronger ties to industry, which led to a complementary effect on the volume of government grants (Bozeman and Gaughan 2007; Link et al. 2007). If public universities want to implement their mission statements, including increasing cooperation, fostering technology transfer, and raising additional research funds, they need to professionalize their structures with respect to supporting individual scientists in the application process for third-party funds.

9. Summary

In this last chapter of my dissertation, the results of the previous papers are summarized and a tabular representation of the main effects is provided. Although the papers had different ways of operationalizing the dependent and central variables, they all related to the same general topic. The commercial activity of university scientists can vary widely from simply selling or licensing scientific results, to consultancy, to the founding of a university spin-off (O'Shea et al. 2008; Phan and Siegel 2006). Although all sorts of commercialization vary among their strengths of the individual scientists' involvement with regard to the degree of freedom and the independence to commercialize, their goals and mechanisms were similar in deciding to leave the academic sphere and enter the commercial arena. Therefore, both unifying and divisive factors affecting the different kinds of commercialization were identified.

Table 23: Summary of main effects

Variable	Effect
Dependent: Spin-off	From paper 2, paper 3 and paper 4
Peer effect	(+) paper 2 and paper 4; (+) paper 3 in combination with jack-of-all-trades and diverse skill set
Informal contacts	(+) paper 2; (0) paper 4
Formal contacts	(+) paper 2 and paper 4
Applied research	(+) paper 2; (0) paper 4
Prestige	(-) paper 2 and paper 4
Gender (1=female)	(0) paper 2; (-) paper 3 and paper 4
Age	(-) paper 2 and paper 4
Basic budget	(0) paper 4
Federal programs	(+) paper 4
TTO	(0) paper 3 and paper 4
Jack-of-all-trades	(+) paper 2 in combination with peer effects and diverse skill set

Variable	Effect
Dependent: Cooperation	From paper 1
Peer effect	(+) but not in the final model
Intrinsic motivation	(-)
Extrinsic motivation	(+)
Classical outputs	(+)
Entrepreneurial outputs	(+)
Mertonian norms	(-)
Gender (1=female)	(0)
Age	(-)
TTO	(0)

Variable	Effect
Dependent: Consulting	From paper 2
Peer effect	(+)
Informal contacts	(+) but not in the final model
Formal contacts	(0)
Applied research	(+)
Prestige	(0)
Gender (1=female)	(0)
Age	(+)

Variable	Effect
Dependent: Licensing and sales	From paper 2
Peer effect	(+)
Informal contacts	(+)
Formal contacts	(+)
Applied research	(0)
Prestige	(+)
Gender (1=female)	(0)
Age	(+)

Legend: (+) statistical significant positive effect; (-) statistical significant negative effect; (0) no statistical significant effect

Probably the most important and central influence factor in this dissertation is the effect of peers on individual scientists. The findings showed that the peer effect had the strongest influence on an individual scientist's decision to become commercially active in most analyses. There were formal peer effects, such as the influence of a spin-off on the faculty of the scientist, as well as direct and personal peer effects, such as former colleagues who founded a spin-off. In these cases, it is interesting that the personal contacts with peers who founded a spin-off had a greater influence than the institutionalized effects of general faculty spin-offs. However, institutional spin-offs also showed a positive effect on the likelihood of founding by scientists at universities. The strength of the peer effect indicates the immense importance of the socialization of young scholars at universities, at least if commercial activities are expected and desired by the university itself. As the analyses conducted in this dissertation showed, positive and negative (direct) incentives can influence the career paths of individual scientists. However, more important for the commercialization of scientific results and knowledge are the support and acceptance of their direct working environments and peers or the lack of this support and acceptance. Therefore, complementary to an incentive system, it is more important that universities should create an environment that supports the commercial activity of individual scientists and encourages the transfer of academic knowledge to the commercial sphere and thus into practice.

As described in paper 3 in this environment the work-life balance should be taken into account. The work overload of university scholars should be avoided. A concentration on one or two academic tasks would be better than forcing every university scientist to work on all three tasks. A scholar who does research and transfers the results of research into practice could be exempt from teaching at the university. If it is useful to implement a system like in the US, where there are scholars purely for research or exclusively for teaching, is not so much a practical, but more a political and ideological question and expression of dogmatic differences and personal beliefs.

In addition to the question of whether a systemic change in academia is wanted is the question of whether the general relation between academia and practice, or more precise, industry, is significantly dependent on the prevailing culture at the faculty level. The decision to commercialize research, the number, quality, and frequency of contacts with industry and practice in general as well as the type of research and the type of outputs of this research is particularly dependent on the real existing and lived culture (not the official culture) of a faculty. Fundamental ideological differences exist with regard to the links between academia and industry. Although the supporters of the classical Mertonian norms propagate the strict division between both spheres, the followers of academic capitalism want a stronger orientation of research to the demands of industry and practice.

Even though in reality neither position exists in the extreme, the results in paper 1 indicate that the real existing and lived culture at a university and the personal beliefs regarding contacts with industry have a significant influence on the commercialization of academic research. As shown in paper 1, habitual norms could have both an indirect influence, such as through the role models provided by peers, and a direct influence on the commercialization activity of university scientists. However, the influence of university culture is increased, even more than the direct effects suggest, through the indirect effects. For example, there are direct connections between internalized academic norms and the kind of research that is done by scholars. As shown in Table 24, if a scientist tends to agree with Mertonian norms, he or she probably is oriented to basic research. If a scholar is oriented to academic capitalism, they probably conduct applied research.

Table 24: Correlation Mertonian norms and outputs

	Mertonian norms	Basic research	Applied research
Mertonian norms	1	.083**	-.095**
Significance levels *** p<0.01; ** p<0.05; * p<0.1			
N= 709			

Faculty culture also influences the role models and peers of a scientist. However, it is unclear whether this relationship is causal or not. The predominant culture of a faculty shapes the opinions and activities of its members, but an organization's culture is a product of more than traditional values and the latest guidelines. Individuals are both shaped by and shape the culture of the organization. Therefore, there is certainly an interaction of peers and role models, and the academic culture at a university (Samsom and Gurdon 1993). Even though in most universities guidelines, the transfer of academic knowledge and technology are predominant goals, it does not mean that those guidelines are internalized in the everyday work lives or the thinking of university scholars. An effective change in university culture can hardly be mandated especially because many universities officials, who also act as role models, reject the new culture, give only lip service to the new agenda, and do not incorporate the new culture. Therefore, lip service and guidelines are less important in changing the culture of universities than is the lived culture in a faculty (Jain et al. 2009; Haas and Park 2010).

Cultural change is also important in overcoming the cognitive distance between the academic sphere and the industrial sphere. In both spheres, the thought patterns are fundamentally different (Wayne and College 2010). In the economic and social sciences in general, this distance might not be as great as in the natural sciences and other disciplines. Nevertheless, there is also a divergence in the objectives and basic comprehension of work modes. However, the understanding of different work modes and objectives is crucial in performing the successful and smooth transition to the commercialization of academic research. The problem of different cultures and thought patterns however is not only at the universities side. To establish cooperation, industry has to understand and, at least to some extent, internalize academic thought patterns and habitus. Otherwise, conflicts are inevitable.

Overcoming this cognitive distance is a barrier that should not be underestimated. It requires both a certain reflectivity concerning abilities and the willingness to modify behavior. When people of different cultures meet, direct and personal contact is the best and probably the only way to develop an understanding of different ideas and behaviors. Therefore, in more than one paper in this thesis, direct contacts with industry showed a positive influence on the willingness of university scholars to start commercial activities.

An interesting observation concerning the contacts with industry was the differentiation between formal and informal contacts between industry and academia. Even though both forms of contacts tended to have positive effects on the commercialization of academic research and knowledge, the effect of informal contacts was stronger and occurred more frequent than the effect of formal contacts did. If a scientist had personal contacts with industry or peers in industry, their tendency to commercialize their research was greater than if they had only formal contacts with industry. This finding reinforced the previous findings of the crucial influence of peer effects on the behavior of individuals. Furthermore, even in the relative absence of personal contacts, formal contacts with industry supported the willingness to commercialize academic research and knowledge. Even though, all the data were collected from scientists in the specific field of biotechnology, the findings strongly indicate that this relationship also applies in other fields of academic research.

In addition to contacts with industry, the type of research is an important factor that could increase or decrease the willingness to commercialize research. University culture and peers influence the kind of research scientists do, as well as their inclination to commercialize their research (Jain et al. 2009; Haas and Park 2010). Whether a researcher does basic research or applied research also depends on the lived culture of the faculty. Researchers who tend to do applied research are more likely to commercialize their research than scientists who do basic research. The reason is that applied research is better suited for transfer into practice then basic research is. Therefore, companies are interested in applied research because it can more easily be sold or licensed. However, basic research is also important for science and therefore the economy. Without basic research, there can be no real applied research. Here the fundament for the progress of a scientific discipline is laid. Without this basis further research would not be possible, or it would be limited at least (Debackere and Veugelers 2005). Therefore, basic research may be of interest to companies. In general, the results of basic research can be transferred to concrete products less easily than the results of applied research can, so companies prefer cooperation with applied research scientists. The thesis that companies enter into partnerships with universities in order to outsource their basic research cannot be confirmed in this dissertation. Therefore, it seems there is a relatively stable relationship between applied research and commercialization.

Although there is a relatively clear relationship between applied research and the commercialization of academic knowledge, this relationship is less clear with regard to research outputs. Entrepreneurial outputs showed a relatively clear trend toward a positive statistical effect in terms of commercialization of research. Classical research output, however, showed a diverse picture. Although paper 1 showed clearly that productive researchers are more likely to be engaged in commercial activities, paper 2 and paper 4 showed diffused results. Although a high prestige in the scientific community, based on the publications of a scientist, has a positive effect on more passive forms of commercialization, like licensing and sales, the effect of prestige to more active forms of commercialization, such as the establishment of a spin-off, is entirely negative. This can be seen as an indicator that risk aversion increases as prestige in the scientific community increases. The greater consequences of failure in commercialization activities for researchers who already have a good prestige could discourage them from founding spin-offs.

Another explanation is that companies do not have the same expert view inside a branch of research as scientists do. Therefore, it is also possible that scientists first need prestige in the scientific community to be perceived as potential partners in cooperation with industry. This perception could lead to situations in which scholars with less prestige would prefer to commercialize their research or knowledge via licensing or sales, but because they lack prestige, they are not seen as potential partners for cooperation and therefore have to choose the alternative of the university spin-off to commercialize their research. Hence, the thesis that star scientists are more likely to found a university spin-off seems to be invalid. However, we must take into account that the data used in the star scientist literature were collected in the early days of biotech research and industry. First, the opportunities for start-ups in a completely new market were enormous. Second, only very few companies would be ever considered as a cooperation partner. Therefore, it was interesting to observe that in mature industries, the preferences of researchers and eventually companies had changed over time.

Another finding regarding the impact on the commercialization of academic knowledge was the federal funding of the commercialization of academic research and knowledge. Funding programs play very different roles with regard to support in different regions and countries. Although government subsidy programs are not favorited by scientists in the US, they are much more demanded in Europe, especially in Germany and Switzerland (Kelley et al. 2016). The findings showed that the federal support for founding a university spin-off is especially attractive if the basic budget of a scientist is low.

As shown in paper 4, government stimulus programs led to a higher rate of founding of spin-offs. Other factors had also been interesting in the analyses. For example, the knowledge or the application of such a program and by that the interest in the general topic of commercialization alone does not increase the likelihood to found a spin-off. Only if actual support by a program was granted, was there a positive effect on the probability of founding a university spin-off. This finding is contrary to the assumption that funding only creates deadweight loss and that the supported scholars would be able to found a spin-off without subsidies.

Although younger researchers have a greater interest in applying for support from programs, older researchers are more likely to be funded. This incongruence is not necessarily a problem because it may well be that more experienced researchers do research that is better suited for commercialization or that older researchers can develop better business models. Nevertheless, it is still questionable whether the award criteria of such programs are optimally aligned. Although it is not surprising that the prestige of a researcher has a positive effect on obtaining support from programs, this must not always be purposeful in terms of public support of commercialization. Because prestige is generally achieved through publications, that is, classical output, it does not indicate the practicability of the ideas or the entrepreneurial skills of the researcher. Furthermore, the results showed the importance of personal contacts with peers or role models in the personal environment. This finding is a strong indication of the importance of social capital in the award process. It also indicates the importance of mutual learning in bridging the cognitive distance between the different spheres. Private research institutions are better at raising third-party funds, which indicates that state universities have to adjust and professionalize their structures.

Regarding the professionalization of structures, the findings showed that TTOs had no direct significant impact on the commercialization of research. Both state universities and semi-public research institutions need to professionalize their TTOs. However, TTOs are at least able to create a greater awareness of commercialization and federal programs. In the further processes, however, they are less involved. The problem may be a lack of professionalism, or it might originate in the system of commercialization by university scientists. In Germany, for example, universities are involved in the commercial reward of a spin-off and other forms of commercialization. Therefore, employees of universities can try to keep the university out of the commercialization process. Moreover, the limited quality of data on TTOs should also be noted. The work of TTOs is not the focus of this thesis, and it was not included in the original data collection. It was therefore only applicable if a TTO did exist at the institution of a researcher or not. No information is available about the staff, equipment, and other resources of TTOs. There are also huge differences in quality, so the work of the TTO requires further research. Using data collected from 98 top universities in the UK, Chapple et al. (2005) showed that universities with younger TTOs were more efficient in transferring technology. In addition, generalist universities have a greater need for diverse staff on their TTOs than specialized universities do. Siegel et al. (2003) analyzed data collected from 98 respondents who were included in technology transfer and the work of TTOs. Their findings showed that TTO staffing and the cultural barriers between universities and firms were two of the most important organizational factors in the effectiveness of TTOs.

Regarding gender, the findings in this thesis were inconsistent. The analyses showed that female researchers tended to have a lower inclination to found spin-offs than their male counterparts did, which raises the question of why females have a lower propensity to start their own businesses. One reason could be that men generally have riskier lifestyles and personality than women do because of socialized gender roles. Men are expected to take risks, provide for their families, and have careers, whereas women are expected to take passive roles in society. Parenting and household duties are expected to be the focus of females rather than the pursuit of a career or the achievement of self-realization. Traditional role patterns are also evident in the entrepreneurship literature (e.g. Suprinovič and Norkina 2015). It has been shown that in industrialized countries, the gender ratio of founder quotas in conservative societies shows a significant higher tendency of males to become entrepreneurs than in more liberal societies.

However, in this thesis, the findings showed that gender had a significant influence only when certain mediator effects were present. For example, gender in connection with federal programs had a significant influence. If the role assignments mentioned above were implemented socially, discrimination could affect granting aid from programs. This effect could lead to the low support for female scientists in founding activities and to a low rate of the founding of spin-offs by female scholars.

Table 25: Correlation gender and aid from programs

	Gender (female=1)	Granting aid from programs
Gender (1=female)	1	-.116**
Significance levels *** p<0.01; ** p<0.05; * p<0.1		
N= 337		

However, the findings indicate that the influence of gender is also dependent on the type of commercialization. Only in the creation of spin-offs did gender show a negative correlation. When consulting or licensing and sales were analyzed, gender did not have a significant influence. A reason for this result could be that the latter types of commercialization are less risky, so women tend to choose them more often. Another reason could be that conservative investors do not believe that females can handle the high risk of founding an enterprise; therefore, they are reluctant to invest in female entrepreneurs.

The overall aim of this dissertation was to expand the mechanistic view on the commercialization of academic research in order to broaden an interdisciplinary dimension. While the perspective of the homo economicus approach, originated in economic sciences, mainly characterizes current research on this topic, it is important to extend this theoretically limited model's view of further components and perspectives. I hope that my dissertation will expand our perspective of the commercialization of academic research, particularly through the addition of (social) context factors.

Even if available data is derived from a single discipline of science, namely biotechnology, the results should also be applied to other science disciplines. Of course, further research would have to be carried out in other scientific fields in order to analyze whether the results of this thesis can effectively be applied to other research disciplines, including those that are not part of the natural sciences. Further, we must explore whether the results of this dissertation can be reproduced in an international context. The data used in my analyses are from researchers from Germany and Switzerland, both rather conservative countries. Whether, especially in consideration of the (social) context factors, the results can be replicated in other countries that have other university systems and habitus must therefore be thoroughly researched.

Despite the above-mentioned limitations, it can nevertheless be said that more attention has to be given to the university culture and the social integration of the individual researcher into university networks, especially regarding the predominant mechanistic view. University incentive systems, in particular, rely heavily on extrinsic incentives to motivate researchers to commercialize their research. However, these mostly monetary incentives alone are often not sufficient to induce more intrinsically motivated or Mertonian-influenced researchers to commercialize their work. A fundamental cultural change towards a more positive attitude towards commercialization is necessary for such researchers. For this purpose, the networking of the individual spheres of the triple helix model would have to be deepened in order to develop a mutual understanding of the patterns and habitus of other spheres and to intensify contacts of individuals within these spheres. The achievement of these goals will foster the commercialization of university research and consequently promote the transfer of technology and knowledge from the university to practice.

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