UNIVERSITY OF TWENTE.

# Master Thesis

# The impact of innovativeness and collaboration complexity on university spin-off funding

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ARTICLE INFO

Due date 9 March 2018

*Keywords:*
University-industry collaborations
Innovativeness
Collaboration complexity
University spin-offs
University spin-off development projects
Funding decision
Funding support

ABSTRACT

The importance of university spin-offs has been widely acknowledged by literature. R&D collaborations with these spin-offs increasingly arise in order to gain access to researchers' knowledge externalities and research competencies. Existing research found these collaborations to be beneficial to the innovative performance and commercialization process. However, acquiring funding is crucial to achieve this, which still has a limited research availability. Specifically the early stage success factors for acquiring funding support. The purpose of this study is to investigate in the impact of innovativeness and collaboration complexity within university spin-off development projects on the final decision of a Dutch funding agency for funding support. In order to test the hypotheses, 113 research proposals were analyzed by conducting a binary logistic regression. Findings indicate a positive effect of the innovativeness and collaboration complexity on the final decision for funding support. This study can be used for future university spin-offs engaging in R&D collaborations by taking these factors into consideration to increase the likelihood of acquiring funding support, which consequently helps to prevent project failure at the early stage.

## 1. Introduction

Universities are key providers of valuable and novel academic knowledge within modern-day societies by educating substantial proportions of the population. (Perkmann, Tartari, McKelvey, Autio, Broström, D'Este, Fini, Geuna, Grimaldi, Hughes, Krabel, Kitson, Llerena, Lissoni, Salter, & Sobrero, 2013). Not only do universities educate, continuously working on innovations and conducting innovative activities remains of high importance as well. Moreover, commonly businesses derive from universities, creating employment as a result, which cultivates society and can enrich culture (Salter & Martin, 2001; Bercovitz & Feldman, 2006; Goldstein, 2010).

Businesses generated by universities are referred to as university spin-offs. These are often acknowledged in literature as fundamental stimulants of economic growth and change on local, regional, national, and international level (Clarysse & Moray, 2005; Bercovitz & Feldman, 2006). More specifically, Pirnay, Nlemvo, & Surlemont (2003, p. 356) define university spin-offs as "new firms created to exploit commercially some knowledge, technology or research results developed within a university.". Next to the significant contributions to the economies by producing, diffusing, and by the deployment of academic knowledge and their innovativeness (Bercovitz & Feldmann, 2006), university spin-offs specifically are the entities engaging in the initiation and realization of innovation derived from an academic environment.

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However, university spin-offs are significantly different from non-academic spin-offs. In the early stage of launch, university spin-offs are confronted with two fundamental hindrances (Vohora, Wright, & Lockett, 2004). The main difference between both university spin-offs and non-academic spin-offs is their foundation. Whereas non-academic spin-offs are spun off from private sector firms as a result of a recognized market opportunity and exploiting it through the establishment of a start-up, university spin-offs are originated and driven from a non-commercially, but highly innovative oriented research purpose. The innovativeness is the first factor to be examined within this study. Successfully transforming innovative ideas developed by academics into ready-to-market products or processes requires competences and resources often lacked by a majority of university educated entrepreneurs. In order for university spin-offs to compensate for these shortcomings, interrelationships between universities and partners from the corresponding industries are increasingly established. These interrelationships are referred to as the collaboration complexity within this study, which is examined due to its relevance. In general, academics benefit from these interrelationships by the interaction amongst both parties leading to knowledge exchange from a different perspective and, in this study, potentially acquiring funding support. The long-term goal for academics striving for collaborations with industry partners is either to commercialize their research or to further develop the innovation, referring to a more research-related goal (D'Este & Perkmann, 2011). From the industry perspective, their lack of capabilities to do technological research, providing solutions to certain issues within the industry partner's firm is a critical factor for the increase of this kind of collaborating (Valentín, 2000; Perkmann et al., 2013). Goldstein (2010) referred to this change as the 'entrepreneurial turn' of this form of collaborating, increasing the significance of university spin-offs as the industry sectors acknowledged their successes in terms of providing demanding innovations. To bring the importance of university spin-offs in perspective, Clarysse et al. (2005) found most advanced economies to be aiming for the generation of economic prosperity by the exploitation and diffusion of public research through university spin-offs. Successful university spin-offs can grasp high business benefits if their innovation is developed and commercialized correctly. As this leads to sustainable competitive advantage and fostering financial performance, leaving no limit to the potential growth of the spin-off.

However, it is not a given that university spin-offs are bound to be successful within their operating industries. Adequate investments on a sustainable basis are a crucial requirement for a university spin-off to preserve sufficient working resources and capabilities to attain continuous growth in order to provide long-term significant and positive contributions to the economy and society (Salter, & Martin, 2001). Acquiring these investments and the influence upon these positive investment decisions is the main topic of this study. University spin-offs are resulting from academic research projects, from here onwards referred to as university spin-off development projects. As this study intends to measure the early stage success factors of university spin-offs, the main subjects are university spin-off development projects, involving (multiple) collaborating partners, that have the potential to lead to a university spin-off.

Although the university-industry collaborations have been widely acknowledged in literature, the perspective of university spin-offs and the early stage success factors has been studied in a relatively limited manner (Bruneel, D'Este, & Salter, 2010). The early stage success factors in this study refers to the innovativeness and collaboration complexity as possible determinants of the likelihood to receive funding support. Funding support can allow university spin-off development projects gains in working resources to foster continuous growth. In addition, acquiring funding support indicates an externally-validated feat of accomplishment. Islam, Fremeth, & Marcus (2018) demonstrated that the acquirement of funding support by spin-offs has tremendous value besides the monetary contributions. It also indicates that the spin-off succeeded at getting a significantly discerning evaluator on board. Their study showed that this positively impacts the chance for obtaining additional venture capitalist financing, stressing the importance of the first funding support being awarded to, in this case, the university spin-off development project. So, without funding support the projects and spin-offs are unable to realize and develop their innovation and are more likely to fail. Therefore, it is interesting to examine which of the aforementioned early stage success factors influence the likelihood to receive funding support from a funding agency. By tackling potential hindrances analyzed within this study at such an early stage can provide future research projects and

spin-offs with a higher chance of succeeding and acquiring funding support. Thus, the main purpose of this article is to investigate the impact of the innovativeness of the university spin-off development projects and the complexity of collaboration compositions on the decision for funding support for these projects that have the potential to turn into a university spin-off. Subsequently, this paper intends to address the following research questions:

**RQ1:** *What is the influence of the project innovativeness on university spin-off funding support?*

**RQ2:** *What is the influence of collaboration complexity on university spin-off funding support?*

This study contributes to the literature on university spin-offs, focusing on the early stage success factors influencing the decision for funding support for university spin-off development projects. Different from prior research that have mainly focused on the impact of innovativeness and collaboration complexity on the final innovative performance within U-I collaborations (e.g. Beck & Schenker-Wicki, 2014; Hottenrott & Lopes-Bento, 2016; de la Potterie, 2006; Shu, Wang, Gao, & Liu, 2015), this study investigates their impact on acquiring funding support for university spin-offs in their early stage of still being a research project. Data was collected from a Dutch funding agency, which provided an anonymous and aggregated database of 113 research proposals of technical derivatives of Dutch universities aiming for funding support. In doing so, this study explores the impact of the two aforementioned variables on the final decision for funding support by conducting a binary logistic regression. Results show that both the innovativeness and collaboration complexity positively influence the decision for funding support. Thus, a higher level of innovativeness and collaboration complexity is favored by the funding agency. From a practical perspective, findings of this study can be used for future university-industry R&D collaborations by taking these into consideration to increase the likelihood of acquiring funding support. Consequently, these determinants help to prevent project failures at the early stage.

The paper is structured as follows. The next section presents the theoretical background and hypotheses, containing a more general perspective of the R&D collaborations leading to the creation of university spin-offs. Further, the impact of the innovativeness and collaboration complexity on the funding decision of potential investors for university spin-off development projects will be explored. Furthermore, the methodology of the research will be described, elaborating on the variables and the corresponding research methods applied. Afterwards, the research results will be presented alongside the descriptive statistics, providing a clear overview of the research participants and variables. Finally, the conclusion section consists of an in-depth discussion of the main findings, implications for practitioners, research limitations, and directions for future research.

## 2. Theory and hypotheses

### *2.1. R&D collaborations*

University spin-offs are acknowledged to be actively engaging in innovative activities and new product development. As mentioned before, more increasingly they do so by forming partnerships with external parties, combining knowledge and generating novel insights. As internal knowledge sharing of individuals may lead to further product development, university spin-offs can still have a shortcoming on all the knowledge and resources necessary to realize the innovations. Both parties engaging within the R&D collaboration gain benefits in terms of technological innovation, but also by accessing resources of one another (Un, Cuervo-Cazurra, & Asakawa, 2010). It is common for a university spin-off to collaborate with multiple R&D partners simultaneously to increase the knowledge variety substantially (Boardman, & Corley, 2008; Faems, Van Looy, & Debackere, 2005).

However, being part of a project team consisting of multiple R&D collaborators increases the complexity of managing these partnerships (Powell, Koput, & Smith-Doerr, 1996). Prior research shows that the type of innovation influences the likelihood of a firm engaging in R&D collaborations. Radical innovation-oriented entities are more likely to have R&D collaborations than firms that are not, due to its novelty requiring more and new knowledge (Tether, 2002). More specifically, universities and their derivatives are more likely to be established within R&D collaborations with R&D-intensive firms operating in turbulent environments (Belderbos, Carree, & Lokshin, 2004).

In general, Un et al. (2010) classify four different types of R&D collaborations. Table 1 shows the classification by breadth of knowledge and the accessibility of the knowledge by the firm.

| | | Ease of Accessing New Knowledge for Product Innovation by the Firm | |
|---|---|---|---|
| | | Higher | Lower |
| Breadth of New Knowledge for Product Innovation | Higher | 1. R&D collaboration with universities | 3. R&D collaboration with customers |
| | Lower | 2. R&D collaboration with suppliers | 4. R&D collaboration with competitors |

***Table 1.*** *R&D collaboration types classified by the breadth of knowledge and the accessibility of knowledge.*

As the matrix implies, R&D collaborations with universities are most influential, having the highest breadth of knowledge complemented by a high level of knowledge accessibility. Thus, R&D collaborations with, in this case, university spin-offs are most valuable for firms and the present article will directly contribute to this area of research as a part of university-industry collaborations. The next section examines the value of R&D collaborations for university spin-offs more in-depth.

#### ***2.1.1.*** *University spin-offs and R&D collaborations*

In general, it is recognized by literature on academic entrepreneurship that university spin-offs play an important role in introducing novel research and technologies to the market (D'Este & Iammarino, 2010; Etzkowitz & Leydesdorff, 2000). An important role is devoted to collaborating with these entities. As universities have an unparalleled knowledge base and thus their spin-offs are often more capable of product innovation than other partners (Perkmann, Neely, & Walsh, 2011). As their knowledge base exists of multiple disciplines in areas not commonly coexisting within other firms, unique opportunities arise for accessing and implementing knowledge (Un et al., 2010). In general, universities aim at generating radical, breakthrough innovations that have the potential of creating completely new markets as well as incremental innovations that can lead to the expansion of existing markets (Tether, 2002). Both forms of innovation then have the possibility to lead to the establishment of patents, either for own use or for licensing, and university spin-offs.

However, there is an ongoing discussion concerning the adequacy of academic entrepreneurs within such spin-offs due to their science-oriented background and the general lack of commercial competences to successfully market such innovations (e.g. Vohora et al., 2004; McAdam & McAdam, 2008; Boardman & Ponomariov, 2009), and thus are recommended to get involved and collaborate with industry partners as well to complement for all of each other's shortcomings. Thus, both university and industry partners are valuable in their own way for the university spin-offs.

### 2.2. The Impact of Innovativeness within University Spin-Offs on the Funding Decision for Funding Support

One of the fundamental ingredients of university spin-offs is their innovative capabilities as an instrument of growth, market creation, expansion, and to increase market share (Gunday, Ulusoy, Kilic, & Alpkan, 2011). As globalization plays a significant role, the importance of integrating innovation has been recognized. Since the impact of globalization creates turbulence within environments, the added value of current products and services are rapidly deteriorating. In the context of this study, innovativeness is the key instrument for compiling collaborations within specific university spin-off development projects. Subramanian & Nilakanta (1996) argued the lack of research existing regarding innovativeness and its impact on organizational performance. However, over the past two decades, innovativeness gained significant interest as an area of research, especially due to its practical relevance on the aspect of influencing organizational performance (Darroch, 2005; Gunday et al., 2011; Oke, Burke, & Myers, 2007). As organizational performance is a key indicator for (commercial) success of a university spin-off in the eyes of a funding source, the innovativeness could therefore also be expected to influence the decision for funding support.

Walker (2004) notes the impact of innovation on organizational performance being substantial, generating a better market position by creating a sustained competitive advantage leading to a superior performance. Although, criticism arose in existing literature on the lack of clarification in

regard of defining the term innovation (Garcia & Calantone, 2002; Gatignon, Tushman, Smith, & Anderson, 2002). Within this study, this issue is resolved by applying the most cited definition of innovation by Schumpeter (1934), describing innovation as a commercially successful invention. Furthermore, an innovation can be divided into process and product innovations as a foundation. Biemans (1992) exemplifies process innovations being relatable to processes of product manufacturing in terms of efficiency and effectivity. Product innovations, however, are described as improvements of the quality of life of end consumers. Moreover, within process and product innovations, both categories can be subdivided into radical innovations and incremental innovations. *Radical* innovations are those innovations that revolutionizes products with a crucial impact on its environments (Ettlie & Rubenstein, 1987). Biemans (1992) describes that the 'radical' part of the innovation can be viewed from both the perspective of the consumer as the manufacturer. The radicalism is always relative to current available substitutes within the markets (Partanen, Chetty, & Rajala, 2011). *Incremental* innovations, on the other hand, are characterized by a steady development and improvements in regard of the added-value of already existing processes and products (Partanan et al., 2011). In general, process and product, radical and incremental, are all categories of innovation extensively used within existing literature (e.g., Biemans, 1992; Ettlie & Rubenstein, 1987; Gunday et al., 2011; Partanan et al., 2011).

However, both are significantly different from each other. Although radical innovation has the biggest potential in terms of creating entire new markets, it also brings along a substantial amount of risk. With risk also comes along uncertainty, as potential customers have been unaware of the pioneering solution (Ali, 1994). In addition, radical innovations prevent one from conducting market research, as this type of innovation creates or expands markets, making it nearly impossible to generate accurate insights. Forecasting and generating insights on aspects such as competition, customers, market size and growth is either impossible or highly complicated (Balachandra & Friar, 1997). Although radical innovations to a certain extent have a fruitful potential to generate profits in comparison to incremental innovations. Incremental innovations, on the other hand, are generally implemented within thoroughly-established markets (Ali, 1994). In contrast to radical innovations, incremental innovations can be substantiated by thorough market analysis. Thus, risk levels remain to a low extent and uncertainty can be minimized by conducting thorough market research. Although incremental innovation can have a lower profit potential in the early stage in comparison to radical innovations (Balachandra, 1997; Souder & Chakrabarti, 1980; Souder, 1987). The aforementioned findings make it clear that at first sight the funding decision could fluctuate under different circumstances regarding risk, uncertainty, and product or process profit potential.

Although, in order to reduce certain risks, firms tend to apply for a patent in order to secure a monopoly position in regard of their innovation (e.g. Archibugi, 1992; Peeters, & de la Potterie, 2006; Shu, Wang, Gao, & Liu, 2015). It is a document granting the inventor the exclusive rights to exploit the invention commercially without the worry for competitors duplicating the invention. The patenting activity of a firm has been acknowledged as an objective measure for their technical outputs (Heeley, Matusik, & Jain, 2007). In addition, existing literature found that spin-offs actively participating in patenting activities obtain more support from (potential) investors, especially in the eyes of venture capitalists' funding decision (Baum & Silverman, 2004; Mann & Sager, 2007). Thus, in the context of this study, university spin-off development projects with a patent already in their possession can act as an indicator of their level of innovativeness. In addition, as these research projects are still in an early stage, being granted a patent indicates its potential and subsequently its competitive position and novelty. It also reduces uncertainties such as competitor duplication, blocking out competitors by increasing market entry barriers. This again results in higher profit margins due to the monopoly position the university spin-off has (see e.g. Griliches, 1998; Haupt, Kloyer, & Lange, 2007). Thus, as uncertainties are limited by patenting the innovation, indicating a higher potential from an investor's perspective, this is likely to influence the decision for funding support.

Furthermore, within this study, innovativeness is considered in the case of university spin-off development projects as an indicator potentially leading to funding support. With the above taken into account, for potential investors to fund these projects it is assumed to be best to have a higher innovativeness. Higher innovativeness can bring along uncertainties due to a higher degree of

radicalism, as it often creates entire new markets, which are nearly impossible to analyze. Demand is often created by the innovation instead of creating a product based on customer demand. Nevertheless, higher innovativeness in this study means a higher likelihood of acquiring a monopoly position, blocking out competitors by increasing market entry barriers, restricting competitors of product duplication and thus a higher profit potential. (Balachandra, 1997; Branscomb et al., 2002; Darroch, 2005). Thus, the innovativeness of the university spin-off is a crucial factor for R&D success and it is assumed that it subsequently influences the funding decision of potential investors for university spin-off development projects. Thereby, based on the above literary findings and under certain circumstances, the following hypothesis can be developed:

**H1:** *A higher level of the innovativeness of university spin-offs will positively influence the chance of receiving funding support.*

### 2.4. The Impact of Collaboration Complexity on the Funding Decision of Potential Investors

In general, it has been empirically proven that R&D collaborations can be highly beneficial for all of the involved collaborating partners (e.g. Balachandra & Friar, 1997; Perkmann et al., 2013). In this study, the complexity aspect within a collaboration is a possible determinant of the decision for funding support of a funding agency. The complexity of a collaboration is considered as the diversity of partners involved within the collaboration and the innovation stage(s) the collaboration is taking place in. Hottenrott & Lopes-Bento (2016) define the stages of innovation to be starting at the idea generation, followed by basic forms of research towards applied research and prototyping, developing the product, and finally the market introduction.

However, collaboration complexity in terms of partner diversification and the innovative stage(s) the collaboration operates can possibly affect the collaboration performance. As an increase of collaboration complexity will imply a cost increase of managing and coordinating these collaborations, deteriorating potential returns of the collaboration (van Beers & Zand, 2014). Also, costs of disclosure are likely to be higher when the collaboration involves more partners and a variety of stages in the innovation process (Hottenrott & Lopes-Bento, 2016). Although, it is logical that an increase in collaborating partners will result in a more time-consuming collaboration. Indeed, this can bring along a cost increase, however, the potential benefits will more likely arise with more, different collaborating entities, as there are more options to create new resources and more knowledge combinations. In order to benefit from the inclusion of a more diverse project team, there must be a certain level of technological complementarity within the collaboration, a solid technological knowledge base among all collaborating partners should exist, also referred to as the basic knowledge (Cohen & Levinthal, 1990). Technological complementarity refers to overlapping technological sectors and the technological knowledge base between the collaborating firms. More specifically, it refers to the knowledge both parties possess about certain shared technologies (Petruzzelli, 2011).

When shared knowledge is limited between collaborating firms, the importance of absorptive capacity comes into play. Collaboration success depends on the capability of both parties to absorb new knowledge in addition to their prior technological knowledge on a basic level (Cohen & Levinthal, 1990). Basic knowledge is referred to as the fundamental understanding of general techniques upon which a scientific item has been built (Petruzelli, 2011). Subsequently, a higher level of technological complementarity between collaborating entities in regard of basic technologies is considered to stand parallel to a higher level of absorptive capacity (Lane & Lubatkin, 1998). This due to a mutual understanding of fundamental technologies on which they can build within the collaboration. Even though this study is not measuring this empirically, its presence is assumed due to the fact the data is all from high-tech universities and related partners.

As mentioned before, university spin-off development projects often lack certain commercial competences due to their science-oriented background. In addition, existing literature finds that such projects or spin-offs counter additional hindrances related to a non-existing producing and operating history, often insufficient customer and supplier relationships, limited knowledge of the related market(s), and, in general, unstructured or non-existing routines and techniques (Santos & Eisenhardt, 2009; Villanueva, Van de Ven, & Sapienza, 2012; Zheng, Liu, & George, 2010; Zott & Huy, 2007). Higher collaboration complexity

contributes by solving these lacking competences and network ties as the data used in this study exists of collaborations with well-established and experienced partners only. Meaning that a higher complexity also involves more partners with a wide range of customer and supplier relationships and market knowledge.

Moreover, the concept of collaboration complexity in this study involves two dimensions, based on the Hottenrott & Lopes-Bento (2016) study. The collaborating partner(s) involved and the innovation stage(s) the university spin-off development project is in. More collaborating partners leads to a higher level of collaboration complexity, which limits the aforementioned hindrances and contributes to the benefits of diverse knowledge, resources, and ideas. Further, three innovation stages are used based on the research proposals' standardized formats, each stage representing a step closer to commercialization. Subsequently, a higher innovation stage or multiple stages involved within the university spin-off development project implies a higher level of collaboration complexity. This indicates a more advanced production of the project rather than being at the first stage. Also, this implies the product or technology being closer towards market introduction and commercialization.

With the above taken into account, for potential investors to fund university spin-off development projects it is assumed to be best to have a higher level of collaboration complexity. Even though the potential hindrances related to a higher risk of managerial issues, higher collaboration complexity means a higher chance of market introduction and commercialization. In addition, a higher degree of collaboration complexity is most likely to stimulate the development of new knowledge combinations, resources, network ties, and can be an overall stimulant of the innovation process, which, at last, can be appealing in the eye of investors. Thus, the more complex the collaboration, the more potential the project has to be successfully developed, introduced, and commercialized. Thereby, based on the findings above, the following hypothesis can then be developed:

**H2:** *A higher level of collaboration complexity within university spin-offs will positively influence the decision of receiving funding support.*

## 3. Methodology

### 3.1. Research setting and data sample

In order to empirically test the hypotheses identified in the previous chapter, a wide variety of research proposals from various university spin-off development projects for potential funding are analyzed. Eventually, the university spin-offs are established based on technological derivatives of Dutch universities. The research proposals are submitted by academic researchers for a funding consideration by a Dutch funding agency.

The main goal of the funding program by the Dutch funding agency is to finance scientific research projects with a high commercialization potential that have the potential to turn into a spin-off. The research collaborations are composed of scientific oriented entities participating within specific research projects that are potentially eligible for funding support provided by a third party funding agency. The main target of the collaboration is to gain funding support for the project that can potentially lead to the successful project commercialization and the creation of a spin-off. Moreover, next to financial contributions, both parties are eligible for knowledge sharing and are first to gain insights in the obtained collective results. Furthermore, the database of the Dutch funding agency has been compiled based on 113 fully anonymized and aggregated research proposals of university spin-off development projects. The partners involved within the collaborations are mostly located within the Netherlands.

### 3.2. Variables

A clear overview of all variables used within this study have been reported in Table 2.

### 3.3. Data measurements

#### *3.3.1. Dependent variable*

*Funding Support* is defined as the decision of the potential funding actor for the specific university spin-off development project or university spin-off as to whether funding support is granted or not. The final decision is derived from the research proposals submitted to the aforementioned Dutch funding agency. To measure this, the dependent variable will have a binary scale with values of 0 and 1. The

| | |
|---|---|
| ***Dependent variable*** | |
| *FundingSupport.* | Dummy variable with a value of 1 indicating if funding support is awarded and 0 if it is not awarded. |
| ***Independent variables*** | |
| *Innovativeness.* | Degree of product and/or process innovativeness within the university spin-off development project in terms of having the potential to be patented. This is a categorical variable ranging from 0 to 3, with 0 meaning there is no patent (yet) and 3 meaning that a patent has been filed already. |
| *CollabComplex.* | Identifying in which stage of the innovation process the collaboration takes place together with the partner diversification involved based on Hottenrott & Lopes-Bento, 2016. |
| ***Control variables*** | |
| *ProfAsAppl.* | Identifying whether the applicant of the research project is a (full) professor (1) or not (0). |
| *TotalCitat.* | Total number of citations of the applicant based on Web of Science. |

***Table 2.*** *Defining the dependent, independent, and control variables.*

distinction between both is that a 0 is assigned to the case where there is no funding support provided. On the other hand, a 1 is assigned to the case where there is funding support provided.

### ***3.3.2.*** *Independent variables*

*Project Innovativeness* is defined as a classification of four categories of the patenting procedure which the project is currently in. As patenting is a well-known indicator to gain insights into the knowledge-related aspects of a firm or, in this case, the university spin-off development project. Also, a patent is interrelated to a novel product or process. However, to actually obtain a patent in an early stage indicates the level of novelty (radicalism) of the innovation. (Archibugi, 1992; Carree, Piergiovanni, Santarelli, & Verheul, 2015; Pavitt, 1982). This is measured using a categorical variable ranging from 0 to 3. A value of 0 is assigned to those projects with either missing information regarding patents or there are no patenting activities undertaken yet. A value of 1 is assigned to each project where there is no possibility to acquire a patent or the project team does not aim to patent their innovation. Further, a value of 2 is assigned to each project where the patent potential is currently being evaluated, meaning there is an intention to acquire a patent for their innovation. This evaluation could be, for example, in terms of a patent search by an attorney or a legal advisor. Finally, a value of 3 is assigned to each project where it is clearly mentioned that a patent application has already been filed. Although, this does not mean that they already attained a patent nor does this assure that the application will be successful. Thus, for this variable it is assumed that a research project with a patent already obtained will most likely be more innovative.

*Collaboration Complexity* is defined as the diversity within the collaboration in terms of the type of collaborating partner(s) involved and the stage(s) of the innovation process the collaboration takes place in. Table 3 shows the matrix on which the collaboration complexity will be based. This measure is based on the Hottenrott and Lopes-Bento (2016) study. In addition to Hottenrott & Lopes-Bento (2016), Beck & Schenker-Wicki (2014) in a former study also built a similar model investigating in the collaboration with external partners, stressing the importance of partner diversity. However, prior studies have analyzed this complexity dimension solely for the innovation performance. (see e.g. Beers & Zand, 2014; Faems, Van Looy, and Debackere, 2005). In this study, building on prior studies with an emphasis on Hottenrott & Lopes-Bento (2016), it is implemented to investigate its impact on the funding decision of a funding agency. Also, the matrix is used in this study has been limited to three stages, as these are the most common phases of the research projects within their research proposals for funding support. Further, as the collaboration complexity is based on two dimensions, which are the partner type(s) and the stage(s) of the innovation process, a corresponding equation can then be composed as follows:

$$\textit{Collab. Complexity} = \sum_{s=1}^{3} Stages \times \sum_{t=1}^{4} Types$$

To clarify this equation, if there is one collaborating partner engaging in two of the innovation stages,

| | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|
| | Research/ Prototyping | Development/ (Pilot-)Testing | Combination of Stage 1 & 2 |
| Partner Type | | | |
| 0. No partner(s) | 0 | 0 | 0 |
| 1. Research Institutions | 1 | 2 | 3 |
| 2. Industry | 2 | 4 | 6 |
| 3. Combination | 3 | 6 | 9 |

***Table 3.*** *Collaboration Complexity based on Matrix Hottenrott & Lopes-Bento (2016).*

then this form of collaboration has a complexity value of 2 x 1 = 2. The entire matrix with all corresponding collaboration complexity outcomes can be seen in table 3.

#### *3.3.3. Control variables*

Two control variables have been included in order to control for alternative factors that can possibly explain the outcome of the dependent variable. First, the main applicants' academic status is controlled for by a binary variable measuring whether the main applicant is a (full) professor (1) or not (0). Furthermore, the number of citations of the main applicant is controlled for, which is computed from the total sum of citations on all of the main applicant's publications using Web of Science to maintain consistency. These variables are likely to account for the knowledge, resources, and capabilities that the main applicant possesses. A full professor with a substantial amount of publication citations is more likely to have more research experience, knowledge, resources, and capabilities (D'Este & Perkmann, 2011), which could be favored by the funding source, thus might influence the decision for funding support.

### 3.4. Data collection

As mentioned before, within this study all the necessary data concerning the investigated university spin-off development projects, their R&D collaborations, and the final funding decision were based on the enriched database of the Dutch funding agency. In order to comprehensively test the hypotheses, additional data has been collected. Other sources such as ORBIS, REACH, Web of Science, public stats databases were used to collect the additional information.

### 3.5. Data analysis

In order to test the developed hypotheses within chapter 2, a binary logistic regression analysis was conducted with the use of the SPSS 24 software package (Pallant, 2013). In addition, some general descriptive statistics are used to describe the analyzed university spin-off development projects.

## 4. Results

Table 4 reports descriptive statistics and the corresponding correlation matrix of all variables included in the binary logistic regression analysis. It is worthwhile mentioning that 37% of all research proposals within this study were granted funding support based on a scale of 0 to 1. Also, the total collaboration complexity was relatively low with a mean of 3.87 based on a scale of 0 to 9. Further, the research funding decision and the innovativeness of the project are medium positively (.301) interrelated, which implies that a higher degree of innovativeness results in a higher likeliness for the research project to get funding support. Also, the same goes for the research funding decision and the project complexity, which is also medium positively interrelated (.200). This implies that a higher level of collaboration complexity results in a higher likeliness for the university spin-off development project to get funding support.

The results of the binary logistic regression are reported in table 5. Within this regression analysis of the dependent variable, the first model presented in table 5 shows the effect of the control variables 'Professor as Applicant' and 'Total Citations'. Models 2 & 3 evaluates the effect of each independent variable separately. Model 4, finally, presents all variables combined, which shows a good fit with the data. Thus, the results of Model 4 were used for further discussion within the next sections.

| | Range | Mean | S.D. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| Funding Support | 0-1 | .370 | .485 | 1 | | | | |
| Innovativeness | 0-3 | 1.960 | .935 | .305** | 1 | | | |
| Project Complexity | 0-9 | 3.870 | 2.444 | .200* | .033 | 1 | | |
| Professor as Applicant | 0-1 | .380 | .488 | .152 | .167 | -.107 | 1 | |
| Total Citations | 0-19180 | 2277.810 | 3527.230 | -.014 | .142 | -.139 | .291** | 1 |
| N of cases 113 | | | | | | | | |

***Table 4.*** *Range, means, standard deviation and correlations of the variables (N =* 113*).*

*$p < 0.05$ (2-tailed)
**$p < 0.01$ (2-tailed)

| | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|
| | B | s.e. | B | s.e. | B | s.e. | B | s.e. |
| Constant | -.725** | .271 | -2.069** | .542 | -1.553** | .474 | -2.934** | .714 |
| Professor as Applicant | .724 | .422 | .596 | .440 | .827 | .435 | .712 | .454 |
| Total Citations | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 |
| Innovativeness | | | .706** | .231 | | | .710** | .237 |
| Project Complexity | | | | | .188* | .084 | .192* | .089 |
| Nagelkerke $R^2$ | .036 | | .148 | | .096 | | .200 | |
| Chi-square | 3.828 | | 6.623 | | 12.619 | | 9.009 | |

***Table 5.*** *Determinants of: Funding support for university spin-off development projects*.

*N* = 113; tested one-sided; Hosmer and Lemeshow is not significant ($p > 0.05$)

*$p < 0.05$.
**$p < 0.01$.

Hypothesis 1 investigated the impact of the innovativeness of the university spin-off development projects on the final decision whether the projects receives funding support or not. Hypothesis 1 predicted a positive effect of the innovativeness on the final funding decision. The results shown in table 5 provides a positive effect (B = .710) at a significance level of 0.01. Thus, hypothesis 1 is not rejected and can be confirmed by Model 4 (table 5), indicating that a higher innovativeness increases the likelihood of receiving funding support.

Hypothesis 2 investigated the impact of the collaboration complexity of the university spin-off development projects on the final funding decision for the project to receive a valorization grant. The predicted effect mentioned in this hypothesis was that there would be a positive effect on the dependent variable. Model 4 in table 5 shows that indeed there is a positive relationship (B = .192), which is also significant at the level of 0.05. Therefore, hypothesis 2 can be accepted by Model 4. Thus, according to Model 4 it could be stated that a higher rate of collaboration complexity and innovativeness within the university spin-off development projects positively contributes to the chance of acquiring funding support. The control variables do not seem to have a significant impact on the chances to receive funding support.

## 5. Discussion & Conclusions

As the general field of research concerning university-industry collaborations has been widely acknowledged (e.g. Boardman, & Ponomariov, 2009; Bruneel, d'Este, & Salter, 2010; D'Este, & Iammarino, 2010; Perkmann, Neely, & Walsh, 2011; Petruzzelli, 2011), there is little prior research on the specific aspect of funding support for university spin-off development projects. In particular the influencers of the final decision for these projects to receive funding support. This study contributes to the existing literature by analyzing the innovativeness and collaboration complexity in the early stages of university spin-off development and how these factors affect the project's chance of receiving funding support for their innovation. This study shows a positive and statistically significant

effect of the innovativeness on the final funding decision of the university spin-off development projects. This illustrates that the innovativeness of the project is an important determinant of the final funding decision. In line with the proposed hypothesis, this suggests that a higher degree of innovativeness equals an increase in the chance of receiving funding support for the project. Existing research identifies that the degree of innovativeness of a product or process innovation is a vital determinant of its commercial potential (see e.g. Avlonitis, & Salavou, 2007; Cohen, 2010; Cooper, 1999; Cooper, & Kleinschmidt, 1987; Katila, 2000). The university spin-off development projects pursuing a higher innovativeness in terms of its patent pursuit, patent application process or patent possession seem to be able to better signal future commercialization potential to the funding bodies, and thereby limiting uncertainty inherent in the funding process which manifests in a positive funding decision. (Avlonitis, & Salavou, 2007; Cohen, 2010; Cooper, & Kleinschmidt, 1987). A patent is commonly used as an objective measure of high and novel technological output and is often interrelated to the innovation's radicalism (Hurmelinna-Laukkanen, Sainio, & Jauhiainen, 2008). Existing research identifies the more radical innovations to attract a greater amount of risk due to the revolutionary characteristics (see e.g. Ali, 1994; Garcia, & Calantone, 2002; Gunday, Ulusoy, Kilic, & Alpkan, 2011; Oke, Burke, & Myers, 2007). Nevertheless, more recent literature identifies the patent portfolio to be highly beneficial for funding as it is a measure of the (high) technical output, which raises more backing from investors (Baum & Silverman, 2004; Mann & Sager, 2007). In addition, as these university spin-off development projects are still in an early stage, being granted a patent indicates its potential and subsequently its competitive position and novelty (see e.g. Griliches, 1998; Haupt, Kloyer, & Lange, 2007). Thus, even though the risks are greater, a higher innovativeness of the university spin-off development projects in this study is preferred by the Dutch funding agency, increasing the likelihood of receiving funding support.

Concerning the effect of the collaboration complexity on the final funding decision for the university spin-off development projects, the project team's diversity and the innovation stage the project is currently aiming to complete were analyzed. Both dimensions were then multiplied with each other in order to quantify the collaboration's complexity. As expected, the results indicate a positive and statistically significant effect of the collaboration's complexity on the funding decision for the university spin-off development projects. This suggests that an increase of the collaboration's complexity positively affects the funding decision for the project to receive funding support. Which seems logical in a certain way, as an increase in a project's complexity goes hand in hand with an increase in the project's participants. Existing research identifies that R&D collaborations require a more extensive knowledge base due to the fact that the project centers a novel concept (see e.g. Perkmann, Tartari, McKelvey, Autio, Broström, D'Este, Fini, Geuna, Grimaldi, Hughes, Krabel, Kitson, Llerena, Lissoni, Salter, & Sobrero, 2013; Petruzzelli, 2011). As the number of project partners increases, so does the available knowledge. More knowledge can be shared, additional resources are available, and new ideas can be generated. As these projects often lack experience, collaborating with more partners complements for shortcomings such as customer and supplier relationships, industry knowledge, production techniques, and, in general, operating experience. Additionally, including partners from both research institutions and the industry increases the potential due to the combination of very diverse knowledge bases and perspectives. Academics are more theoretically grounded and industry partners are well-established and experienced practically, creating a broader, more extensive knowledge base (e.g. Vohora et al., 2004; McAdam & McAdam, 2008; Boardman & Ponomariov, 2009). This again develops the project team's ability to tackle the complexities that are involved within innovations, which contributes to the entire innovation and commercializing process (Beck, & Schenker-Wicki, 2014; Beers, & Zand, 2014; Hottenrott, & Lopes-Bento, 2016). Further, a higher innovation stage in this study's matrix also increases the project's complexity value. A higher stage indicates the project team is more advanced in production rather than executing a lower stage. If a project indicates it wants to execute multiple stages within the same period of time, this means a faster introduction to the market, commercialization, and exploitation of the innovation. This again raises more backing from the funding agency as it leads to a shorter period of actual commercial exploitation, which is favorable for the investor. Thus, an increase in the innovativeness alongside the project's collaboration complexity favors the acquiring of funding support and indirectly causes the prevention of early stage project failure.

### 5.1. Theoretical and Managerial Implications

This paper provides an extension of the existing literature on university-industry collaborations by introducing the concept of university spin-off development project funding and how its innovativeness and collaboration complexity influences the final funding decision for acquiring funding support. This study provides an overview of the different innovation types, theory on the project team's collaboration complexity, and the importance within university spin-off development projects. Empirically, this study contributes findings to the crucial phase regarding the generation of monetary funding for university spin-off development projects. The empirical analysis has been performed using an enriched database of university spin-off development projects proposals, provided by a Dutch funding agency, derived from the leading universities in the Netherlands. Prior research has mainly focused on the impact of innovativeness and collaboration complexity on the final innovative performance of U-I R&D collaborations (e.g. Beck, & Schenker-Wicki, 2014; Hottenrott, & Lopes-Bento, 2016). Although some have investigated external financing determinants of non-university start-ups (e.g. Nofsinger & Wang, 2011), to my knowledge, this study is the first to link innovativeness and collaboration complexity to university spin-off funding. The key contributions of this paper can be presented twofold. First, this study reveals that the innovativeness of university spin-off development projects could be an important determinant for acquiring funding support. Second, the size of the collaborative (academic) R&D partnerships combined with the scale of innovation stages to be completed might be interrelated to the project's innovativeness. Higher innovativeness goes hand in hand with the degree of novelty involved with the innovation. The expansion of the number of project participants then again could compensate for each other's shortcomings in terms of research capabilities, which eventually adds to the existing knowledge base by developing new knowledge combinations. Moreover, doing so might favor an enhanced innovative performance (e.g. Beck, & Schenker-Wicki, 2014; Beers, & Zand, 2014; Hottenrott, & Lopes-Bento, 2016), which indicates the project's potential (e.g. Avlonitis, & Salavou, 2007; Cohen, 2010; Cooper, 1999; Cooper, & Kleinschmidt, 1987; Katila, 2000), thus contributing to the acquirement of funding support.

Through a practical perspective, this paper could be of high importance to academics and firms participating (or plan to do so in the near future) in joint R&D partnerships in the form of university spin-off development projects. This study contributes to the enhancement of the existing academic R&D projects management practices, and adds important insights to the optimization of these projects' characteristics stimulating the likelihood of acquiring funding support. The empirical analysis of this study indicates that there are early stage factors at the initiation stage of an university spin-off development projects which might already influence the probability of receiving funding support for the project. The collaborative university spin-off development projects should strive for a patent as this indicates the innovativeness of the innovation, which determines its revolutionary and commercial potential. Furthermore, university spin-off development projects should strive for a diverse and larger composition of its team. This would enable the project as a whole to access new resources and knowledge combinations, thus expanding its knowledge base significantly, which contributes to effectively exploiting the novelties associated with the university spin-off development projects.

### 5.2. Limitations and Implications for Further Research

This study also contains some limitations, which provides inputs for future research. First, the dataset included funding proposals of university spin-off development projects restricted to the Netherlands only. Thus, results could not be generalized abroad and cultural differences are not taken into consideration. In order to do so, data must be extended on an international level. Further, this study focuses on the acquiring of funding support for university spin-off development projects. However, it would be interesting to see whether the acquirement of funding support actually contributes to the survival of the project. In addition, another avenue for future research would be to see whether the aspect of prior collaboration experience among partners actually contributes to the final outcome as Sampson (2005) mentions. Also, Sherwood & Covin (2008) mentions that prior alliance experience contributes positively to the trust levels within the partnerships. This again contributes to the process of tacit knowledge sharing, which is an important factor as the innovativeness increases. As there is still limited literature on the acquiring of research funding for university spin-off

development projects, this study should therefore be seen as a foundation for avenues for further research.

## 6. Acknowledgements

I would like to thank Igors Skute for his continuous support, valuable comments and suggestions, and overall a very pleasant collaboration throughout the entire period of this study. Further, I would also like to thank Dr. Isabella Hatak and Dr. Kasia Zalewska-Kurek for their roles as examiners, but also for their assistance and sharing insights.

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