MASTER

University spin-offs and network activities
explaining the influence of networks on the performance of high tech university spin-offs

de Wildt, S.J.G.

Award date:
2014
University Spin-Offs and Network Activities:

Explaining the Influence of Networks on the Performance of High Tech University Spin-Offs

by Sjoerd J.G. de Wildt

Identity number: 0653825
in partial fulfillment of the requirements for the degree of

Master of Science
in Innovation Sciences

Supervisors:
Dr. B.M. Sadowski, TU/e, TIS
Dr. M. Davids, TU/e, TIS
TUE. School of Industrial Engineering and Innovation Sciences.

Series Master Theses Innovation Sciences.

Subject headings: Open Innovation, University Spin-Off, Value Creation, High Tech Systems & Materials Sector, Value Network, Network Resources
Abstract

Networks can provide high tech University Spin-Offs (USOs) the necessary tangible and intangible resources to enable the technology transfer and create the spin-off. It was, though, recognized in earlier studies that USOs often struggle to establish successful relationships with actors that possess these resources. Nevertheless, literature about USOs fails to explain in more detail how a USO interacts with its network. Consequently, to explain common held assumptions from literature about network activities for Dutch high tech USOs, the following research question is addressed: How do networks come into existence, and how do they influence success and performance of USOs in the Dutch HTSM sector? With respect to this question, it is argued that successful USOs overcome the main challenges during their growth more easily. Therefore, success and performance were defined by means of a five-stage growth model, which provided input for a conceptual model about the growth characteristics of high tech USOs. Subsequently, to investigate the influence of networks on the performance of USOs in the Dutch HTSM sector an explanatory multiple-case study was executed. The results confirm literature and suggest that Dutch high tech USOs, particularly in the Brainport region, generally do not differ from other high tech USOs. Moreover, the network is indeed recognized as critical for the USOs to overcome the main challenges during their growth and thus, for their success. Within this perspective, eventually, also a recommendation is given for universities to better support their spin-offs.
Executive Summary

The aim of this study

Based on extensive research, high tech USOs often are created to exploit commercially-viable research findings. Typically, they transfer a high potential technology from the university into the commercial environment and subsequently, are active in (emergent) high growth markets. In their early years, they are among the SMEs that are recognized to be the future technology leaders of the Dutch HTSM sector. Generally, though, high tech USOs face several challenges which should be overcome before they are able to fulfill their full industrial potential, beyond the challenges faced by other new high tech firms. The struggle of USOs to establish successful relationships with customers and suppliers and the need to replace their academic-oriented network for a more market-oriented network, are particularly relevant in the Dutch HTSM sector; this sector is characterized by open innovation and intensive cooperation. Therefore, by answering the following research question, this study then, tried to explain how these Dutch high tech USOs got access to their networks, and how these networks helped them overcoming the major challenges before and after their start up: How do networks come into existence, and how do they influence success and performance of university spin-offs in the Dutch HTSM sector?

For this to be investigated, a literature study was first performed on existing literature about high tech USOs in general and their interaction with networks. These findings were then compared with Dutch high tech USOs. Unfortunately, only USOs from the Brainport region responded and therefore, generalization could only go as far as the Brainport region instead of the whole Dutch HTSM sector. Subsequently, data was collected by means of semi-structured interviews and public documents. The unit of analysis was ‘network activities’. Logically, these are activities of a USO that involve the network. Based on literature networks were defined as “a set of inter-organizational links and relationships that are needed to create a product or service.” These relationships can provide USOs with several important resources, such as material resources (i.e. components) and two kinds of intangible resources; to directly create a product (i.e. development know-how) and to indirectly create a product (i.e. commercial awareness, prior business experience, etc.) by means of shaping the direct context (i.e. creating the spin-off). Obviously, open innovation is an example of such a network activity.

Major challenges faced by high tech university spin-offs

It was found that high tech USOs from the Brainport region generally are similar to other high tech USOs, as they are described in literature. Therefore, their growth can be summarized in five main stages, which are shown in the figure on the next page. During these stages the network was indeed recognized as an important factor for the analyzed USOs in overcoming the most critical problems that could hinder them from reaching the ultimate sustainable returns phase.

First, the focus of the research phase is mainly on perfecting the academic research and publication of the findings. From this research then, opportunities emerge that serve an unfulfilled market need. Once this opportunity has been recognized, USOs move to the opportunity-framing phase. The most important challenge then, that arises during the second stage is the challenge of transforming the ill-structured opportunities recognized in the research phase into a consistent and structured venture creation project. This involves the construction of a business plan and an assessment of the potential of the technology. Academic entrepreneurs often lack commercial expertise and an entrepreneurial background. Therefore, they need to find a surrogate entrepreneur, such as a business developer, that is able to create the venture around their opportunity. Contrary to literature, finding such a surrogate entrepreneur is found
not to be very hard, if some money is offered. The technological and commercial development in this phase, though, are quite expensive. So, during this development stage already moderate to high financial resources are necessary. USOs need therefore, to find sources for funding.

Figure A. The five stage growth model that is typical for high university spin-offs (Vohora, Wright, & Lockett, 2004). The model is also confirmed for high tech university spin-offs in the Dutch Brainport region.

Then, at the beginning of the pre-organization phase, the USO is created. Now, a lack of financial resources even becomes the main barrier for the technology transfer, especially in the first year after start up. Hence, in order to move to the next phase, USOs have to pass the ‘credibility threshold’. This threshold results from the fact that customers estimate a technology according to the status and the reputation of its source. However, in its early years a USO has, besides the publications of its academic entrepreneur, not much status and reputation, and thus credibility, to rely on. Therefore, overcoming this critical juncture is often related to acquiring some key customers. They are necessary to acquire some initial credibility, which should help to overcome skeptical customer perceptions, gain access to markets and successfully achieve the transition from a concept to a legitimate business. Once sufficient credibility is gained, the USO will eventually also acquire sufficient funding. All in all, the pre-organization phase is one of the most critical phases in the development of the spin-off; without access to a network and appropriate partners it is hard to survive the pre-organization phase for high tech USOs in the Brainport region.

The fourth phase, called the re-orientation phase, has as goal to grow and strengthen the spin-off. Hence, this phase also can be characterized as a transition phase from the pre-organization phase to the phase of sustainable returns. Once sufficient credibility has been gained and enough financial resources are acquired. The retrieved funding from the previous phase enables the USO to generate returns by offering its customers a product of value. During this phase the entrepreneurial team faces the challenge of continuously identifying, acquiring and integrating resources and subsequently, re-configuring them. A lack of network capabilities, which enable a firm to link its resources to those of other firms, and a lack of
absorptive capacity, in this phase, or in earlier phases, might be a barrier for high tech USOs to optimally do this.

Eventually, a successful USO will reach the final sustainable returns phase. This phase is characterized by the USO achieving sustainable returns. Sustainable returns can be revenues from customers for products sold, milestone payments from collaborative agreements or investment from existing or new investors. This characterizes that the spin-off is able to create value from having developed the appropriate resources, capabilities, and social capital; the entrepreneurial team has achieved the ability to continuously re-configure existing resources, capabilities, and social capital with new information, knowledge and resources. Typically, at this stage USOs move off the university campus into the commercial environment. However, most times the spin-off maintains some links with the university, even though it moved out of the university and has established its own commercial identity.

Insights and implications for parent universities of high tech university spin-offs

The networks of high tech USOs were explained to be at least very important. Specific partners can provide the USOs with the required resources and knowledge to overcome the main barriers that are experienced by high tech USOs during their growth. In that way they significantly contribute to the performance and success of USOs in the Brainport region. Subsequently, these partners are found in several ways. Basically the network of the USO arises or evolves in three different ways: by actively seeking from the side of the USO, by means of social capital, or by using a third-party.

The creation of a network does not per se mean that all challenges are automatically overcome. It was found that USOs need appropriate partners in order to profit from the network. In their early years, though, USOs often lack network capabilities and absorptive capacity to find and connect themselves to these appropriate partners. These issues provide clear opportunities for the parent university of high tech USOs, especially for the Eindhoven University of Technology.

- Entrepreneurial skills can be learned-by-doing.

Universities should increase their focus on entrepreneurial skills in order for their students and researchers to benefit from this, because it was elaborated that academic entrepreneurs often lack these skills. This can, of course, be done by means of courses offered at the university.

- A general advisory board can provide necessary intangible resources.

The university could actively help its USOs by making entrepreneurs available which already possess the necessary entrepreneurial skills and among others also prior business experience and social capital in several fields. Those entrepreneurs then, can help the USOs with their expertise to connect them with appropriate partners and help them overcoming some common problems. This can be organized by means of a general advisory board of the parent university which can be accessed by all its USOs. As USOs then grow older and become more experienced, the role of the advisory board decreases, in this way more attention can be paid to new USOs. On the one hand, this provides USOs with better support in their early years, because before the creation of the spin-off these entrepreneurs could give USOs among others commercial advice. Subsequently, after the start up they could connect the USOs to appropriate partners, such as customers and help the USOs gain some credibility and thus, to acquire some required funding. On the other hand, the university also benefits, because it becomes more attractive for students and researchers, who eventually maybe want to commercialize their research findings.
Preface

Without too many problems I overcame the first four years of my education at Eindhoven University of Technology. Full of ambition, and never realizing what it takes, I then, started with my master thesis. Eventually, with ups and downs I overcame the last hurdle on my way to a professional career, which I am really looking forward too.

Several months ago, though, I initially started this project with a focus on user driven innovation. Along the way, however, the subject changed to university spin-offs and open innovation in the Dutch HTSM sector. After extensive literature and field research I eventually, came to the conclusion that high tech university spin-offs have many more reasons to be involved in networks than only open innovation. Therefore, the final topic for this study became university spin-offs and their network activities. Research was carried out with the help of four participants, all in high positions within their company. Besides the input they gave for my research they also provided me a nice view on what could be waiting for me in my future career. However, accompanied by an extensive literature study, these interviewees form the foundation of this report. Together they have shown that university spin-offs in the Brainport region do not significantly differ from high tech university spin-offs as they are described in literature. Moreover, the findings of this study give an important insight in how a parent university can better support its spin-offs in order for them to survive the ‘valley of death’ and become the future leaders of their sector. All in all, I hope that readers of this report can benefit from reading it and that they realize the importance of their network. In an ideal situation, this report becomes a guide on how to start a successful university spin-off. In reality, however, this report has some shortcomings which first should be addressed by future research. Especially, future research should focus on the first stages of the creation of a university spin-off: opportunity recognition, and opportunity framing. I believe this field is still unexplored since most research focuses on university spin-offs after their creation.

Finally, writing and constantly reconfiguring this report sometimes frustrated me, sometimes caused me stress, and sometimes made me lose my motivation. However, I learned a lot from it, and most of the times I enjoyed writing it; overall it makes me proud on what I accomplished these last months. Therefore, I want to thank everybody who contributed to the completion of this report, these include family, fellow students, and some specific employees at Eindhoven University of Technology. On a more personal level, I also want to thank my interviewees, which I will keep anonymous, for their valuable input for the research that I conducted. Finding appropriate cases was quite problematic and without the time they devoted to me, this study had been impossible to carry out. Within this perspective, I also want to thank my supervisors of which special thanks go out to my first supervisor Bert Sadowski for his guidance, patience, and expert feedback.

Sjoerd de Wildt
January 19, 2014
# Table of Contents

1. **Introduction** ................................................................................................................................. 1  
   1.1 Research problem .......................................................................................................................... 2  
   1.2 Research question .......................................................................................................................... 3  
   1.3 Research method ............................................................................................................................ 3  
   1.4 Report structure .............................................................................................................................. 4  

2. **Literature Review: University Spin-Offs and Network Activities** .................................................. 5  
   2.1 An introduction to the concept of open innovation ........................................................................ 5  
      2.1.1 Open innovation defined ....................................................................................................... 5  
      2.1.2 Benefits of open innovation ................................................................................................. 6  
      2.1.3 Value creation by means of open innovation ......................................................................... 6  
   2.2 Knowledge and collaborations ....................................................................................................... 6  
      2.2.1 High tech knowledge .......................................................................................................... 7  
      2.2.2 The interactive learning process ........................................................................................... 8  
      2.2.3 Barriers to the transfer of knowledge .................................................................................... 9  
   2.3 University spin-offs and network activities ................................................................................. 10  
      2.3.1 Typology of the university spin-off ...................................................................................... 10  
      2.3.2 University spin-offs and open innovation .......................................................................... 11  
      2.3.3 Barriers to the transfer of knowledge for university spin-offs ............................................. 13  
   2.4 Summary ..................................................................................................................................... 14  

3. **Towards a Conceptual Model** ....................................................................................................... 17  
   3.1 A stage model of high tech university spin-off creation ............................................................... 17  
      3.1.1 Research ............................................................................................................................ 18  
      3.1.2 Opportunity framing ........................................................................................................ 18  
      3.1.3 Pre-organization ................................................................................................................ 20  
      3.1.4 Re-orientation .................................................................................................................... 21  
      3.1.5 Sustainable returns ............................................................................................................ 21  
   3.2 Summary ..................................................................................................................................... 22  

4. **Methodology** ................................................................................................................................. 25  
   4.1 Justification of the case study approach ....................................................................................... 25  
   4.2 Case and unit of analysis .............................................................................................................. 26  
   4.3 Research design ............................................................................................................................ 27  
   4.4 Case selection ............................................................................................................................... 28
5. **Empirical Analysis: Dutch High Tech University Spin-Offs** .......................... 35

5.1 Research Context: An introduction to the Dutch HTSM Sector .......................... 35
   5.1.1 High tech defined ................................................................................................. 35
   5.1.2 The HTSM sector described ................................................................................ 35
   5.1.3 Geography of the Dutch HTSM sector ............................................................... 37

5.2 Case study evidence: An introduction to the cases .............................................. 37
   5.2.1 Case 1: A short history on the creation of the university spin-off ..................... 38
   5.2.2 Case 2: A short history on the creation of the university spin-off ..................... 38
   5.2.3 Case 3: A short history on the creation of the university spin-off ..................... 39

5.3 Case study evidence: Empirical analysis of case 1 .............................................. 40
   5.3.1 Research phase ....................................................................................................... 41
   5.3.2 Opportunity framing phase .................................................................................... 42
   5.3.3 Pre-organization phase .......................................................................................... 43
   5.3.4 Re-orientation phase ............................................................................................. 44
   5.3.5 Sustainable returns phase .................................................................................... 45

5.4 Case study evidence: Empirical analysis of case 2 .............................................. 46
   5.4.1 Research phase ....................................................................................................... 48
   5.4.2 Opportunity framing phase .................................................................................... 49
   5.4.3 Pre-organization phase .......................................................................................... 49
   5.4.4 Re-orientation phase ............................................................................................. 50

5.5 Case study evidence: Empirical analysis of case 3 .............................................. 53
   5.5.1 Research phase ....................................................................................................... 55
   5.5.2 Opportunity framing phase .................................................................................... 56
   5.5.3 Pre-organization phase .......................................................................................... 57

5.6 Case study evidence: Opportunities ........................................................................ 59

5.7 Summary .................................................................................................................... 59

6. **Summary and Conclusions** ............................................................................ 62
6.1 Summary ........................................................................................................................................... 62
6.2 Conclusions ....................................................................................................................................... 64
6.3 Managerial implications .................................................................................................................... 64
6.4 Limitations ........................................................................................................................................ 65
6.5 Future research .................................................................................................................................. 67

Bibliography .............................................................................................................................................. 68

Appendix A. The evolvement of the value chain in the HTSM sector ......................................................... 73
Appendix B. Applied qualitative data collection types .................................................................................. 74
Appendix C. Protocol ..................................................................................................................................... 75
Appendix D. Case 1: complete table of Pirnay et al. (2003) ...................................................................... 80
Appendix E. Case 2: complete table of Pirnay et al. (2003) ..................................................................... 81
Appendix F. Case 3: complete table of Pirnay et al. (2003) ..................................................................... 82
Appendix G. Growth characteristics of high tech university spin-offs ....................................................... 83
Appendix H. Closed bibliography1 ............................................................................................................. 85

1 Due to the anonymity of the participants, this bibliography is not published.
List of Tables

Table 1. Roadmaps for the HTSM sector: Applications and technologies ................................................ 36

Table 2. General characteristics of the analyzed cases................................................................. 38

Table 3. Type I university spin-off based on the findings of Pirnay et al. (2003) compared to case 1.....40

Table 4. Type I university spin-off based on the findings of Pirnay et al. (2003) compared to case 2.....46

Table 5. Type I university spin-off based on the findings of Pirnay et al. (2003) compared to case 3.....54
List of Figures

Figure A. The five stage growth model that is typical for high university spin-offs.................................................. VI

Figure 1. Graphical presentation of the research approach.............................................................................................. 4

Figure 2. Model of closed and open innovation................................................................................................................ 5

Figure 3. Tension field of knowledge sharing and protection........................................................................................... 7

Figure 4. Barriers to knowledge transfers .......................................................................................................................... 10

Figure 5. A typology of university spin-offs..................................................................................................................... 11

Figure 6. Conceptual model of the characteristics per growth phase of Type I high tech USOs................................. 24

Figure 7. Conceptual model of the unit of analysis and case for this study........................................................................... 27

Figure 8. Summation design (1)........................................................................................................................................ 28

Figure 9. Data analysis in qualitative research.................................................................................................................. 31

Figure 10. Survival chances firms per top sector in 2010................................................................................................. 37
# List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D</td>
<td>Research &amp; Development</td>
</tr>
<tr>
<td>IP</td>
<td>Intellectual Property</td>
</tr>
<tr>
<td>HTSM</td>
<td>High Tech Systems &amp; Materials</td>
</tr>
<tr>
<td>SMEs</td>
<td>Small and Medium Enterprises</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
</tr>
<tr>
<td>USO</td>
<td>University Spin-Off</td>
</tr>
<tr>
<td>TU/e</td>
<td>Eindhoven University of Technology</td>
</tr>
</tbody>
</table>
1. Introduction

In the traditional value system, suppliers provided producers with inputs. These inputs were used to develop goods or services. Subsequently, the goods and services were sold to buyers, which were mostly also the users of the good or service. In this traditional value system there was no room for users in the product development process (Bogers, Afuah, & Bastian, 2010). Firms decided what was of value for the customer and value was created inside the firm. The concept of the ‘value chain’ characterizes the unilateral role of the firm in the creation of value (Prahalad & Ramaswamy, 2004).

When it comes to Research & Development (R&D) in this system, only internal R&D was important. It was even viewed as an important strategic asset; in many industries, internal R&D was an entry barrier that stopped small firms from entering the market. Only large companies had the resources and the (long-term) research programs to compete. Innovation was based on the closed innovation model and R&D was technology-push oriented (Nobelius, 2004). Closed innovation equaled the philosophy that successful innovation requires control. Firms were in total control of their own innovation process. They had to generate their own ideas that they then had to develop, manufacture, market, distribute and service all by themselves. In this model there was no room for small or medium firms. Large firms protected their technologies with Intellectual Property (IP) and prevented in this way these competitors from exploiting their ideas. Profits were then, again reinvested in their internal R&D (Chesbrough, 2003; 2004).

From the mid 1960s on the market became increasingly important. The R&D process became more market-pull oriented and more emphasis was placed on market efforts. The early 1980s, then, were the beginning of what the R&D process looks like nowadays. Firms started to look at the R&D process as an integrative activity and they started to involve customers to learn from and with. Following on this development, the fifth generation of R&D management can be characterized as the era of open innovation (Nobelius, 2004; Chesbrough, 2003). R&D is been seen as a network. In this network the focus is on the collaboration between competitors, suppliers, distributors, etc. External knowledge has become an important factor for firms. Consequently, they do not only rely on their own (internal) knowledge anymore. So, through the years a shift has been made from closed innovation within firms to open innovation between firms (Chesbrough, 2003). This also implies that the competition between single firms has become less important, although probably still the rule. Rather, nowadays it is about competition between partnerships and networks of allied firms (Dyer & Singh, 1998).

The same shift, which is illustrated in appendix A, can be seen in the value chain in the Dutch High Tech Systems & Materials (HTSM) sector; from an almost closed value chain controlled by the large Original Equipment Manufacturers (OEMs) in the 1980s it shifted towards an open supply chain nowadays. Today, OEMs are firms that have a relationship with the original manufacturer and resell their product with added value (Beal, 2010). An OEM is thus, not a manufacturer. Contrary, OEMs mainly focus on activities such as the shipment, pricing and branding of products; customer ownership and account control; quality assurance and support; etc. (Popp & Meyer, 2010). This makes clear that in the open supply chain OEMs outsource most of the process to their specialized suppliers, and they have moved themselves to both ends of the chain (i.e. R&D at the start and Sales & Service at the end); OEMs only determine the product features and deliver the integrated product to their customers. Nowadays in the Dutch HTSM sector open innovation is the important strategic asset (Topteam High Tech Systemen
en Materialen, 2011). Hence, in order for networks in the HSTM sector to survive it is important that knowledge is shared (Vanhaverbeke, Vermeersch, & Zutter, 2012). Therefore, collaboration is becoming increasingly important and it enables greater accomplishments and efficiency than firms nowadays could reach in isolation.

1.1 Research problem

As one of nine top sectors in the Netherlands, the HTSM sector is an important driver of the Dutch economy and it belongs to the top of the world. The Dutch government has the ambition to maintain and even improve this position; in 2020 the sector has to return in the top five of the world and double its exports (Holland High Tech, 2013; Rijksoverheid, 2013). It was already seen that the HTSM sector is characterized by open innovation (Brainport Industries Coöperate U.A., 2012). Moreover, with respect to the ambitions it was concluded that Small & Medium Enterprises (SMEs) with their high tech starters are critical for innovation within the sector. On the basis of their capabilities, these SMEs should be the future for the high tech sector and they should become established players in the market. Eventually, they should substitute the current important firms. The reason for this is that the strategic value of the current player’s capabilities will naturally erode over time as new competitive problems emerge and thus, as those SMEs appear to substitute them (Lane & Lubatkin, 1998). An example of a program that helps the current high potential SMEs in becoming one of the future leaders is the ‘next OEM’ approach. The objective of this approach is to support these SMEs to make the final step and to bridge the ‘valley of death’, as they call it. Their ambition is to grow the number of large OEMs by combining breakthrough technology with inspiring entrepreneurship and smart capital (NextOEM, n.d.). In this study the focus is on University Spin-Offs (USOs) in the HTSM sector. High tech USOs in their early years are a typical example of high potential SMEs that face major challenges on their way to become established firms in the market. Those challenges originate in the history of the USOs (Pirnay, Surlamon, & Nlemvo, 2003).

Contrary to the US, in Europe the USO is a relatively new phenomenon; the first USOs appeared in the mid-1970s. Especially in these early years, universities were often totally indifferent to them and sometimes even opposed to their development. Hence, USOs originated in a historically non-commercial environment and therefore, face several entrepreneurial challenges which could hinder them from becoming future leaders, beyond those faced by other new (high tech) firms (Ndonzuau, Pirnay, & Surlamon, 2002). Two significantly different challenges faced by USOs, before achieving sustainable returns and financial profitability, are firstly a lack of financial resources and lack of commercial skills on the side of the academic entrepreneurs, and secondly they may suffer from conflicting objectives of key stakeholders as the university, the academic entrepreneur himself, the suppliers, etc. These, barriers may hinder a USO in its growth (Vohora, Wright, & Lockett, 2004). Another problem faced by USOs, particularly relevant in the Dutch HTSM sector, is that they generally struggle to establish close links with customers and suppliers. Walter, Auer, & Ritter (2006) argue that the failure rate of partnerships of USOs can even reach seventy percent.

All in all, based on extensive research, high tech USOs often are created to exploit commercially-viable research findings. Typically, they transfer a high potential technology from the university into the commercial environment and subsequently, are active in (emergent) high growth markets. In their early years, they are among the SMEs that are recognized to be the future technology leaders of the Dutch HTSM sector. However, generally high tech USOs face several challenges which should be overcome
before they are able to fulfill their full industrial potential. Particularly relevant in the Dutch HTSM sector, is their struggle to establish successful relationships with customers and suppliers. Therefore, in order to possibly support Dutch high tech USOs, it would be interesting to investigate how they are engaged with networks. This also determines the unit of analysis of this study as ‘network activities’. These are activities of a firm, or in this case USO, that involve the network. Obviously, open innovation is an example of a network activity. Network activities, though, are a broader concept than only open innovation; later, this will be explained in more detail.

1.2 Research question

With respect to USOs, scientific literature has become mature over the past years. Studies of Rothaermel, Agung, & Jiang (2007) and Djokovic & Souitaris (2008) summarize the present status of current USO literature. Within the field of networks and USOs, a lot of research has already been conducted that explored the interaction between them. It has, for instance, been found that a USO needs network capabilities to find appropriate partners and benefit from their relationship. These network capabilities enable a USO to link its resources to those of other firms. Hence, they are positively related to the performance of the USO (Walter et al., 2006). These network capabilities, though, are mainly earned by means of experience. Something the academic entrepreneurs of a USO typically lack in their early years, just as e.g. commercial awareness and an entrepreneurial background (Pérez & Sánchez, 2003). A contradiction here, is that the network, although difficult to access for young high tech USOs, often can provide USOs with these intangible resources. Therefore, within the perspective of the research problem, according to Djokovic & Souitaris (2008), there is still a question that has yet to be explained; how do networks come into existence and how do those networks then, influence the performance of USOs?

In order to answer this question, a number of questions have been devised. First, it is important to summarize current literature on these topics. What does current literature explain about USOs and networks and more importantly their interaction? And what does literature fail to explain? Then, in order to be able to analyze how networks influence the performance of high tech USOs it is important to define success and performance. Moreover, a methodology should be developed to find an answer on the research question in the specific context of this study: the Dutch HTSM sector. Therefore, these requirements taken into account, the following research questions have been established for this study.

How do networks come into existence, and how do they influence success and performance of university spin-offs in the Dutch HTSM sector?

(i) To what extent takes literature about university spin-offs their network activities into account?
(ii) How can success and performance of high tech university-spin-offs be measured?
(iii) What is the best way to analyze the network activities of Dutch high tech university spin-offs?
(iv) In what way are university spin-offs in the Dutch HTSM sector engaged with network activities?

1.3 Research method

To study these research questions a method was chosen that basically consists out of three important parts. Figure 1 summarizes this qualitative approach. As a first step, a literature study on high
tech USOs and their network activities is executed. The objective of the literature study is to explore current literature on USOs and find out how this involves network activities.

Second, a conceptual model that should define success and performance for this study describes the main growth characteristics of high tech USOs in five stages. This model displays the assumed characteristics of high tech USOs during their growth and, therefore, serves as the literal replication for the case study, which should enhance the external validity of this study.

Third, a multiple-case study will be described to test the conceptual model on real high tech USOs; more specifically, in the HTSM sector. When the conceptual model is replicated by the USOs, then the findings of the case study are valid. Hence, data analysis should show the complex relationship between Dutch high tech USOs and their networks. Moreover, general and other important findings in the interviews are explained in a story. The findings are used to translate findings of academic literature to the specific organizational context of USOs and their networks active in the HTSM sector.

1.4 Report structure

A purpose of this research is thus, to find out how high tech USOs interact with their network. More precisely, how does the interaction with networks influence the performance of Dutch high tech USOs. In order to answer these questions, the chapters of this report correspond to the research questions as they were proposed in section 1.2. Consequently, this report starts with a literature review. The aim of this chapter 2 is to find an answer on the following question: To what extent takes literature about university spin-offs their network activities into account? Then, in chapter 3 a conceptual model will be developed to describe the determinants of success and performance of high tech USOs in this study and to explain how these high tech USOs interact with their networks. Next, the methodology for this study is explained in the chapter 4. This section should give an answer on the question: What is the best way to analyze the network activities of Dutch high tech university spin-offs? Subsequently, chapter 5 elaborates on the results and answers in what way university spin-offs are involved with network activities in the Dutch HTSM sector? Eventually, the conclusions and limitations follow in chapter 6. In this chapter an answer is provided on the research question: How do networks come into existence, and how do they influence success and performance of university spin-offs in the Dutch HTSM sector? At the end of this chapter also a recommendation will be provided considering how high tech USOs can better be supported in overcoming the major barriers during their growth.

Figure 1. Graphical presentation of the research approach.
2. Literature Review: University Spin-Offs and Network Activities

The aim of this chapter is to find an answer on the following question: To what extent takes literature about university spin-offs their network activities into account? Considering this question, it was recognized by Pérez & Sánchez (2003) that the establishment of close links with a variety of partners is critical for USOs to survive, because a network can provide a USO with a variety of important resources held by other actors (Walter et al., 2006). These resources are both important for enabling the technology transfer from the university to the commercial environment, and for creating the spin-off. Considering the technology transfer Lubik, Garnsey, Minshall, & Platts (2013) found that especially high tech USOs require partnerships in order to acquire resources and create commercial value by means of open innovation. Therefore, this chapter starts with an introduction to the concept of open innovation and how this contributes to the creation of value in general. Then, the focus of this chapter shifts to inter-firm collaborations specifically. The third section of this chapter identifies, then, to what extent literature on USOs takes these concepts into account. Finally, the chapter will end with a summary to answer the question proposed at the beginning of this paragraph.

2.1 An introduction to the concept of open innovation

As Lee & Tsang (2001, p. 588) state: “a successful entrepreneur needs not only to manage the internal operation of his firm, but also to establish external networks.” Basically, this is what open innovation is about. The exact definition of open innovation, according to literature, will be provided below. Second, it will be elaborated on some benefits of open innovation. Finally, it will be explained how open innovation can lead to value creation.

2.1.1 Open innovation defined

According to Chesbrough (2003, pp. 36-37) in a model of open innovation, “firms commercialize external (as well as internal) ideas by deploying outside (as well as in-house) pathways to the market.” In other words, a firm is looking to combine and commercialize both its own ideas (internal) as well as those of other firms (external) and look for opportunities to bring the innovations to the market (Lindegaard, 2011). So, there is a porous boundary between a firm and the environment. This makes it able for ideas and innovations to move easily between these two, the firm and its environment. Both the models of closed and open innovation are illustrated in figure 2 (Chesbrough, 2003).

![Figure 2. Model of closed (left) and open (right) innovation (Chesbrough, 2003).](image-url)
An important note, however, with respect to open innovation has to be made. Bogers (2011) has shown that firms are located at a continuum from essentialy closed innovation to completely open. So, they do not necessarily have to be located at one of the ends and be either closed or open. In contrast, firms need to find their place between closed and open innovation (Chesbrough, 2003).

2.1.2 Benefits of open innovation

Open innovation has some clear benefits with respect to closed innovation. First, according to Walter et al. (2006) networking firms are better able to anticipate new preferences, they are aware of the behavior of competitors quite fast, and eventually they can imitate competitors’ innovations. Second, open innovation results in faster development and market launch of new products and services. Due to the use of external ideas and knowledge also more diversity is brought to innovation. This increase in diversity will lead to uncovering more opportunities. Furthermore, open innovation makes the innovation process stronger which results in an improved success rate of new products and services. Last, firms can share the risks and the uncertainties of both the market and the technology of innovation (Lindegaard, 2011). Nevertheless, Walter et al. (2006) also point to some negative implications of networks and collaborations. They argue that networks may lock firms into unproductive processes where valuable resources and knowledge are wasted. Moreover, some collaborations continue beyond their useful lifespan, subsequently they will fail to serve the strategic interests of the partners which may result in opportunistic behavior to outlearn each other.

2.1.3 Value creation by means of open innovation

Also Dyer & Singh (1998) recognize the importance of collaborations between firms and thus open innovation. In their study they point out that firms which combine, exchange, or invest in private assets, knowledge, and resources or capabilities are able to profit from ‘relational rents’. They define relational rents as supernormal profits that are jointly generated in an exchange relationship. These relational rents cannot be created by an individual firm, but only through the joint private contributions of the alliance partners. However, these relational rents are not free. Firms need to make relation-specific investments, these are also called transaction costs of the firm. The higher these investments are, the greater the potential for relational rents will be. Also the investment in interfirm knowledge-sharing routines increases the potential for relational rents. Interfirm knowledge-sharing routines are defined by Dyer & Singh (1998, p. 665) as “a regular pattern of interfirm interactions that permits the transfer, recombination, or creation of specialized knowledge”. The creation of specialized knowledge is an important element in developing competitive advantage. So, knowledge exchange is an essential part of open innovation. This is confirmed by Dyer & Hatch (2006). They argue that firms that have access to ‘network resources’, because they are participating in a network with established knowledge sharing routines between the members, will have an advantage with respect to firms that are not able to participate in such networks. Network resources are defined as “valuable knowledge acquired through the network” (Dyer & Hatch, 2006, p. 702). Subsequently, such a network, as just has been described, is called a ‘value network’. The definition of a value network is given by Johnson, Whittington & Scholes (2011): a set of inter-organizational links and relationships that are needed to create a product or service.

2.2 Knowledge and collaborations

It has been identified that important resources can be acquired through the network by means of open innovation. This section specifically focuses on knowledge as network resource and how it is
transferred in a collaboration. Dyer & Singh (1998) distinguish two different kinds of knowledge: codified and tacit. Codified knowledge can be transmitted without loss of completeness once the rules that are required for decoding it are known. On the other hand, tacit knowledge, also known as know-how, is about knowledge that is sticky, complex, and not easily to codify. It is embedded in a firm’s social context. Furthermore, the stickyness of this kind of knowledge is being reflected in the incremental cost of transferring it (Szulanski, 1996). Therefore, know-how is unique and much more difficult to imitate and transfer (Dyer & Hatch, 2006; Lane & Lubatkin, 1998). The characteristics of knowledge are thus, an important factor for the transfer of knowledge. Figure 3 shows that the knowledge characteristics are an exogenous factor, and thus cannot be controlled, central in the tension field of knowledge sharing and protecting. Next, it is therefore explained, based on the characteristics shown in the model, how knowledge in the specific environment of this study can be defined (Bogers, 2011). Obviously, this environmental dimension - the HTSM sector which is characterized by open innovation increasingly focus on intensive cooperation - stimulates the sharing of high tech knowledge among partners.

![Figure 3. Tension field of knowledge sharing and protection (Bogers, 2011).](image)

2.2.1 High tech knowledge

According to Pirnay et al. (2003) knowledge that is used in high tech industries is both codified and tacit. On the one hand, high tech knowledge is mostly based on some research findings and IPs, so codified knowledge. On the other hand, the researcher(s) and his know-how are needed for the technology
to work and to use it appropriately; this can be classified as tacit knowledge. Looking at the characteristics of knowledge proposed by Bogers (2011), high tech knowledge mostly is new or enhanced (i.e. innovative), complex, and embedded in new technologies and/or IPs (Pirnay et al., 2003). Moreover, the complementarity of high tech knowledge is very high, because in the current open supply chain of the Dutch HTSM sector most components are developed separately by suppliers. Eventually, these components need to be assembled by lower tiered suppliers or system integrators, before an OEM sells them (Adner & Kapoor, 2010). This also shows that high tech knowledge mostly is very specific; each supplier is responsible for another specific component of the end-product (Haffmans & Weele, 2004). Finally, Adner & Kapoor (2010) also argue that high tech knowledge is quite easy to imitate, because it mostly depends on codified knowledge.

All in all, within the HTSM sector the type of knowledge that is used is more or less the same for all actors. This is confirmed by the fact that Bogers (2011) describes the knowledge embodiment and characteristics as mainly exogenous factors, which means that they are out of control of the user of the knowledge. Hence, they are context dependent. Of course, it kind of depends on the decisions and activities of the actor how the knowledge is embedded, but most high tech knowledge is embedded in a combination of technologies, IPs, and people, maybe even in some firm routines. This makes the knowledge both codified and tacit. Furthermore, it can be classified as new, complex knowledge which mostly is very specific and complementary.

2.2.2 The interactive learning process

Considering the transfer of knowledge, Lane & Lubatkin (1998) distinguish three methods for learning external knowledge: passive, active, and interactive learning. Passive learning is about learning by means of information about technical and managerial processes from sources such as journals, seminars and consultants. More active types of learning can be benchmarking or competitor intelligence. These types can provide a broader view of the capabilities of other firms. However, with this type of learning only the observable part of another firm’s experience can be acquired. Contrary, interactive learning means that a ‘student’ firm gets close enough to a ‘teacher’ firm to understand both the observable parts of a teacher’s capabilities, but also the more tacit parts. This requires face-to-face interactions between student and teacher. Open innovation, and the focus of this study, is about this latter type of learning.

Know-how is, thus, only accessible through interactive learning and cooperation instead of contractual exchange (Pirnay et al., 2002). Both passive and active learning types have limited capacities to contribute to valuable new capabilities; only observable knowledge can be learned and this means it is not rare or costly to imitate (Lane & Lubatkin, 1998). Subsequently, the access of know-how through interactive learning results in more cases to a sustainable competitive advantage. So, firms in collaborations that are specifically effective in transferring know-how are much more likely to outperform competitors that are not able to do this. An important condition to use external knowledge is that a firm needs ‘absorptive capacity’. This means that a firm is able to “recognize the value of new, external information, assimilate it, and apply it to commercial ends” (Cohen & Levinthal, 1990, p. 128). This ability may differ with respect to different partners. This is called ‘partner-specific absorptive capacity’. This depends on the level of overlapping knowledge bases of the alliance partners and secondly on the extent to which partners have developed interaction routines. Dyer & Singh (1998) argue that the greater this partner-specific capacity is, the greater is the potential for relational rents as a consequence of
knowledge sharing. Besides having this absorptive capacity, it is also important for a firm to create appropriate incentives for its alliance partners that encourages them to be transparent, to actually transfer the knowledge, and not to free ride on the knowledge acquired from the partner. Besides those incentives, though, there are much more factors which influence the transfer of knowledge. Actually, as shown in figure 3, there is a tension field between sharing and protecting internal knowledge in an interactive learning process. Bogers (2011) calls this the ‘innovation paradox’. This was also recognized by Walter et al. (2006) who stated that a productive balance between learning crucial capabilities and protecting firm-specific competences leads to the development of friendship, respect, and trust within a collaboration. Subsequently, it is also shown in the model of Bogers (2011) that such a good relationship increases the sharing of knowledge, and thus the interactive learning process, in a partnership. Rese & Baier (2011) confirm that trust and commitment in such collaborations are indeed very important.

2.2.3 Barriers to the transfer of knowledge

Absorptive capacity is thus among others recognized as an important condition to enable an interactive learning process between collaborating firms, and thus the transfer of knowledge. An example of a knowledge transfer within a high tech network is the transfer of knowledge embedded in components from supplier to a lower-tiered supplier or to the OEM. The knowledge embodiment in these cases could be an important factor, according to Bogers (2011); i.e. it depends on the firms and the type of collaboration which type of embodiment is most important. IPs are, for example, more often strategically used in a collaboration, while knowledge embedded in people is much more openly shared. Another important factor could be the characteristics of the collaboration, such as the number of partners, the experience of and with partners, etc. However, knowledge can also be transferred from a university or knowledge institution to the OEM. In this latter case, knowledge is much more openly shared, because universities are generally much more focused on knowledge sharing rather than protecting it (Bogers, 2011). Obviously in an open supply chain the transfer of knowledge among the alliance partners is critical, but not as straightforward as it seems like. Besides a lack of absorptive capacity on the side of the recipient, which has just been indicated, Dyer & Hatch (2006) describe a few other barriers to the flow of knowledge across value networks. With their research they extend the findings of Szulanski (1996), who only focused on barriers to intra-firm knowledge transfers, to barriers to inter-firm knowledge transfers.

Besides the just mentioned barrier, a second barrier is a lack of credibility on the part of the source of knowledge. Furthermore, a lack of motivation on the side of the source or the recipient can be a barrier. These barriers will, though, be dealt with more extensively in the next section. Finally, a tough relationship between the alliance partners and causal ambiguity, as a result of the complexity of the knowledge, might be barriers to the knowledge transfers across networks. Knowledge characteristics and embodiment, though, are the same within the whole sector. Attributes on the side of the knowledge are therefore, similar for both ends of the relationship within a high tech collaboration. So, they are not considered as factors that could hinder the knowledge transfer within a high tech relationship. Moreover, Dyer & Hatch also point out two external barriers in their study. There can be network constraints that prevent an easy knowledge flow, but there may also be the case of rigidities in the existing process that make adoption of a new process costly or difficult. These barriers seem not to apply to start-ups, but only to established OEMs and suppliers that have managed to realize strong long-term relationships. These criteria and thus, these external barriers do not apply for young high tech USOs as this study focuses on. An overview of all the barriers to knowledge transfers across networks is shown in figure 4.
Figure 4. Barriers to knowledge transfers (Dyer & Hatch, 2006). Highlighted are the barriers that apply to this study.

2.3 University spin-offs and network activities

So far, this chapter has introduced the concept of open innovation and it has shown how (high tech) firms can benefit from each other in a collaboration. The aim of this chapter is to connect these theories to the object of focus in this study: high tech USOs. This section, thus, describes where USOs stand in these discussions. First however, it is important to exactly define the concept of USOs. Then, something is explained about USOs and open innovation. Last, this chapter combines the earlier mentioned literature about open innovation and knowledge sharing within collaborations with literature on USOs.

2.3.1 Typology of the university spin-off

According to Pirnay et al. (2003, p. 356) USOs can be defined as “new firms created to exploit commercially some knowledge, technology or research results developed within a university”. An important condition is that the initiators of the spin-off made a direct transfer from the university to the new firm, because it cannot be ruled out that the experience accumulated by the initiator during his intermediate employment has a significant effect on the new business formation. Walter et al. (2006) add that USOs transfer a core technology from the parent organization, the university, to the private sector. In this way they contribute to the technology transfer in two stages. First, a technology is transferred from the university to themselves, mostly by means of the transfer of people. Second, they transfer a technology to their customers; this transfer is mostly done through cooperation in product development and consulting (Pérez & Sánchez, 2003).

Within the group of USOs more distinctions can be made. These distinctions can be made along two dimensions: (1) the status of individuals involved in the spin-off, and (2) the nature of knowledge transferred. Concerning the first dimension, according to literature, USOs can be founded by either researchers coming from the ‘scientific’ community with a substantial research experience or by students coming from the ‘student’ community with little in-depth research background. As regards to this distinction the first case of USOs can be defined as ‘academic spin-offs’ and the latter as ‘student spin-offs’. Academic spin-offs are in principle created to exploit some promising results obtained by university researchers and student spin-offs are mostly started to exploit a business opportunity that is barely grounded on extensive research activities. The second dimension builds on the fact that a USO is a
mechanism of knowledge transfer from the university to the industry. As already explained, two types of knowledge are distinguished that can be transferred: (1) information or codified knowledge, and (2) know-how or tacit knowledge. USOs that rely on codified and technological knowledge exploited for industrial purposes are defined as ‘product-oriented spin-offs’ and spin-offs that rely on the exploitation of tacit knowledge can be defined as ‘service-oriented spin-offs’. Figure 5 shows an overview of the different types of USOs that can be distinguished according to the identified dimensions. Furthermore, in appendix D, E, and F the different types are described according to some characteristics. According to Pirnay et al. (2003), Type I represents high tech USOs. This type of USO is product-oriented and mainly based on codified knowledge (e.g. technology). However, also tacit knowledge is involved. These spin-offs are created to exploit commercially-viable research findings.

![Figure 5. A typology of university spin-offs. Highlighted is the high tech spin-off: Type I (Pirnay et al., 2003).](image)

### 2.3.2 University spin-offs and open innovation

Networks are important in order to gain access to both tangible resources, such as technological components, and intangible resources, such as development know-how. However, literature about USOs recognizes also other important intangible resources that are not acquired by means of open innovation, but can be acquired through the network. Examples of such network resources are commercial awareness and prior business experience. Mainly, these kind of intangible resources are necessary during the early development of USOs in order to recognize and frame the opportunity, and eventually to create the spin-off based on this opportunity (Vohora et al., 2004; Ndonzuau et al., 2002; Pirnay et al., 2003).

Only recently, literature about USOs specifically started focusing on how USOs can profit from open innovation activities, as it was described at the beginning of this chapter. In their study Lubik et al. (2013) found a clear positive relationship between the level of access to resources through partners and the value created by a USO. They also showed that these partners are typically corporate partners, e.g. suppliers or investors, the parent university, governmental organizations, other universities and sometimes even other USOs. With respect to this, Lee & Tsang (2001) have also confirmed that networking has a positive effect on a firm’s performance. They also showed that the number of partners is
positively related to a firm’s growth. During the process of creating the spin-off academic entrepreneurs, therefore, increasingly open their mind for external stakeholders; they realize that relationships with other parties are required in order to succeed (Walter et al., 2006). So, it is important for USOs to link its resources to those of other firms. The ability of a spin-off to do this, and thus to initiate, maintain, and utilize relationships with external parties are called network capabilities (Walter et al., 2006). According to Walter et al. (2006), USOs generally struggle to establish close relationships to customers and suppliers after their spin-off. Hence, the performance of USOs increases as their network capabilities increase. In total, literature distinguishes four components of network capabilities: (1) ‘coordination’, which is about linking the firm to other firms and linking different individual relationships into a network of mutual supportive interactions; (2) ‘relational skills’ include many things. Examples are communication ability, extraversion, conflict management skills, empathy, emotional stability, self-reflection, sense of justice, and cooperativeness; (3) ‘partner knowledge’ then, means that a firm has well organized and structured information about other firms’ partners and competitors. This is important in order to create appropriate exchange routines and governance structures. This prevents a network from instabilities or it makes it easier to deal with these instabilities. Partner knowledge stabilizes the position of a firm in a network; Finally, (4) ‘internal communication’ is crucial for being responsive and open, and for effective organizational learning within collaborations. Each of these components supports the others (Walter et al., 2006). Experience can help a spin-off to improve these skills and processes. Partner knowledge, for instance, is also gained over the years. A USO, therefore, needs experience with networks. This is confirmed in the model of Bogers (2011). Bogers argues that ‘experience of and with partners’ is a determinant for the characteristics of a collaboration. So, while a young USO gains experience, also its network capabilities improve. Therefore, in time it should get easier for USOs to initiate, maintain, and utilize relationships with external partners.

Once networks have been established and appropriate partners have been found, knowledge and other resources need to be shared. Regarding the flow of knowledge, Bogers (2011) emphasizes the tension field between knowledge sharing and protection. In the model, which is shown in figure 3 of this report, one can see five dimensions which have an impact on whether knowledge is shared or protected. Consequently, these dimensions influence the knowledge transfer between USOs and their network. Of these dimensions, described by Bogers (2011), three dimensions are more or less the same for the HTSM sector. First, the ‘environmental dimension’ is obviously the same for high tech USOs. Moreover, the ‘knowledge characteristics’, of knowledge that is involved in the high tech industry, are also quite similar for the whole industry. As it was seen, high tech knowledge often is new, very specific, both codified in IPs and tacit in the sense of know-how, the complementarity is high and it is most times easy to imitate. Finally, besides the characteristics of knowledge, the ‘knowledge embodiment’ in the high tech sector is also more or less similar. In the beginning, knowledge is mainly embedded in IPs and a technology. Moreover, know-how about the technology is embedded in technology originator. With the extension of the entrepreneurial team, tacit knowledge, embedded in the employees and in firm routines, becomes increasingly important (Vohora et al., 2004). All in all, these dimensions, typical for the high tech sector, do not influence the knowledge transfer differently for different firms.

The last two dimensions described by Bogers (2011), however, ‘the relational dimension’ and the ‘collaboration characteristics’, are different for every collaboration. Therefore, they might have a different influence on every relationship between high tech firms, in contrast to the environment, the knowledge characteristics and the knowledge embodiment. These latter dimensions influence the collaboration, but
not different for every high tech collaboration. This is also reflected in the fact that the collaboration characteristics and the relational dimension are endogenous factors; hence firms have control over these dimensions. Subsequently, it is quite obvious that the relational dimension has an influence on the knowledge transfer, because ‘trust’ and ‘commitment’ are key concepts in a partnership (Rese & Baier, 2011). All partners should be committed to the collaboration and they should be able to be trusted. With respect to trust, it might be a problem for knowledge sharing, particularly for USOs in their early development, that USOs may lack some credibility; they have not much status or reputation to rely on (Timbrell, Andrews, & Gable, 2001; Pirnay et al., 2003; Vohora et al., 2004). Furthermore, the collaboration characteristics point out the importance of both ends of the relationships as concepts as ‘partner size’, ‘experience of and with partners’ and ‘duration’ are important (Bogers, 2011). Clearly, these are also factors that possibly hinder USOs during their early development in establishing successful relationships and acquiring necessary resources through their network, because as it was explained earlier as small start-up they mostly lack experience with partners.

It is the same point made by Dyer & Hatch (2006). They described in their study seven issues that could hinder the knowledge transfer between firms. These issues can arise on three different sides: (1) On the side of the knowledge, (2) on the side of the source, (3) and on the side of the recipient. Some previous research also recognizes context factors that could hinder the knowledge transfer. However, Szulanski (1996) found no support for context as a barrier of the knowledge transfer.

2.3.3 Barriers to the transfer of knowledge for university spin-offs

To be more specific, on the side of the USO two problems can arise which could hinder the knowledge transfer: (1) ‘a lack of motivation’ and (2) ‘a lack of absorptive capacity’ (Szulanski, 1996; Dyer & Hatch, 2006). First, a lack of motivation on the side of the recipient means that the recipient is reluctant to accept knowledge from the outside. In other words, in order for a USO to share knowledge with partners it needs to open up towards its partners and be willing to accept the knowledge of them (Szulanski, 1996). Especially in the beginning, as researcher being a part of the academic culture, this might be a problem. Later on, though, especially high tech USOs are dependent on partners. Therefore, a lack of motivation cannot be a problem anymore (Vohora et al., 2004). Second, a lack of absorptive capacity is confirmed by many studies as possible barrier for the knowledge transfer. Cohen & Levinthal (1990, p. 128) describe absorptive capacity as the ability to “recognize the value of new information, assimilate it, and apply it to commercial ends”. In order to acquire this ability prior related knowledge is needed. In other words, this means that prior related knowledge (internal knowledge) is necessary in order to exploit external knowledge (Lokshin, Belderbos & Caree, 2008). So, without absorptive capacity a USO is unable to properly exploit the external knowledge acquired from its partners. These findings are also confirmed by Dushnitsky & Lenox (2005). They argue that firms with an internal R&D department increase their likelihood of cooperative R&D with other firms. Moreover, firms with an expertise in a given research domain exhibit higher levels of knowledge absorption from external sources. Lane & Lubatkin (1998) add that firms with similar basic knowledge experience higher levels of interorganizational learning. Their findings are confirmed by Bogers (2011), who argues that the more similar firms are, the more they share. Schmiedeberg (2008) then, explains that the implications of absorptive capacity in the context of external knowledge are twofold: (1) It facilitates the search for appropriate cooperation partners or suppliers, because a firm can judge more easily about the quality of potential partners; (2) Absorptive capacity raises the expected outcome of external knowledge projects,
because firms will choose more profitable knowledge projects if external knowledge is conducted to supplement internal knowledge. All in all, literature clearly confirms the importance of absorptive capacity in order to successfully exploit external knowledge. Subsequently, it seems obvious that absorptive capacity is necessary for the knowledge transfer.

Just as on the side of the USO, one could also be more specific about attributes of the partner, or the source of knowledge, which could hinder the knowledge transfer. Dyer & Hatch (2006) again distinguish two different attributes that hinder the knowledge transfer between firms on the side of the source: (1) ‘a lack of motivation’ and, probably more important, (2) ‘a lack of credibility’. First, a lack of motivation on the side of the source is described by Szulanski (1996) as a knowledge source being unwilling to share its crucial knowledge for the following reasons: It may believe it will not be sufficiently rewarded for sharing hard-won success. Moreover, a source can also just be unwilling to devote time and resources to support the knowledge transfer. Second, credibility is in the dictionary defined as: “The fact that someone can be believed or trusted” (Cambridge University Press, 2013). In this case ‘someone’ is the source of the knowledge also known as the partner of the USO. From this definition follows that trust is an important concept in being a credible partner. This was also explained earlier, and it is in line with the findings of Bogers (2011) and Rese & Baier (2011). Subsequently, it seems logical that a lack of credibility on the side of the partner may hinder the knowledge transfer. All in all, these problems can be overcome when a spin-off has a sufficient level of network capabilities. As already explained, network capabilities improve with experience, just as partner knowledge improves with experience with partners. Therefore, a sufficient level of network capabilities enables a USO to screen its partners with respect to their motivation and credibility. A similar notion was made by Schmiedeberg (2008) about absorptive capacity; it facilitates the search for appropriate cooperation partners or suppliers, because a firm can judge more easily about the quality of potential partners. An appropriate partner, of course, is trustworthy and willing to devote time and resources to support the knowledge transfer. So, with network capabilities and absorptive capacity the problem of a lack of motivation or credibility on the side of the knowledge source can be overcome.

2.4 Summary

In a model of open innovation firms look to combine and commercialize both their own ideas (internal) as well as those of other firms (external) and look for opportunities to bring the innovations to the market. Consequently, this process of interfirm interactions, an essential part of open innovation, permit the transfer, recombination, or creation of specialized knowledge. Firms that have access to such knowledge, or network resources, have a competitive advantage with respect to firms that are not concerned with value networks. With respect to the research context, open innovation in the HTSM sector obviously is mainly about the sharing of high tech knowledge. This can be defined as knowledge that is mostly embedded in a combination of technologies, IPs, and people, maybe even in some firm routines. This makes the knowledge both codified and tacit. Furthermore, it can be classified as new, complex knowledge which mostly is very specific and complementary. It is the development know-how, necessary to understand the technology, that is only accessible through interactive learning and cooperation. Subsequently, the access of know-how through interactive learning results in more cases to a sustainable competitive advantage. An important condition to use external knowledge is that a firm needs ‘absorptive capacity’. This means that a firm is able to recognize the value of new, external information, assimilate it, and apply it to commercial purposes. However, besides a lack of absorptive capacity on the side of the recipient, literature describes more barriers to the flow of knowledge across value networks. Other
barriers that seem to matter are a lack of credibility on the part of the source of knowledge, and a lack of motivation on the side of the source or the recipient.

Literature then, defines the object of analysis in this study, USOs, as “new firms created to exploit commercially some knowledge, technology or research results developed within a university”. Four types of USOs are distinguished. These distinctions can be made along two dimensions: (1) the status of individuals involved in the spin-off, (2) the nature of knowledge transferred. Subsequently, Type I USOs are described as high tech. This type of USO is product-oriented and mainly based on codified knowledge (e.g. technology). However, also tacit knowledge is involved. These spin-offs are created by researchers coming from the scientific community to exploit commercially-viable research findings. It was recognized in literature that the establishment of close links with a variety of partners is critical especially for these high tech USOs to survive, because partnerships can provide the USO with a variety of important resources held by other actors. These resources are both important for enabling the technology transfer from the university to the commercial environment, and for creating the spin-off. In literature a clear positive relationship between the level of access to those resources through partners and the value created by a USO was found. Networks are, thus, important in order to gain access by means of open innovation to both tangible resources, such as technological components, and intangible resources, such as development know-how. However, also other intangible resources that are not acquired by means of open innovation, such as commercial awareness and prior business experience, can be acquired through the network of a USO.

Generally, literature explains that the transfer of knowledge within a network is influenced by many factors. A tension field, for instance, with five dimensions was recognized, which influences whether knowledge is shared or protected. Three of these five dimensions are mainly exogeneous and thus USOs have hardly any influence on them; they are characteristic for the HTSM sector. Two dimensions, however, are different for every collaboration: the relational dimension and the collaboration characteristics. Hence, these dimensions might have a different influence on every relationship between, in this case, high tech firms. It is quite obvious that the relational dimension has an influence on the knowledge transfer, because ‘trust’ and ‘commitment’ are key concepts in a partnership. All partners should be committed to the collaboration and they should be able to be trusted. Furthermore, the collaboration characteristics point out the importance of both ends of the relationships as concepts as ‘partner size’, ‘experience of and with partners’ and ‘duration’ are important. These dimensions, thus, show that it might be hard for USOs in their early years to acquire some necessary tangible or intangible resources by means of knowledge sharing, because USOs have in their early years a weak credibility towards external partners and they lack experience with them.

As mentioned in the first paragraph, literature also recognized some direct barriers to the transfer of knowledge within a collaboration. On the side of the USO a barrier could be ‘a lack of motivation’. It is, however, argued that this might be particularly a problem in the beginning, due to an academic culture that prevails at most universities. Later on, however, it was recognized that USOs open their mind to external partners and are dependent on them, so later this cannot be a problem anymore. Another, probably the most important, barrier on the side of the USO is ‘a lack of absorptive capacity’. A lack of absorptive capacity was confirmed by many studies as possible barrier for the knowledge transfer; without absorptive capacity a USO is unable to properly exploit the external knowledge acquired from its partners. Schmiedeberg (2008) explains that the implications of absorptive capacity in the context of
external knowledge are twofold: (1) It facilitates the search for appropriate cooperation partners or suppliers, because a firm can judge more easily about the quality of potential partners; (2) Absorptive capacity raises the expected outcome of external knowledge projects, because firms will choose more profitable knowledge projects if external knowledge is conducted to supplement internal knowledge.

Two other direct barriers to the transfer of knowledge were recognized on the side of the source of knowledge in a collaboration. These are ‘a lack of motivation’ and, probably more important, ‘a lack of credibility’. First, a lack of motivation on the side of the source is described as a knowledge source being unwilling to share its crucial knowledge, because it may believe it will not be sufficiently rewarded for sharing hard-won success, or because it is just be unwilling to devote time and resources to support the knowledge transfer. Second, the most important concept in being a credible partner is trust; trust being an important factor in collaborations is confirmed in many studies. Therefore, it seems valid that a lack of credibility on the side of the partner may hinder the knowledge transfer between a USO and its partner. These problems, however, can be overcome when a spin-off has a sufficient level of network capabilities. Network capabilities improve with experience, just as partner knowledge improves with experience with partners. Therefore, a sufficient level of network capabilities enables a USO to screen its partners with respect to their motivation and credibility. A similar notion was made in literature about absorptive capacity. An appropriate partner, of course, is trustworthy and willing to devote time and resources to support the knowledge transfer. So, with network capabilities and absorptive capacity the problem of a lack of motivation or credibility on the side of the knowledge source can be overcome.

All in all, the aim of this chapter was to find an answer on the following question: To what extent takes literature about university spin-offs their network activities into account? Considering this question it was seen that literature indeed recognized ‘activities that involve the network’ as important for USOs; a positive relationship was found between between network activities and the performance and growth of a USO. Open innovation, for instance, has been recognized as an important means by which specific tangible (e.g. components) and intangible resources (e.g. development know-how) can be acquired. However, the network of a USO can also provide it with other necessary intangible resources (e.g. commercial awareness and prior business experience) that are not accessed by means of open innovation. Nevertheless, although it was emphasized that USOs struggle to establish successful relationships with partners, literature does not go into much detail about how these processes specifically work for USOs. Only recently Lubik et al. (2013) focused in more detail on the network and partnerships of USOs. They showed that the network of a USO typically consists of corporate partners, e.g. suppliers or investors, the parent university, governmental organizations, other universities and sometimes even other USOs. However, based on this literature review, there are still many research opportunities to explain the common held assumptions about networking activities for (high tech) USOs. Based on models from literature about collaborations within value networks, one would expect that there are a few important reasons that could explain why USOs struggle with establishing successful relationships within the network and subsequently, why they may struggle to acquire several necessary tangible and intangible resources. It was seen that a weak credibility, a lack of absorptive capacity, a lack of experience and thus also a lack of network capabilities, may be the most important causes that hinder the USO from acquiring several necessary resources to enable the technology transfer and create the spin-off.
3. Towards a Conceptual Model

In order to answer the research question it is important to find a way to define success and performance. Therefore, the objective of this chapter is to answer the question: How can success and performance of high tech university-spin-offs be measured?

There are, of course, many factors that could define success and performance, e.g. the size of the market a firm serves, or its annual profit. However, in the introduction it was recognized that USOs face a lot of obstacles before they are able to become established players in the market. So, in the perspective of USOs not being able to bridge the ‘valley of death’, here success and performance will be defined in terms of growth. Successful firms, obviously, overcome the major problems during their growth quite easy, while less successful firms probably have more trouble overcoming those barriers. Consequently, this chapter is mainly based on literature of Pirnay et al. (2003) Vohora et al. (2004) and Ndonzuau et al. (2002). They provide a model that describes the growth of a high tech USO in five separate stages. These stages will be elaborated on in the next sections. Eventually, based on the characteristics of high tech USOs that are mentioned in literature, a conceptual model is developed which shows how success and performance of a high tech USO can be determined. Moreover, also the importance of networks for the success and performance of high tech USOs during their growth will be explained. The characteristics will cover the three key pillars of entrepreneurial success: the business opportunity, the entrepreneur which exploits the opportunity, and finally the required resources to do this. Finally, the conceptual model is presented at the end of this chapter in figure 6. Because this model presents the growth of a typical high tech USO as described in literature, it will also serve as literal replication for the empirical analysis. More about this will be explained in the next chapter.

3.1 A stage model of high tech university spin-off creation

The five-stage model starts with some research results and it ends in a phase where the high tech USO attains sustainable returns and creates economic value (Ndonzuau et al., 2002). Between the current and all previous phases, there is constant feedback. For example, when a USO moves from the opportunity framing phase (i.e. second phase) to the pre-organization phase (i.e. third phase), it is also still occupied with activities from the opportunity framing phase and even of the phase before that: the research phase (i.e. first phase). However, as USOs proceed from one phase to another, USOs encounter specific challenges that need to be overcome. If those challenges are not overcome the spin-off will not move to the next development stage and hence, its growth will stagnate. Eventually, when these challenges remain unresolved for a long time before a USO attains sustainable returns, the initial resource endowment will become exhausted and consequently, the spin-off will fail. Vohora et al. (2004) describe these challenges as ‘critical junctures’. These critical junctures arise, because of conflicts between a USO’s existing level and type of resources, capabilities and social capital, and those required to be active in the next phase of development (Vohora et al., 2004).

Considering the interaction with networks during this growth process Pérez & Sánchez (2003) found that early network dynamics of USOs clearly differ from network dynamics in a later stage. This is because particularly high tech USOS need to partly replace their academic-oriented personal network with a more market-oriented network. In the early stages USOs are more interested in knowledge transfers and networking activities with their parent organisation. Later on they become less eager to collaborate with universities and technology centers. Subsequently, their networking with customers increases at the same time as the technology transfer increases (Lubik et al., 2013). As will be shown, this happens around the
transition from the opportunity framing phase to the pre-organization phase. Finally, Pérez & Sánchez (2003) identified four specific actors that are typically involved in the creation of the spin-off: (1) the technology originator, (2) the parent organization, (3) the surrogate entrepreneur, and last (4) the venture investor. These actors will be described as they appear in the next sections.

3.1.1 Research

High tech USOs always emerge from scientific research. During this research the focus of the technology originator(s), also known as the academic entrepreneur(s), - the person or group of researchers that bring the technology from basic research to the point where the technology transfer can start - mainly is on perfecting the academic research and publication of the findings. This research is conducted at the parent organization, in this case the university, which is therefore obviously also involved from the very beginning. Knowledge in this phase is mainly codified, but also the know-how embedded in the technology originator is important. Within this phase often valuable IP is created, which generates the potential opportunity for commercialization of the technology (Pirnay et al., 2003). This means there is an unfulfilled market need and the developed technology is the solution that satisfies that need. Commercialization of this opportunity only starts in the next phase. Hence, in this phase there is not yet a market to enter and also no entry barrier. When the unfulfilled market need then, is recognized the critical juncture of ‘opportunity recognition’ has been overcome and opportunity framing starts. The challenge of this juncture thus, is to recognize break through ideas that lead to business proposals for commercial exploitation (Vohora et al., 2004; Ndonzuau et al., 2002). However, it requires specific skills, attitudes, insights, and circumstances for an academic researcher to connect knowledge with a commercial opportunity. It is argued by Vohora et al. (2004) that overcoming this critical juncture is the ability to synthesize scientific knowledge with an understanding of markets that is enhanced significantly by higher levels of social capital in the form of partnerships, linkages, and other network interactions. So, while the tangible needs, like financial and material needs, during this phase are mostly low, it stands out that there are already moderate intangible needs, such as networking. Ndonzuau et al. (2002) confirms this by stating that the identification of ideas in this first stage already requires the development of expertise with internal partners (i.e. professors) or with external partners (i.e. consulting firms). Although, a problem might be in this stage and in the next one that academic researchers, which lack commercial expertise, “do not like being told what to do or how best to do it, even if they are not the expert” (Vohora et al., 2004, p.164). So, they are not very open minded to external stakeholders. In this phase this might even be a bigger problem than in the next phase, because in the ‘scientific paradigm’, as prevails in the academic culture, there are only two ways of exploiting knowledge: (1) publications, and (2) education. Commercial exploitation per se is not a goal for scientists.

3.1.2 Opportunity framing

In this second stage the main goal is to transform the ill-structured opportunities recognized in the research phase into a consistent and structured venture creation project. Typically, for this a surrogate entrepreneur(s) is approached. He takes the technology created by the academic entrepreneur in order to create a venture around it. Basically, the surrogate entrepreneur ‘frames the opportunity’. In this phase two specific issues need to be addressed by the surrogate entrepreneur: (1) the protection, and (2) the development of the produced idea. On the one hand, the protection of the idea emphasizes two problems. First, it should be made clear who is or are the owners of the idea and second, how is the technology going to be protected against competitors, because in a Type I USO the idea-bearer is only sometimes
also the idea-explorer (Pirnay et al., 2003). The development of the idea, on the other hand, involves a screening process where the technology, by means of a prototype, is being evaluated and tested for its applications outside the laboratory. This leads to some material needs, but still low to moderate needs. Once the technology has been developed and it has been evaluated for its validity and performance, attempts will be made to frame the technology within a commercial opportunity. This involves the construction of a business plan and an assessment of the potential of the technology (Vohora et al., 2004; Ndonzuau et al., 2002). According to Pirnay et al. (2003) the potential of high tech USOs in general is quite high. This means that they generally act in international markets and have a high export potential.

During this development stage already moderate to high financial resources are necessary. The technological and commercial development is quite expensive, while the spin-off is not even yet created and, thus, makes no money. A university, in this case, can help, but it cannot cope with financing both the technological and the commercial development. So, they need other sources for funding. Here, the venture investor comes first into view; he should provide funding for the new firm. Finding such an investor is, though, not straightforward. On the one hand, public funding is particularly dedicated to fundamental research. On the other hand, very few private financial backers invest so early in the process, because of the unpredictability of the high tech market and the supposedly low entrepreneurial capabilities of researchers. This financing gap is a key problem in this stage of the spin-off creation and therefore, the entry barrier is also moderate to high (Ndonzuau et a., 2002; Pirnay et al., 2003). Nevertheless, at the end of this stage a spin-off should be created. However, first the critical juncture of this stage needs to be overcome. This critical juncture is called ‘entrepreneurial commitment’. Entrepreneurial commitment is defined by Vohora et al. (2004, p. 160) as acts that bind the academic entrepreneur to a certain course of events. This juncture emerges due to a conflict between the need for a committed entrepreneur to develop the USO and the inability to find someone with the necessary entrepreneurial capabilities, because most academic entrepreneurs lack an entrepreneurial background. Entrepreneurial background characteristics include the education level and the experience of the entrepreneur. Both have a direct effect on the performance of the future spin-off. Moreover, most studies report that all prior experience (i.e. entrepreneurial, industrial, and managerial experience) has a positive relationship with a firm’s performance. Moreover, experience is also positive related to a firm’s growth (Lee & Tsang, 2001).

Finally, there are four underlying reasons for the critical juncture of entrepreneurial commitment to emerge. First, the academic entrepreneur lacks access to successful entrepreneurial role models. Second, he lacks the prior business experience together with a lack of faith in its own abilities to succeed in a foreign commercial environment. Third, the academic entrepreneur may lack self-awareness about personal limitations and sometimes a lack of humility. Moreover, as already explained, academic entrepreneurs are not very open-minded towards external stakeholders. Finally, it seems to be very hard for the academic entrepreneur to identify, access, and acquire the services of a surrogate entrepreneur; somebody that helps creating the venture around the initial business opportunity. This is mainly caused by a limited social capital leaving the academic entrepreneur unable to identify and access suitable individuals from within their own networks. Also, as explained above, a lack of financial resources to offer to the surrogate entrepreneur might be a cause. All in all, this suggests that in this phase already moderate to high intangible resources are necessary for two major reasons. The USO thus, needs access to a network, because (1) the academic entrepreneur needs to find a surrogate entrepreneur to help creating the spin-off and (2) to finance the project (Vohora et al., 2004).
3.1.3 Pre-organization

From this stage on, the USO is created. Still small scale and highly dependent on its founders, Pirnay et al. (2003) argue that high tech USOs may enter in an emergent, high growth, market and thus, have a high expected growth rate. Growth is also the main objective at this stage. Strategic plans for the spin-off can now be developed and implemented. This involves taking decisions over which path to follow. So, which existing resources and capabilities should be developed, which should be acquired now and in the future, and when and where to access these resources and knowledge? Decisions taken in this stage will impact the entire future success of the USO. Hence, these decisions are very important and thus, as argued by Vohora et al. (2004) and Pirnay et al. (2003), prior entrepreneurial experience, human capital, and access to networks of expertise are placed at a premium. After the previous stage, the dependence on external stakeholders now increases to a maximum. As a result, the entrepreneur opens his mind from this stage on even more for external stakeholders (pirnay et al., 2003).

Ndonzuau et al. (2002) identifies two main problems during this phase: (1) the relationships that should be established between the spin-off and its parent organization (the university), and (2) the availability of resources. First, In order to help the USO overcoming several issues some universities actively try to help finding solutions, while other universities consider these issues as beyond their mission. Nevertheless, most universities maintain a relationship with their spin-offs. This can be done for three reasons: (1) universities can hold some equity shares of the USO (financial resources); (2) USOs can exploit a patented technology owned by universities (intangible resources); and last (3) USOs may have access to some university facilities (material resources). These relationships could lead to conflicts of interests between the university and the spin-off (Ndonzuau et al., 2002). The availability of resources was identified as a second problem at this stage. A good business opportunity cannot be successful without management expertise and good social networks. So, the intangible resources required during this phase are high. Considering these intangible resources there are, though, two issues: How to identify key people and how to involve them. Furthermore, the USO also needs tangible resources; there is a moderate need for materials. Moreover, especially small USOs cannot execute the entire production process in-house. This and the moderate material needs require high levels of funding. Therefore, a lack of financial resources could be an important problem for USOs in this phase (Walter et al., 2006; Lubik et al., 2013; Brainport Industries Coöperate U.A., 2012). Particularly, the access to such resources is a problem, rather than the acquisition of them. Consequently, in order to move to the next phase, the USO has to pass the ‘credibility threshold’, as the critical juncture is called. The necessary resources cannot be acquired without either some initial funding or through co-optation of resources through existing relationships and external networks. Therefore, Pérez & Sánchez (2003) identify a lack of financial resources as the main barrier for technology transfers in the first year after the launch of a high tech USO. This implies that the entry barrier to the market in this phase is still moderate to high. The underlying reason for this is a lack of credibility, which constrains the academic entrepreneur to access and acquire important resources, such as seed finance and human capital to form an entrepreneurial team. More precisely considering this lack of credibility then, customers estimate a technology according to the status and the reputation of its source (Timbrell et al., 2001). In its early years a USO has, besides the publications of its academic entrepreneur, not much status and reputation, and thus credibility, to rely on (Pirnay et al., 2003). Therefore, overcoming this critical juncture is often related to acquiring some key customers. They are necessary to acquire some initial credibility, which should help to overcome skeptical customer perceptions, gain access to markets and successfully achieve the transition from a concept to a legitimate business (Vohora
et al., 2004). Trust is a key factor in this case (Bogers, 2011). It is, though, hard for starting spin-offs to establish a mutual-trust relationship with customers. Therefore, this is one of the most critical phases in the development of the spin-off; without appropriate partners it is hard to survive the pre-organization phase for high tech USOs (Pérez & Sánchez, 2003; Van der Borgh et al., 2012; Walter et al., 2006).

3.1.4 Re-orientation

The retrieved funding from the previous phase enables the firm to fulfill its moderate to high material needs and to generate returns by offering its customers a product of value. Consequently, the need for financial resources decreases to moderate, because the spin-off should now be able to provide for its own funding. During this phase the entrepreneurial team faces the challenge of continuously identifying, acquiring and integrating resources and subsequently, re-configuring them. Along the way, as a result of the experience it gained, the team has learned how to develop newly acquired resources, information, and knowledge. Also it aggregated new capabilities. The ultimate goal for high tech USOs is growth (Pirnay et al., 2003). In this phase thus, it is important to grow and strengthen the spin-off. It is also expected that high potential USOs have not reached their full industrial potential yet at this stage and therefore, still have a high expected growth rate (Ndonzuau et al., 2002; Vohora et al., 2004). In order to exploit this full potential, the firm has to proceed to the last stage and thus, pass the last critical juncture: ‘sustainable returns’. Sustainable returns can be revenues from customers for products sold, milestone payments from collaborative agreements or investment from existing or new investors. This characterizes that the spin-off is able to create value from having developed the appropriate resources, capabilities, and social capital; the entrepreneurial team has achieved the ability to continuously re-configure existing resources, capabilities, and social capital with new information, knowledge and resources. Again, this emphasizes the unchanged high intangible needs of a high tech USO. Furthermore, an organizational structure, policies, and routines are developed and enable the allocation of resources to be coordinated and the rate of their consumption to be controlled in order to attain appropriate returns. These developed internal capabilities and routines continually need to be adapted. For USOs that are unable to deal with a lack of social capital, resource weaknesses and inadequate internal capabilities it is particularly hard to overcome this final critical juncture. Therefore, it is important to address such problems already in early development phases (Vohora et al., 2004).

3.1.5 Sustainable returns

Eventually, a successful USO will reach the final sustainable returns phase. This phase is characterized by the USO achieving sustainable returns. The achievement of sustainable returns, of course, lets the financial needs, such as seed capital and funding capitals, even decrease more to low needs; the material needs will; and last, as explained, the intangible needs will remain high (Pirnay et al., 2003). The ultimate objective for the entrepreneurial team is to access and reconfigure resources to aggregate the capabilities which enable the spin-off to reach this final phase. Typically, at this stage the material needs of the USO increase to moderate to high and therefore, USOs move off the university campus into the commercial environment. However, most times the spin-off maintains some links with the university, even though it moved out of the university and has established its own commercial identity (Vohora et al., 2004). According to Pirnay et al. (2003), the dependency on the founders of the high tech spin-offs will eventually decrease to low dependency. Moreover, the expected growth rate will, just after reaching this final phase, still be high, but over time it may eventually slowly decrease. Last, high tech USOs are involved with technologies that are very complex and constantly evolving, therefore they need
to keep adapting their routines and internal capabilities to the circumstances. Subsequently, R&D expenditures will, by definition, stay high (Smith, 2000; Pirnay et al., 2003; Vohora et al., 2004).

3.2 Summary

Success and performance in this study are defined in terms of growth. Successful firms, obviously, overcome the major problems during their growth quite easy, while less successful firms probably have more trouble overcoming those barriers. Therefore, in this chapter a conceptual model about the problems and characteristics of high tech USOs was developed which shows how success and performance can be determined. Subsequently, in order to explain the success and performance of high tech USOs, literature provided a five-stage model about the growth of high tech USOs. This model starts with some research results and it ends in a phase where the USO attains sustainable returns and creates economic value, as USOs then proceed from one phase to another, they encounter critical junctures that need to be overcome. When those challenges are not overcome the spin-off will not move to the next development stage and hence, its growth will stagnate and eventually, when these challenges remain unresolved for a long time, the spin-off will fail.

USOs thus, always emerge from scientific research. During this research phase the technology originator(s), also known as the academic entrepreneur(s), brings the technology from basic research to the point where the technology transfer from the university to the commercial environment can start. Within this phase often valuable IP is created, which thus generates the potential opportunity for commercialization of the technology. When the unfulfilled market need, which the developed technology should satisfy, is recognized the critical juncture of ‘opportunity recognition’ has been overcome. The challenge of this juncture is to recognize breakthrough ideas that lead to business proposals for commercial exploitation. However, it requires specific capabilities for an academic researcher to connect knowledge with a commercial opportunity. Overcoming this critical juncture is the ability to synthesize scientific knowledge with an understanding of markets that is enhanced significantly by higher levels of social capital.

In the second stage, the opportunity framing phase, the main goal is to transform the ill-structured opportunities recognized in the research phase into a consistent and structured venture creation project. Typically, for this a surrogate entrepreneur(s) should be approached for which the academic entrepreneur needs access to a network. The surrogate entrepreneur takes the technology created by the academic entrepreneur in order to create a venture around it. The development of the idea involves a screening process where the technology, by means of a prototype, is being evaluated and tested for its applications outside the laboratory. Once the technology has been developed and it has been evaluated for its validity and performance, attempts will be made to frame the technology within a commercial opportunity by means of the construction of a business plan and an assessment of the potential of the technology. For the technological and the commercial development then, access to a network is necessary; a venture investor, which is quite hard to find, should provide funding for the new firm. Moreover, to create the spin-off at the end of this phase, the critical juncture of ‘entrepreneurial commitment’ need to be overcome. This is defined as acts that bind the academic entrepreneur to a certain course of events. The juncture emerges due to a conflict between the need for a committed entrepreneur to develop the USO and the inability to find someone with the necessary entrepreneurial capabilities, because most academic entrepreneurs lack an entrepreneurial background.
Once the spin-off is created and high tech USOs enter the pre-organization phase, strategic plans for the spin-off can be developed and implemented. Therefore, in this phase prior entrepreneurial experience, human capital, and access to networks of expertise are placed at a premium. The main problems during this phase are that relationships should be established between the spin-off and the university, and the availability of especially financial resources. Consequently, in order to move to the next phase, a USO has to pass the ‘credibility threshold’, as the critical juncture is called. This threshold arises from the fact that the necessary resources cannot be acquired without either some initial funding or through co-optation of resources through existing relationships and external networks. However, in its early years a USO has not much credibility to rely on, while customers mainly estimate a technology according to the status and the reputation of its source. Therefore, overcoming this critical juncture is often related to acquiring some key customers. They are necessary to acquire some initial credibility, which should help to overcome skeptical customer perceptions, gain access to markets and successfully achieve the transition from a concept to a legitimate business.

The retrieved funding from the previous phase enables the firm to fulfill its material needs and to generate returns by offering its customers a product of value. During the re-orientation phase, then, the entrepreneurial team faces the challenge of continuously identifying, acquiring and integrating resources and subsequently, re-configuring them. Along the way the team has learned how to develop newly acquired resources, information, and knowledge. Nevertheless, in order to exploit its full potential, a high tech USO has to proceed to the last stage and thus, pass the critical juncture of ‘sustainable returns’. These can be revenues from customers for products sold, milestone payments from collaborative agreements or investment from existing or new investors. It characterizes that the spin-off is able to create value from having developed the appropriate resources, capabilities, and social capital. Furthermore, an organizational structure, policies, and routines are developed and enable the allocation of resources to be coordinated and the rate of their consumption to be controlled in order to attain appropriate returns.

Eventually, a successful USO thus, will reach the final sustainable returns phase. This phase is characterized by the USO achieving sustainable returns. The ultimate objective for the entrepreneurial team is to access and reconfigure resources to aggregate the capabilities which enable the spin-off to reach this final phase. Typically, at this stage USOs move off the university campus into the commercial environment. Even though the USO moved out of the university and has established its own commercial identity, mostly it still maintains some links with its parent university.

Finally, to answer the question how success and performance of high tech USOs can be measured, the findings from literature have shown that the growth of a high tech USO can be mapped in a five-stage growth model. During the growth high tech USOs have to overcome major challenges, which are called critical junctures. It was explained that successful USOs have less problems to identify, acquire, integrate, and re-configuring the necessary resources and capabilities during these growth phases to overcome these critical junctures. Consequently, spin-offs that perform better have less trouble overcoming the problems and making it to the final sustainable returns phase. All in all, success and performance of high tech USOs can be measured in terms of growth by means of the conceptual model in figure 6 that shows the different growth phases of high tech USOs and the major challenges that need to be overcome.
Type I

Figure 6. Conceptual model of the characteristics per growth phase of Type I high tech university spin-offs. This figure is mainly based on the figures and findings of Vohora et al. (2004), Ndonzuau et al. (2002) and Pirmay et al. (2003).
4. Methodology

In order to test the findings of the first chapters into a real context, which was in this study identified as the Dutch HTSM sector, it is important to find an answer on the next question: What is the best way to analyze the network activities of Dutch high tech university spin-offs? This chapter, therefore, explains the methodology that is used for the empirical research in this study.

With three technical universities in the Netherlands it seems to be no problem to find high tech USOs. However, finding those high tech USOs is not as straightforward as one would expect. The University of Twente, for instance, does not keep up a clear list of all its spin-offs. Contrary, the Universities of Delft and Eindhoven do keep up a list of their spin-offs. However, in contrast to what one maybe expects, not all these spin-offs belong to the HTSM sector. Many USOs of the technical universities belong to other sectors, such as the Chemicals sector, the Life Science and Health sector, or the Energy sector. Therefore, after analyzing the high tech USOs just approximately fifteen were found. Assuming that not all of these USOs will respond to participate in this research, the population is too small to draw strong conclusions from a quantitative approach, such as a survey. Therefore, in order to research the questions that are proposed in the introduction, a qualitative research design is chosen. Creswell (2009, pp. 175-176) indicates several characteristics of qualitative research. Some of these characteristics are: Data in qualitative research is collected in the field where participants experience the problems which are under study. Moreover, data is collected by researchers themselves through examining documents, interviewing, or observing. These multiple sources of data that are used are another characteristic in qualitative research. The focus in qualitative research is on the meaning of participants about the problems that are studied. Last, in a qualitative research these meanings need to be interpreted by the researcher. It is all about what the researcher sees, hears, and understands.

These are some of the characteristics of a qualitative research design according to Creswell (2009). In the next sections the decisions that are made in this qualitative design will be justified. Moreover, the data collection and analysis process will be explained. Finally, some remarks will be made about the qualitative criteria of this research.

4.1 Justification of the case study approach

For this qualitative research, then, a case study approach was chosen. Case studies are designed to bring out the details from the viewpoint of the participants, which are in this case USOs in the Dutch high tech industry, by using multiple sources of data (Tellis, 1997; Grünbaum, 2007). The method allows the researcher to preserve the meaningful characteristics of real-life events, as in this case network activities of USOs (Yin, 2003a). Moreover, case studies are particularly useful when the research topic focuses on answering ‘how or why’ questions, which is here the case (Yin, 2009). The definition of a case study then, according to Yin (2009) and Grünbaum (2007), is twofold: First, a case study is an empirical research that investigates a contemporary phenomenon in depth and within its real-life context, particularly when the boundaries between the phenomenon and its context are vague. Second, the case study research relies on multiple sources of evidence and it benefits from the prior development of theoretical propositions to guide data collection and analysis.

There are several types of case studies. The objective can be descriptive, exploratory or explanatory (Grünbaum, 2007). As has been shown in the previous chapters, there is already a lot of literature on network activities and USOs, even specific on high tech USOs, their growth, their problems
and on their interaction with networks. To test these theories for USOs in the Dutch HTSM sector, it has, therefore, been chosen in this study for an ‘explanatory’, also called ‘theory-confirming’ case study with multiple cases. This type of case study tests the explanatory power of a particular theory and it is used for doing causal investigations (Moses & Knutsen, 2007, pp. 132-133; Tellis, 1997; Yin, 2003a). This theory has been explained in the previous chapters. The conceptual model will be tested with this case study.

According to Creswell (2009, p. 184) a case study involves a detailed description of the context or individuals of the study. Moreover, Moses & Knutsen (2007, p. 139) argue that case studies are best suited when the theories being tested involve complex relationships. These arguments are particularly applicable in this study, because network activities are all about context and relationships between different actors. Another characteristic of case studies is their reliance on the historical method. However, as Moses & Knutsen (2007, p. 139) point out, the case study is more than a historical study. A case study points beyond the object immediately at hand, whereas a historical study is just about setting the historical facts straight. A case study tries to move from a purely empirical level of interpretation to generalization.

4.2 Case and unit of analysis

In case studies the unit of analysis is a critical factor. Case studies are generally very selective, mostly the focus is just on one or two issues that are fundamental for understanding the problem that is being examined (Tellis, 1997). Therefore, the unit of analysis is a central concept in connection with understanding, preparing and implementing the case study (Grünbaum, 2007). The definition, though, of the unit of analysis is heavily debated on. For instance, according to Tellis (1997) the unit of analysis is generally a system or action rather than an individual or a group of individuals. Contrary, Sjoberg, Williams, Vaughan & Sjoberg (1991, pp. 36-37) argue that it is an individual, a community, an organization, a nation-state, an empire, or a civilization. The debate regarding the unit of analysis mainly focuses on the ambiguity between the ‘case’ and the ‘unit of analysis’. So, in order to define the unit of analysis in this study it is important to distinguish between these two (Grünbaum, 2007). Furthermore, according to Patton (2002, p. 229): “The key issue in selecting and making decisions about the appropriate unit of analysis is to decide what it is you want to be able to say something about at the end of the story.” Patton (2002) does, however, not make a difference between a case and a unit of analysis; cases are units of analysis. Grünbaum (2007) points out that Yin (2009) does the same in the holistic designs he described; the case and unit of analysis are indistinguishable. If, though, it is not clear how two central concepts in the case study method can be separated in a meaningful way, it will be very hard to speak of any kind of generalizability. Therefore, Grünbaum (2007) offers an alternative conception, which will be used in this study. Grünbaum (2007) describes a case as some layers that surround the unit of analysis. Consequently, the unit of analysis will be in the heart of the case on a lower abstraction level and it will constitute specific information about the unknown that the study wants to enlighten. The aim of a study is in principle what determines the unit of analysis. So, according to Grünbaum (2007) the unit of analysis is similar with the knowledge that the participants of the study can provide the researcher with. This also means that the unit of analysis can be as well individuals as actions of individuals. Figure 7 shows a conceptual model of the unit of analysis and the case in the context of this study based on the findings of Grünbaum (2007). As can be seen the unit of analysis of this study is ‘network activities’. As the focus in this study is on the high tech sector, cases will be high tech USOs, more specifically USOs in the Dutch HTSM sector.
Figure 7 shows the relationship between the unit of analysis and the case in this study. Moreover, the model distinguishes between micro and macro analytical levels. The unit of analysis forms the micro level and the case forms something that is closely connected with the unit of analysis. To move meaningful from one analytical level, such as the unit of analysis, to another level is as moving up an abstraction ladder, as Grünbaum (2007) describes it. The idea of this ladder of abstraction is to increase the vital transformation of the collected empirical data into explanatory knowledge. In other words, this conceptual model should make it easier to generalize the findings of this case study.

4.3 Research design

For this study multiple cases were examined and analyzed. Subsequently, the small population, the explanatory nature of this research, and the extensive literature on characteristics of high tech USOs, as design it has been chosen for a ‘literal replication design’. This means that cases are compared with literature. If the cases, then, indeed confirm theory, the analyzed cases are expected to be similar to cases as described in literature. This ensures that conclusions can be drawn for cases in specific contexts, without it being necessary to use many cases (i.e. two to four cases) (Yin, 2009). Therefore, this design is specifically suitable for this research. When the cases, however, do not provide similar results or contradict literature, another research design should be chosen and more cases should be searched and analyzed, to show which differences there are between literature and the specific cases. Hence, for a literal replication design, cases should be carefully selected, based on the criteria that apply for this study. A criterion for the number of cases is that after analyzing the cases one has to detect an effect. If no effect is observed, more cases need to be selected, examined and analyzed. Another rationale for the number of cases that is used could be that the sample size should be increased until no new perspectives from the data emerge anymore (Gray, 2004). In this case nine USOs were approached of which three firms responded, which is enough according to Yin for this kind of replication design. Moreover, most answers
in the interview of case 3 only resulted in the confirmation of what was found in the first cases, so it seemed to be enough.

In a replication design each case is considered as a whole study in which convergent evidence is searched with respect to the conclusions of the case. The conclusions are then seen as the information that needs to be replicated by the other individual cases (Yin, 2009; Tellis, 1997). Subsequently, following from Grünbaum’s (2007) distinction between a case and a unit of analysis, a first level summation design is chosen. This design, which is shown in figure 10, suits perfectly with the literal replication design that is applied in this study. In a summation design (1) multiple case are analyzed, all different, but only one unit of analysis is studied in the three cases, namely network activities, as has been clarified before. It is called a summation design, because the units of analysis are added together (Grünbaum, 2007). This seems to be a good design, because the basis for a literal replication design is that similar outcomes are expected for every case.

Besides a literal replication design, this study can also be seen as a cross-cultural comparative design. This means that some commonly held assumptions or theories are tested under a different cultural context (Dreher, 1994). In this study, as has been explained earlier, the findings of Vohora et al. (2004), Ndonzuau et al. (2002), and Pirnay et al. (2003) about high tech USOs are tested for the Dutch high tech sector.

![Context: HTSM Sector](image)

**Figure 8.** Summation design (1): three different cases; one unit of analysis (Grünbaum, 2007).

### 4.4 Case selection

The case selection process then, consists of three steps. First, the unit of analysis has to be defined. Second, the criteria for selecting cases need to be set up. Last, the remaining candidate cases need to be screened. Eventually, this process should lead to the selection of appropriate cases for the case study (Yin, 2003a).

Earlier, the unit of analysis and the cases already were defined: network activities of Dutch high tech USO. Next, the criteria for selecting the cases have to be specified. Multiple cases were required and with regards to the replication logic these cases should show the occurrence of exemplary outcomes. This means that the cases should show strong, positive examples of the phenomenon that is studied, which are in this study network activities (Yin, 2003a). Obviously, a second criterion was that the USOs should be active in the Dutch high tech sector, as will be described in the next chapter. Eventually, from a list of 149 spin-offs of the TU/e, the University of Twente and the University of Delft these criteria reduced the possible participants to sixteen firms. As last step in this case selection process then, the USOs that fitted
the criteria were screened, in order to specify which USOs were indeed appropriate cases. According to Yin (2003a) a pitfall that has to be avoided during the screening process is that it becomes too extensive. In that case, one is already doing mini case studies, which is not the goal of the screening process. Therefore, the screening process was done carefully, but not too extensive and the process was limited to only an online background check on the selected firms. Following from the background check, seven spin-offs were eventually not believed to be appropriate cases. So, after the screening process nine firms seemed to be appropriate, subsequently they were approached for an interview. Of these nine firms, three spin-offs responded. Unfortunately, also after a reminder only spin-offs of the TU/e responded.

A final remark should be made about a case that was already contacted in an early stadium. This was an extra case, besides the three spin-offs. Eventually, that case turned out to be not appropriate within the perspective of this methodology. Nevertheless, the interview went on and was used as pilot interview for the three main interviews. Based on this pilot interview, the final interview and protocol were developed.

4.5 Researcher’s role

As student of the TU/e it was easy to get in contact with some USOs of the university, for this a list of all the USOs of the TU/e was used, as described in the section about case selection. Spin-offs of the other universities, especially of the University of Twente, were unfortunately less clear documented and thus, harder to find. Moreover, it seemed like USOs of the TU/e were more eager to help a student of their own parent university, than the spin-offs of other universities wanted to help a ‘foreign’ student. Hence, the university was an important source to get in touch with firms which could be analyzed as cases. Furthermore, this study was conducted in cooperation with Holland High Tech, which also was able to provide some contact information of useful cases. Subsequently, the role of the researcher changed into interviewer. At the request of the participants then, it was agreed to treat their answers anonymously. During these interviews the researcher may have brought a bias to the study. Especially, the first pilot interview was not entirely fluent. Due to nerves and a lack of experience in this area there might have been some flaws in the interview. After this interview, some changes were made to the questions and the following interviews went increasingly better. All in all, the bias might be fairly limited. Finally, as data analyst the role of the researcher changed to making interpretations. Especially, this part may be vulnerable for biases brought to the study by the researcher. This will, therefore, later be reviewed in the discussion section.

4.6 Data collection and methods

The data collection process includes collecting information by means of several methods, but also establishing a protocol for recording information (Creswell, 2009).

4.6.1 Collecting information

Six sources of evidence can be used: documentation, archival records, interviews, direct observation, participant observation, and physical artifacts (Tellis, 1997). In this study only interviews and documents are used. The use of these sources has different advantages and weaknesses, no source has a complete advantage over another source and instead they might be complementary. In appendix B the options, strengths and weaknesses of documents and interviews are presented.
The documents that are used in this case study are only public documents. These documents are all found on the internet and they vary from newspaper articles to interviews with founders of the firms. An important weakness of documents is that they may not be authentic or accurate. This weakness is dealt with by referring to the documents during the interviews. In this way the plausibility of the documents is checked. Interviews thus, are the second source of evidence used in this case study. Interviews are ideal for case studies, because they are a powerful tool to evoke data on participants’ views, attitudes and meanings that underpin their behaviors. An important purpose of an interview can be that it is used to test out hypotheses. Moreover, they can be used when the questions, which a researcher is interested in, are open-ended or complex (Gray, 2004). Therefore, interviews are a very appropriate source of evidence in this specific case study.

To be more specific about the interviews that were taken in this study, three interviews, including the pilot interview, were conducted face-to-face and one was conducted through the telephone. The interviews were all semi-structured. That means they were non-standardized (Gray, 2004). However, a list of questions was used which was basically the same for every interview. Depending on the answers of the interviewee some questions were dealt with, while others were left out. An advantage of semi-structured interviews is that they allow for examining perspectives and opinions of participants where it is desirable for them to expand their answers. This is crucial when a phenomenological approach is under study, as in this study network activities, where the objective is to explore meanings that participants attribute to concepts (e.g. open innovation) or events concerning the phenomenon (Gray, 2004). Other strengths of interviews can be found in appendix B. On the other hand, important weaknesses of interviews, also shown in appendix B, are: The presence of the researcher may bias the responses of the participant; moreover, there may arise a bias due to poor questions on the side of the interviewer (Tellis, 1997). In order to minimize these biases, first a pilot interview was held. Moreover, a protocol was used during the interviews. The goal of the protocol was to guide the interviewer through the interview and keep the focus on the study objectives (Creswell, 2009). Last, interviewing literature was consulted in the preparation of the interviews.

Finally, the following methodology was used during the interviews: At the start of every interview the purpose was explained and it was explained why the information was being collected. Interviewees then, were told how long the interviews would last and permission was asked to audiotape the interviews. Subsequently, all the interviews were audiotaped, and notes were taken during the interviews. It was emphasized that the participants always had the option not to answer a question. Furthermore, at the end of the interview it was asked if the participant had any questions and he was thanked for his help and his valuable observations. Eventually, the interviews were elaborated using the notes and recordings. Afterwards the elaborated interviews were sent back to the interviewees in order to be verified by them. During all the interviews an interview protocol was used.

4.6.2 Protocol

A case study protocol is directed at a single data point, either a single case or a single respondent. The protocol is more than a questionnaire or an instrument. It contains the instrument but also contains the procedures and general rules to be followed in using the protocol. Having a case study protocol is always desirable; however it is critical in doing a multiple-case study. The protocol is an important way in which the reliability of a case study research can be increased and it is intended to guide the researcher in carrying out the data collection from a single case. Finally, it keeps the focus of the researcher on the
The main tasks and goals, and forces him to anticipate several problems. These include the way the case study reports are to be completed (Yin, 2009, p. 79; Tellis, 1997).

The case study protocol, which can be found in appendix C, contains four sections. First, an overview of the case study project is provided. In this section the project objectives are presented, case study issues are explained and presentations about the topic under study are given. The second section is about the field procedures that are used in the case study. This section provides reminders about the procedure. Next, case study questions are presented. This includes the specific questions that the case study investigator must keep in mind while collecting the data. Finally, a guide for the case study report is given in the last section of the protocol. In this last section, the outline and format for the report are provided (Yin, 2009, p 81.; Tellis, 1997).

4.7 Data analysis

Analyzing the collected data consists of examining, categorizing, or in any other way recombining the evidence to address the literature and conceptual model of this study. Experience and the literature are the basis for the researcher to present the evidence in various ways, using various interpretations (Tellis, 1997). Data analysis for an explanatory case study is best done using pattern-matching techniques. This means that the real course of events, which is observed and collected in the data collection phase, is compared with the hypothesized course of events; here the conceptual model (Yin, 2003a). If the empirically based pattern matches the predicted one, then the reliability of the case study is enhanced (Tellis, 1997). The pattern-matching approach is done through a coding process. The
complete six-step data analyzing process is described by Creswell (2009). These steps are taken as main
guidance for analyzing the collected data. This has led to the following process of data analysis, as can be
seen in figure 9. The figure suggests a linear process building from the bottom up. However, in fact it is
more interactive in practice. Next, it will be described how these steps were used during the analysis of
the data collected in this case study.

1. First, raw data was organized and prepared for analysis. All interviews were elaborated based on
the notes and recordings taken during the interviews. The reports that resulted were sent back to
the interviewees in order for them to check them. After the feedback was processed, separate
bundles were composed for each case with all the information that was found about the cases.

2. Second, a general sense of the data had to be obtained. Therefore, all data was read and for every
case an individual case report was composed (Yin, 2009). These case reports consisted of the
elaborated interviews, the background information found on the firms, and for every USO a
classification was carried out according to the typology given by Pirnay et al. (2003).

3. Third, data needed to be coded. “Coding is the process of organizing the material into chunks or
segments of text before bringing meaning to information” (Creswell, 2009, p. 186). Creswell also
provides some useful steps for the coding process. Subsequently, the following steps were
applied: First, one individual case report was picked and closely studied. Thoughts and topics
concerning the hypotheses and theory were written in the margins at the side of the relevant text.
Next, a list was made of all topics. Similar topics were clustered together. The topics were
organized as major topics concerning findings on what the reader would expect; important topics
that regard larger theoretical perspectives; topics that are unusual with respect to the theory; less
important but interesting and surprising topics; and finally there was a leftover group, which was
not used for analysis. The different topics were given a specific code to classify the other case
reports. Once a new topic emerged it was added to the topic list and all reports were studied again
in order to look for new topics. So, codes were only based on the emergent information collected
from the participants. Eventually, the topics were turned into categories, such as a category about
contextual factors; a category about absorptive capacity; a category about open innovation; a
category about the history of the USO; etcetera. Eventually, related categories were grouped
together and a preliminary analysis was performed on the final list of categories.

4. In the next step a description was made from the categories about the firms and events observed
in the case study. Subsequently, from the categories the most important ones were selected. These
selected categories together form the major findings of this qualitative study.

5. The outcome of this step, then, is what is written in the results chapter, which comes next. The
most important categories which were selected in the previous step are taken together and
represented in a narrative. In this narrative the findings of the analysis are presented. This
includes that the categories were interconnected in the story. In this way it should explain the
complex story of network activities from a different perspective than what was done in earlier
research, i.e. from the perspective of USOs specifically in the Dutch high tech industry.
6. The final step in the data analyzing process is making an interpretation of the data. This means that lessons learned are summarized, but also that the findings are compared to the predefined hypotheses from literature. The lessons learned are based on the interpretation of the researcher. However, the findings from this analysis also led to new questions, which should be addressed in a follow-up study. Of course, all of this can be read in the conclusions sector of this report.

4.8 Qualitative criteria

The use of the case study approach, especially with only three cases, has some clear shortcomings. In this section, therefore, these shortcomings and the qualitative criteria about how to handle them will be dealt with. Leininger (1994) describes six important criteria to evaluate qualitative studies: credibility, confirmability, meaning-in-context, recurrent patterning, saturation, and transferability.

First, credibility, or ‘qualitative validity’, refers to believability or trustworthiness of the findings; it refers to the truth as known or experienced by the participants (Creswell, 2009). This means that the researcher checks for the accuracy of the findings by employing certain procedures. Since the findings of this study are not based on quantitative data, which can be showed to support the findings, but on interpretations made by the researcher of the interviews, this might be a problem. Hence, in order to increase the accuracy of the findings Creswell (2009) suggests incorporating validity strategies. He names several of them, the ones incorporated in this study are: triangulate different data sources of information, use member checking by taking the interview report back to the participants, explain the findings as clearly and elaborated as possible and last, clarify the bias the researcher brings to the study.

Second, confirmability, also known as ‘construct validity’, means obtaining direct and often repeated confirmations of what the researcher has heard, observed, or experienced regarding the topics under study (Yin, 2009). The test for construct validity is especially hard in case study research, because in order to collect the data ‘subjective’ judgments are used. This also is an important weakness of this study; the major source of evidence are the interviews. Interviews are limited by the ability of the participant to describe and conceptualize. It is important that differences in the capacity to use language and discourse are not the cause of the interpretation of differences in experience (Dreher, 1994). The following tactics were used to increase the confirmability of this study: The elaborated interviews were sent back to the participants to be reviewed. Moreover, other sources, such as the documents, were as much as possible used and they were referred to during the interviews. Also every participant was asked the same questions in the interviews. When they coincided the data was successfully triangulated (Yin, 2003b). With some cases this tactic succeeded. However, it was hard to triangulate all the evidence.

Meaning-in-context focuses on the contextualization of ideas and experiences within a total situation, context, or environment. This criterion will be dealt with later in this report. The results of data collection will be analyzed in a bigger context: from the perspective of the Dutch HTSM sector.

Next, recurrent patterning, described by Creswell (2009), Yin (2009) and Gray (2004) as ‘qualitative reliability’, refers to a sequence of events or experiences that tend to be patterned and recur over time in designated ways and different or similar contexts. They describe it as being able to repeat the exact same study and getting the same results. Tactics to increase the reliability of this study were: Using a case study protocol, shown in appendix C; moreover, every step was as clearly as possible described in this chapter. This should enable other researchers to repeat this study, getting the same results.
Fifth, saturation is about the full immersion into phenomena in order to know it as fully, comprehensively, and thoroughly as possible. The researcher finds no further explanation of the phenomenon under study. In fact, there tends to be a redundancy in which the researcher gets the same findings again. This was, as already indicated, reached after the third interview. That is also the reason no more cases were selected besides the initial cases. Consequently, this criterion is satisfied.

Sixth, transferability, also known as qualitative generalization, refers to whether findings of a study can be generalized to another similar context and still preserve the interpretations and conclusions from the completed study. Yin (2009) describes this criterion as a test for the ‘external validity’ of a study. To increase the external validity of this multiple-case study with only a few cases, a replication logic is used. Multiple (literal) cases that result in the same findings are good for the external validity. This is confirmed by Creswell (2009). This is also what was done in this study; three literal cases were selected. Unfortunately, these three cases all come from the TU/e. This might decrease the external validity of this study and instead of the whole Dutch HTSM sector, the findings might only be transferable to a smaller region which will be described in the next chapter: the Brainport region. Moreover, it needs to be pointed out that case studies rely on analytic generalization, instead of statistical generalization. This means that the researcher tries to generalize a particular set of results to some broader theory. It depends on the results and how they replicate the literature, to which extent the conclusions of this study are generalizable. Hence, only after the results in the discussion this criterion can be dealt with.

A last test to judge about the quality of a case study, not described by Leininger (1994), and only for explanatory case studies is the test for the ‘internal validity’. This means that the causal relationships that are searched for are truly causal. In explanatory studies a researcher has to infer that some events lead to particular other events. These causal links cannot be directly observed. Therefore, a researcher should make the right inferences. According to Yin (2009), an important tactic to increase the internal validity, also used in this study, is to use pattern matching during the data analysis. Nevertheless, the internal validity might be a real problem in this study. Due to the few cases being analyzed, other explanations besides the influence of networks, for the success of USOs cannot be excluded. It may, for instance, be the case that the quality or uniqueness of the product is the most important, or only reason for the success of a certain USO. Therefore, to minimize the problems with the internal validity of this study, in the interviews it was clearly asked about the influence of networks on the success of the USOs. Also it was asked for other determinants of their success, although the focus was mostly on the first kind of questions.
5. Empirical Analysis: Dutch High Tech University Spin-Offs

This chapter aims to answer the last sub-question that was proposed in the introduction: In what way are university spin-offs in the Dutch HTSM sector engaged with network activities? Within the explanatory nature of this study it is important to find an answer on this question, because the theories that are described in the literature review and the conceptual model need to be tested in a real context: the Dutch HTSM sector. Hence, in order to answer the question, this chapter presents the main findings of the multiple-case study that was done. First however, the research context will be described, some key concepts will be explained, and the borders of this study will be defined. Then, findings of the three analyzed cases will be presented and some opportunities, recognized in the cases, will be described. Eventually, this chapter ends with a summary which provides an answer on the earlier proposed question.

5.1 Research Context: An introduction to the Dutch HTSM Sector

As already was mentioned, this study took place within the context of the Dutch HTSM sector. The HTSM sector is one of nine top sectors in the Netherlands. These sectors are assigned by the Dutch government, because all over the world the Netherlands have a high potential in these sectors. The HTSM sector is an important driver for the Dutch economy; in 2010 the sector employed almost seven percent of the Dutch working population and accounted for six percent of the added value of the Netherlands (CBS, 2012). Therefore, together with high tech firms and science institutions, the Dutch government invests in the sector. One of the goals of these investments is to stay competitive in the sector and to maintain its position at the top of the world (Brainport Industries Coöperate U.A., 2012; Holland High Tech, 2013; Rijksoverheid, 2012).

5.1.1 High tech defined

Logically, ‘high tech’ relates to high technology industries. The most common definition to distinguish high technology industries from other industries (i.e. medium and low technology industries) is provided by the ‘ISIC Technology Intensity Definition’. R&D intensity is the main factor in this definition; the average expenditures of turnover of a sector need to exceed four percent in order for a sector to be high tech (Smith, 2000). A disadvantage of this definition is that, on the one hand, R&D-intensive firms can occur in low technology sectors, while on the other hand, firms that are not R&D intensive can occur in high technology sectors. No definition of high tech can overcome this problem (Kiner et al. 2009; Santamaría et al. 2009. In: Barge-Gil, 2010). Moreover, national governments often use their own definitions of high tech. According to the ICIS definition, though, the following sectors are high tech by definition: aircraft and spacecraft; pharmaceuticals; office, accounting and computing machinery; radio, TV and communications equipment; and last, medical, precision and optical instruments (OECD Directory for Science, Technology and Industry, 2011). In literature it is agreed on the next aspects that are common to high tech firms: The most important characteristics of a high tech firm are a high R&D intensity and high R&D expenditures (Bruton and Wan, 1994; Lee and Shim, 1995. In: Harbia, Amamoub, & Andersonc, 2009); furthermore, high tech firms are innovative and develop and apply new technologies in their products (Grinstein and Goldman, 2006. In: von Hippel & de Jong, 2009); these products typically have short life cycles, and show a bell shaped curve (Levelt, 2010).

5.1.2 The HTSM sector described

Following on this, according to the Rijksoverheid (n.d.), the Dutch HTSM sector can be characterized as a knowledge-intensive and wealthy sector, which is particularly good in the design and
development of high tech equipment and micro/nano components. For 2014/2015 the ambitions of the sector focus on seventeen ‘roadmaps’, as they are called. These roadmaps can be seen in table 1. They include applications, technologies, and technologies that connect several top sectors together. As can be seen from the table, not all roadmaps correspond to what the ICIS definition describes as high tech. Nevertheless, based on a source of the Dutch government, for this research table 1 will be used as guidance whether firms belong to the HTSM sector.

Table 1. Roadmaps for the HTSM sector: Applications and technologies (Topteam HTSM, 2013).

<table>
<thead>
<tr>
<th>Applications</th>
<th>HTSM technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semiconductor equipment</td>
<td>Components and circuits</td>
</tr>
<tr>
<td>Printing</td>
<td>Photonics</td>
</tr>
<tr>
<td>Lighting</td>
<td>Mechatronics and manufacturing</td>
</tr>
<tr>
<td>Solar</td>
<td>Embedded systems</td>
</tr>
<tr>
<td>Health care</td>
<td>High tech materials</td>
</tr>
<tr>
<td>Security</td>
<td></td>
</tr>
<tr>
<td>Automotive</td>
<td></td>
</tr>
<tr>
<td>Aeronautics</td>
<td></td>
</tr>
<tr>
<td>Space</td>
<td>Cross top sector technologies</td>
</tr>
<tr>
<td>Advanced instrumentation</td>
<td>Nanotechnology</td>
</tr>
<tr>
<td></td>
<td>ICT</td>
</tr>
</tbody>
</table>

In 2010, the Dutch HTSM sector counted 64120 high tech firms (CBS, 2012). Most of these firms are either an OEM or a supplier of these OEMs. Together these firms spent eight percent of their added value on R&D. This corresponds to 2.5 billion euro. According to Holland High Tech (2013) these firms distinguish themselves from the rest of the world, because of their high degree of open innovation; i.e. by means of collaborations between the OEMs, suppliers, and research institutions. This was confirmed by statistics from the CBS (2012): in 2010, four of ten innovating firms, are in collaboration with each other; one third of the firms collaborates with universities; and finally a quarter collaborates with governmental or public research institutions. Open innovation even goes beyond the Dutch borders. From within the sector there are strong international ties with firms and research institutions in Europe, the US, and Asia. This makes the HTSM sector the industry that is most oriented on international innovation and collaboration of the Netherlands (Topteam High Tech Systemen en Materialen, 2011). Finally, with respect to success and performance in the HTSM sector, according to the CBS (2012) the survival rates of high tech start-ups are higher than for start-ups in other Dutch sectors. This is illustrated in figure 10. It shows that almost nine out of ten high tech start-ups are still active after being two years in operation, while the average for the Netherlands is eight out of ten start-ups that survive the first two years. Regarding the survival chances, the high tech sector also outperforms other Dutch top sectors, such as the Chemical and Energy sector.
5.1.3 Geography of the Dutch HTSM sector

The last remark of the previous paragraph showed that the HTSM sector is represented in many parts in the Netherlands. More precisely, the HTSM sector is represented in several smaller regions. However, most commonly when, for instance, European regions are compared with each other considering high tech activities, the Netherlands are represented by ‘West-Nederland’. Such comparisons are executed on provincial level (NUTS-2). ‘West-Nederland’ does, for instance, indeed score well on R&D-employment. However, since the focus is specific on the Dutch HTSM sector this study might even move one NUTS level up to a NUTS-3 level analysis. This level specifically focuses on even smaller regions that are normally overseen in large European comparisons. From the analysis on a NUTS-3 level, then, it stands out that only a small part of ‘West-Nederland’ is considered with a high level of high tech activities; respectively the regions Delft and Westland. Another region that is considered with a high level of high tech activities is the region Twente, located around the Technical University of Twente. However, the main part of activities in the HTSM sector is located outside ‘West-Nederland’, and occurs mainly in the Brainport region (Holland High Tech, 2012). This is located in the South-East part of the province North-Brabant. The Brainport region even accounted for eight of the eleven percent of the total export of the HTSM sector in the Netherlands in 2010 (Brainport Development NV, 2012; CBS, 2012). Moreover, the region accounted for the highest level of private R&D expenditure of the Netherlands in 2008 (Lemkes-Straver, 2008). Finally, since this study is about USOs in the HTSM sector, this study will be mainly considered with the three regions that possess a technical university. These are the regions that are mentioned above: Delft and Westland, Twente, and the Brainport region. Unfortunately, only spin-offs from the Brainport region responded.

5.2 Case study evidence: An introduction to the cases

For this research then, as already has been explained, three USOs were studied and analyzed. On request of the participants, the results will be dealt with anonymously². Therefore, the USOs will be referred to as case 1, case 2, and case 3. First, every case will be described in general terms, in order to make clear what kinds of firms are dealt with. Subsequently, the conceptual model about the creation of a high tech USO will be compared to the empirical evidence and some opportunities will be provided.

² Roman numerals (i, ii, iii, ... ,xiv) in this chapter refer to sources in a closed bibliography which cannot be published due to anonymity of the participants.
Table 2. General characteristics of the analyzed cases.

<table>
<thead>
<tr>
<th>Case</th>
<th>Number of employees</th>
<th>Technology</th>
<th>Year of launch</th>
<th>Current growth phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11-50</td>
<td>Measurement equipment for the optimization of sound and vibrations</td>
<td>2009</td>
<td>Sustainable returns phase</td>
</tr>
<tr>
<td>2</td>
<td>0-10</td>
<td>Design and manufacture of measurement equipment</td>
<td>2007</td>
<td>Re-orientation phase</td>
</tr>
<tr>
<td>3</td>
<td>0-10</td>
<td>Design and manufacture of medical robotics</td>
<td>2012</td>
<td>Pre-organization phase</td>
</tr>
</tbody>
</table>

The table shows the characteristics of the USOs that were analyzed. As the table shows, all USOs can be labeled as small or micro firms based on the number of employees they accommodate. Moreover, the technologies they are concerned with show that the firms are high tech firms. Now, first a short history will be provided about the cases and the interviewees. Then, in the next sections the spin-offs will be described in more detail based on the typology of Pirmay et al. (2003) and the conceptual model. The explanation behind the typology of the USOs can respectively be found in appendix D, E, and F.

5.2.1 Case 1: A short history on the creation of the university spin-off

On the basis of the interview and a thorough analysis of the spin-off with respect to the conceptual model, it was concluded that the case suits well with the literal replication design of this study; the conceptual model was mainly confirmed. Moreover, the USO was observed to be in the final phase of development; the sustainable returns phase. This means the firm past the critical juncture of sustainable returns. With respect to the four actors that are typically involved in the creation of a USO, literature was mainly confirmed: The technology originator, of course with a technical background, initially started the spin-off in 2009 based on the research findings of his Ph.D. at the university. He developed a technology of measurement equipment for the optimization of sound and vibrations. This suits with the definition of high tech provided in the beginning of this chapter. Moreover, being a product-oriented, academic spin-off, the USO also fits in the typology of Pirmay et al. (2003) as a Type I USO. For the creation of the spin-off then, the technology originator approached someone with a commercial background. In 2011, though, the partnership between those two failed and the technology originator had to find a new (surrogate) entrepreneur, which he found in the business developer – further referred to as ‘Business Developer 1’ – with whom the interview was held. He is thus, involved in the firm since 2011 and his personal background lies in the business environment of Philips. The business developer helped the technology originator to create a venture around the technology. The parent university facilitated the USO; it provided the USO a work space at the campus and helped with the innovation-lab. Furthermore, it helped with some financing, e.g. the financing of patent applications. Finally, the university supported the spin-off by connecting it with graduation students and subsidy projects. In this case however, the parent organization was not identified as essential for the spin-off. Finally, the venture investor is not very clear in this case. The firm has chosen not to use any foreign capital. They took care of their own financial resources by providing services to customers and by winning some prizes.

5.2.2 Case 2: A short history on the creation of the university spin-off

The second case also mainly confirmed the conceptual model and was thus concluded to be an appropriate case within the replication logic of this study. With regard to its activities, though, it was not as far as the first case; at the moment of the interview it was in the re-orientation phase. Regarding the four actors, as recognized by Pérez & Sánchez (2003), which are typically involved in the launch of a
USOs

The technology - the design and manufacture of measurement equipment - of the spin-off was a result of a Ph.D. research by the technology originator at the university. Hence, since the spin-off is product-oriented and founded by a researcher, the typology of Pirnay et al. (2003) confirms this case is a high tech USO. Already in 2006, during the research, the technology originator started to look around for some customers and potential investors. Subsequently, the technology originator also met the business developer at an event at the university. Also in this case, the business developer – further referred to as ‘Business Developer 2’ -, who has a personal background at the TU/e at the study Technical Business Administration, was the interviewee. Again, the business developer is what Pérez & Sánchez (2003) describe as the (surrogate) entrepreneur. He is involved in the spin-off since the beginning, and together with the technology originator they passed the critical juncture of entrepreneurial commitment in 2007. Since the creation then, the university in this case also provided the firm with a workspace at the campus and it supported its USO in the beginning with finding partners and knowledge. Moreover, according to Business Developer 2 (vi) the university is a partner for fundamental research for the USO. Finally, there is more than one single venture investor. Actually, several public and private investors were recognized (x). All in all, this case clearly confirms the findings of Pérez & Sánchez (2003) considering the four important actors that typically are involved in the start-up of the spin-off.

5.2.3 Case 3: A short history on the creation of the university spin-off

The last case is the youngest USO of the observed cases. Subsequently, this case was also regarding the growth phases, as shown in the conceptual model, the least developed. The spin-off had still to pass the credibility threshold, so it the moment of the interview it was in the pre-organization phase. Nevertheless, also this last case confirmed the conceptual model. Therefore, all cases fit in the replication design of this study and no new cases have to be analyzed; the design does not have to be adapted. Also in this last case then, the four typical actors were involved in the start-up of the spin-off. First, the spin-off initially emerged from the research that was being conducted at the university. More precisely, in this case there were three researchers that can be characterized as the technology originators. All of these researchers have a personal background at the study Mechanical Engineering at the TU/e, subsequently the interview was held with the one – further referred to as ‘R&D Manager 3’ - which now fulfills the role of R&D manager within the spin-off. Already during the research, which was focused on the development of the design and manufacture of medical robotics, the researchers were supported by some subject-specific individuals, which are now also involved in the entrepreneurial team. This confirms that also case 3 is a product-oriented and academic spin-off, and thus a Type I USO. Once the opportunity then, was recognized the technology originators looked for, and found a business developer with a background from Philips. The (surrogate) entrepreneur helped creating the venture around the opportunity; this eventually succeeded in 2012. Third, the university again provided the USO with a workspace at the campus. Moreover, it did try to support the spin-off with network activities, it was, though, not really able to help. Nevertheless, it supported the USO in some other ways, such as funding. Last, the role of the venture investor is also very clear in this case. Although, just as in case 2, there is no single venture investor, this was probably for this USO at the moment of the interview the most important actor. The USO was talking with lots of potential investors to find out if they were interested and if so when they wanted to start financing. As will be seen in section 8.3.4, the credibility threshold was one of the hardest junctures for the USO to overcome, because it needed a lot of funding and, thus, many investors. However, as R&D Manager 3 (ii) argued, the Dutch business climate is not made for big risky investments.
5.3 Case study evidence: Empirical analysis of case 1

In table 3 the general characteristics of the spin-off, as they are now, are compared to the characteristics given by Pirnay et al. (2003). Below, it will be further elaborated on these characteristics. Then, each different growth phase will be dealt with and described for the USO based on the interview and documents.

Table 3. Type I university spin-off based on the findings of Pirnay et al. (2003) compared to case 1.

<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Case 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>The business opportunity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kind of knowledge involved</td>
<td>Both codified and tacit</td>
<td>Both codified and tacit</td>
</tr>
<tr>
<td>Type of activities</td>
<td>Technological, industrial</td>
<td>Technological</td>
</tr>
<tr>
<td>Barriers to entry</td>
<td>Moderate to high</td>
<td>?</td>
</tr>
<tr>
<td>Potential customer market</td>
<td>International</td>
<td>International</td>
</tr>
<tr>
<td>Expected growth rate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Export potential</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Further R&amp;D expenditures</td>
<td>Moderate to high</td>
<td>Moderate to high</td>
</tr>
<tr>
<td>The entrepreneur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiator(s) of the idea</td>
<td>A team of researchers</td>
<td>A sole researcher</td>
</tr>
<tr>
<td>Pursuing “Idea-bearer”=&quot;idea-explorer”</td>
<td>Sometimes</td>
<td>Yes</td>
</tr>
<tr>
<td>Level of dependency on founders</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Open-minded to external stakeholders</td>
<td>Moderate to high</td>
<td>High</td>
</tr>
<tr>
<td>Goal pursued</td>
<td>Growth</td>
<td>Growth</td>
</tr>
<tr>
<td>The required resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial needs (seed capital, funding capitals, …)</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Material needs (equipment, incubating facilities, …)</td>
<td>Moderate to high</td>
<td>High</td>
</tr>
<tr>
<td>Intangible needs (networking, advice, information, …)</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

First, with respect to ‘the business opportunity’ it was explained by the business developer that some knowledge is embedded in IPs, so codified. Most knowledge, though, is embedded in the employees of the USO. This shows that both codified and tacit knowledge are involved. Moreover, the USO is concerned with technological activities; their technology serves to provide measurements and analyses for their customers (iv). These customers are national as well as international companies. Hence, the export potential of the USO, as was also identified during the interview, is high. Also the expected growth rate is identified as high, because the USO is rapidly expanding and its customers are growing. They even just have outgrown the facilities at the university and therefore, moved into the commercial environment. Finally, not much evidence was found about the barriers of entry and the further R&D expenditures. However, because it is a high tech firm, R&D is by definition not low and in order to keep their advantage
the spin-off keeps investing in research with several partners. Subsequently, their further R&D expenditures are estimated to be moderate to high (iii).

Second, regarding ‘the entrepreneur’ the initiator of the idea is the technology originator: a sole researcher. The technology originator, thus, is the bearer of the idea, because the technology is a result from his own research. Moreover, the technology originator is still involved in the management of the spin-off. Therefore, besides being the idea-bearer he is also the idea-explorer. With respect to the level of dependency on the founders, then, Business Developer 1 (xiv) argued the following: “Now, the company is still in a critical phase where it cannot miss any people. The knowledge is mainly embedded in the employees at the moment. Some processes are described in patents, but still the current employees are necessary to understand the patents. Probably, this holds for most start-ups. Later when they grow, more will be documented and people will increasingly specialize themselves. Then, it will also be easier to replace employees. Now, there is still too much important knowledge embedded in these people.” This answer shows that, although the spin-off is in the final phase, it still cannot miss any employees. The level of dependency on the founders, therefore, is still high. Moreover, the quote again confirms that the firm is concerned with both codified and tacit knowledge, as he says that the people are still necessary to understand the patents. With respect to the open-mindedness to external stakeholders Business Developer 1 (xiv) noticed in one of his answers: “One can also define open innovation as smart innovation. When someone else is better able to do something than yourself, then it is better to get it there. You have to open your mind for other parties.” This shows that it is clearly realized in the spin-off that it needs external stakeholders. Hence, it can be argued that the entrepreneurial team is very open-minded to external stakeholders, which is displayed in table 3 by the label high. Finally, growth is not per se an objective; the USO wants to grow naturally. This means it wants to grow in small steps congruent with its market. Eventually, the ambition is to make its technology accessible to a much wider audience. The technology thus, has to become more efficient and cheaper the next years: “Our ambition is to make the technology that we developed accessible. So, the technology has to become more efficient and cheaper. … Growth is not an objective per se; we just want to grow naturally.” So, the goal for the USO is rather the growth of the use of its technology than the growth of the firm. For this to happen, though, the firm also has to grow with its technology; it has to grow naturally. Hence, in some kind of way growth is the goal.

Third and last, considering ‘the required resources’ the financial needs can be considered as low. It is explained that the firm in the beginning had some problems with acquiring sufficient financial resources. Nevertheless, it was chosen not to use any foreign capital. Now however, being in the sustainable returns phase it was explained that the spin-off is not as financially tight as it was in the beginning. Therefore, the financial needs, such as seed capital and funding capitals, are currently considered to be low. Contrary, the material needs have meanwhile grown to high. While until recently, the space at the campus provided by the university was still sufficient. Now, they have outgrown the facility and just moved into the commercial environment. Finally, the intangible needs are labeled as moderate to high, because Business Developer 1 (xiv) stated during the interview that the network is indeed very important for the USO, it is, though, not essential.

5.3.1 Research phase

As a result from a Ph.D. study at the TU/e in cooperation with Philips, initially, the spin-off and its technology were pulled to the market by opportunities the market offered. The fact that Philips was involved already shows that an academic culture was not a barrier for open-mindedness to external
stakeholders. Although, it is hard to say exactly something about the level of open-mindedness it can be argued that it was at least moderate. The opportunity recognition, then, was confirmed by Business Developer 1 (xiv). On the question about the origin of the spin-off he answered the following about the technology originator: “...During his research he noticed that there was almost no way to measure sound cheap and easily. As a result of this finding he developed a unique product and started the spin-off with it in 2009.” From this it follows that the activities in this first phase were both research and technological. Also it implies that already codified as well as tacit knowledge was involved. The technology that was developed and its documentation were obviously codified. The know-how to do this, embedded in the technology originator, was more sticky and, thus, tacit. Moreover, this answer makes clear that during his research the technology originator recognized an unfulfilled market need; the business opportunity. With this, the critical juncture of opportunity recognition had been overcome and the firm moved to the next phase. It also shows that producing business ideas was not a goal at first. Research was initially the goal, until the opportunity was recognized. Finally, regarding the required resources, the TU/e was the employer of the technology originator in a Ph.D. study. The future spin-off, therefore, had in the research phase just very low financial needs (viii). Later during its growth it had to provide for its own financial resources which led to the fact that its financial needs grew. Just as the financial needs, the material needs were also quite low in this phase. Since the technology originator was an individual, the main material needs were components to develop its technology. Last, nothing was found about the intangible needs during this phase. It is only known that Philips was involved in the research, which might point to moderate intangible needs.

5.3.2 Opportunity framing phase

Subsequently, as a result of the research findings, in this second phase the activities shifted to mainly technological. Moreover, to create the spin-off an entrepreneur was searched to be responsible for the commercial part. This, however, caused some problems for the technology originator. Business Developer 1 (xiv) continues his earlier answer with: “...Subsequently, he looked for someone with a commercial background. He found one at an event, but this cooperation ended in 2011 because of different interests. Then, after a new search the technology originator got in contact with me. I had a background in Philips and I, then, took responsibility for the commercial part.” Together they transformed the business ideas of the technology originator to a business project, which resulted in the creation of the spin-off in 2011. The business developer compensated the lack of entrepreneurial background of the technology originator. This is reflected in the interview when he explained about an important difference between start-ups and non-start-ups: “Often a difference between start-ups and non-start-ups is a different feeling for the value of money. Mostly, a start-up wants to bring its product in the world, while a non-start-up realizes it has to make money. This is a pitfall and important to realize as start-up.” This also shows that the technology originator was at least moderately open-minded to external stakeholders. It required the surrogate entrepreneur to help creating the spin-off around the opportunity. Even after the initial failure, he decided not to proceed on its own. It also indicates the intangible needs in the form of advice about developing a firm were at least moderate. With regard to the other required resources the interview did not provide much evidence in these early phases. Overall, however, during the interview it seemed like the firm was more independent than the other cases. This can, for instance, be seen in the fact that they mainly acquired their money with the help of prizes; their financial needs were never high. Still in this phase the financial needs had increased compared to the previous phase, where the university was still paying its employee for the research. Therefore, the financial needs are argued to have
been low to moderate in this phase. Contrary, business development, which was the main objective in this phase, did not increase the material needs. So, these were still low. Eventually in 2011, the entrepreneurial team managed to overcome the critical juncture of entrepreneurial commitment for a second time.

5.3.3 Pre-organization phase

The pre-organization phase then, is according to literature characterized by the high financial needs of USOs. They need to find sufficient funding to be financially independent and to proceed to the next phase. In order to achieve this, the USO needs to acquire credibility for its product or technology in order to subsequently acquire the necessary financial resources. Mostly, this is connected with finding some key customers. Case 1, though, acquired sufficient financial resources in a rather unique way, as was argued by Business Developer 1 (xiv): “Because of the uniqueness of our product it was not hard to find other parties to co-operate with. Moreover, in our early years we won some prizes for our technology, which has provided us with funding and it gave our technology a lot of exposure. Therefore, suppliers presented themselves to cooperate with us. Finding partners was, thus, not very hard.” So, by winning prizes they acquired some funding. Moreover, it was said that they also were concerned with some consulting activities to provide for some money in their early years. This confirms the findings of Pérez & Sánchez (2003) that USOs just after the start-up become more market-oriented. As Business Developer 1 (xiv) argued, the prizes won by their technology gave them enough exposure, and thus credibility, to pass the credibility threshold and to acquire enough financial resources. The entrepreneurial team intentionally did not choose for foreign capital, because they believed they were able to fulfill their moderate financial needs with the help of the prizes and the consulting. Nevertheless, Business Developer 1 (xiv) confirmed the problem of a lack of financial resources just after the start-up of a USO with the next story about possible problems a USO may encounter during its growth: “Because you lack money in the beginning, you also lack control. Therefore, you should find a partner with similar goals and beliefs as your own company. Because as start-up you often stand financially with your back against the wall, you are mostly forced to make choices which afterwards seem to be the wrong ones. Then, the collaboration often ends in a failure, because of different opinions. Therefore, you have to ensure that you control the things that should be controlled. It is possible to outsource some responsibilities, but ensure that you maintain and elaborate your own good ideas, particularly your control points. These are the points in which you possess unique knowledge or network, and which you should optimally utilize and focus on to maintain your advantage. You need to have a plan for the long term and stick to that plan, and not deviate from it too fast. Finally, ensure that you have understanding of the things you outsource, because you should realize that you cannot do anything on your own.” This answer and the fact that they were early engaged with consulting activities for customers, provide evidence for the fact that the firm was highly open-minded to external stakeholders. With respect to its financial needs, it was already explained that they were relatively moderate. Also the material needs had grown to moderate. Comparing to the previous phase, now the firm needed a work space, which the university provided them with, for their employees and equipment. It will, however, be shown in the sustainable returns phase that the material needs were still growing. Therefore, in this phase the material needs are relatively moderate. Last, the intangible needs in this phase have shown to be still high, especially because the USO needed access to a network of customers to proceed to the next phase.
5.3.4 Re-orientation phase

With the help of prizes it seemed like case 1 had not much trouble proceeding to this fourth phase. Moreover, those prizes and the exposure they gave the USO, were very helpful in building a network. Business Developer 1 (xiv) confirmed this by arguing that they had not much trouble finding partners. This may bring, though, an additional pitfall for young USOs. Business Developer 1 (xiv) answered, on the question how they built their network, with the next quotes.

“You will find partners via network and carrier events. Here, it is important to link experience to the start-up. They can also just find you. We, for instance, have won some prizes which showed the uniqueness of our product, therefore other parties are very eager to cooperate with us. Although, you have to watch for this; parties often claim something what they can do for you, because this gives them the opportunity to ask more for their service, but they are not always capable of live up to this. Sometimes they even claim things they just cannot live up to. In this case, trust and credibility is very important.”

He added to this:

“…As start-up in the beginning, you lack the knowledge to know sufficiently about the products and capacities of other parties or suppliers. Trust and credibility on the side of the supplier, then, are very important. When being a start-up you have to rely on the credibility of the supplier. Experience can help you with this and, therefore, is important.”

These answers confirm the fact that USOs need experience and absorptive capacity in order to connect their resources to the resources of appropriate partners. In the beginning, however, they mostly lack these. This does not necessarily mean that case 1 lacked network capabilities; they were indeed perfectly able to connect themselves to other parties. Their credibility had a major role in this, but also the social capital of Business Developer 1 (xiv): “Generally, we only cooperate with local suppliers. There is, however, one party from Belgium which we co-operate with. This is a good contact from another start-up of mine.” The social capital of the surrogate entrepreneur made it possible to find the partner, which could be assumed to be appropriate. A lack of experience, though, made it hard for them to immediately find other appropriate partners. Therefore, it was recognized as very important to link a USO to experience through its network. Besides a lack of experience he also argued that they lacked the knowledge to sufficiently know about other partners’ products and capabilities. They had to base their judgment about the appropriateness of partners on trust and credibility. This seems to indicate that, in the beginning, the USO also lacked absorptive capacity. Most of these troubles, however, seem to be overcome; in the past months they attracted some big national and international customers.

Finally, no clear transition from the previous phase to this phase was recognized. By definition, however, they managed to overcome the critical juncture of credibility and subsequently moved to this phase. Consequently, this phase can best be characterized as a transition phase from entering the market to attaining sustainable returns. While growing, it seems that this phase mainly is about strengthening the spin-off, just as was argued in literature. Meanwhile though, the USO has outgrown its facilities at the TU/e campus and so the material needs increased at the end of this phase to high. Therefore, recently they moved of the campus into the commercial environment. Both these observations indicate that they passed the critical juncture of sustainable returns and moved to the sustainable returns phase. The critical juncture, however, was not clearly observed.
5.3.5 Sustainable returns phase

In the previous phase, it was shown that the USO lacked some experience and absorptive capacity in the beginning. The next answer by Business Developer 1 (xiv) confirms this again and shows how they learned from their mistakes. Moreover, it shows that, in this phase, their experience and, thus, their network capabilities improved; they were better able to connect their resources to appropriate partners. Their network, consisted of different parties: first, it cooperated with several local suppliers; moreover, although they moved from the campus, the TU/e was still a research partner; other research and co-development partners were, for instance, TNO and ASML; the network obviously also consisted of customers; and finally, the Dutch and European government were indirectly involved in the network by offering grant projects and funds (xiv; v). On the question then, how this network had changed compared to earlier, Business Developer 1 (xiv) answered with the story below.

“After a while, we started cooperating with some software and hardware companies. This collaboration, however, failed a while later, because the companies could not bring what we expected of them. The cause was mainly that we had too little knowledge of the product of those partners. This was also impossible, because at that moment we lacked the in-house knowledge. We just had to believe their blue eyes.

… Nowadays parties are better screened then before; when a supplier comes to offer its product we better ask about the specifications of the product and what it does. A supplier, thus, cannot just claim anything to sell its product….

In the beginning of a new start-up you cannot prevent yourself from dealing with partners that are not appropriate, because you lack the right knowledge and experience to immediately find the right partners. For this, a start-up should have access to experience in the form of people from the business world, particularly independent people which say: “I could help”. This is also an opportunity for the university to hire such people to support its spin-offs, because experience is what you need.”

Especially, the last part of his answer shows that it is important for a high tech USO to find appropriate partners. It needs experience, as was already shown before, in the form of human capital. USOs should have access to a network which can offer human capital in the form of experienced people from the business world. With respect to this network, it has been shown so far, that it was not hard for this USO to connect to network partners. It needed, however, experience and absorptive capacity to find appropriate partners. During the interview, as was expected based on the characteristics of the HTSM sector, it was made clear that the network and open innovation were critical for the success of this USO. Therefore, it was asked what the participant meant with ‘open innovation’. The answer following answer was given by Business Developer 1 (xiv): “One can also define open innovation as smart innovation. When someone else is better able to do something than yourself, then it is better to get it there. You have to open your mind for other parties. So, your suppliers are very important, but you cannot just blindly cooperate with them. Before you start cooperating with certain suppliers you have to perfectly know their product. Knowledge in the width is very important, however mainly you have to invest in your control points. Besides these control points, you should into too much depth.” In this story control points can be described as those points that are unique for a firm and which should be maximally exploited in order to keep one’s competitive advantage on other firms. With respect to these points he added: “You have to make sure that you control what should be controlled. It is okay to outsource some responsibilities, but
keep control over your own ideas, especially your control points.” So, these points need to be preserved and other things can be outsourced, but it has to be made sure that the firm knows sufficiently about the things that are outsourced. Firms, though, have to realize they cannot do anything themselves. So, a firm can and should outsource some responsibilities, but it should always keep control. This seems like a paradox, which makes open innovation so hard according to Business Developer 1 (xiv). The answer thus, confirmed the importance of open innovation, but it also again shows the importance of absorptive capacity. According to Business Developer 1 (xiv) knowledge in width is very important; one needs to perfectly know the product its supplier offers. Especially, in the beginning USOs lack absorptive capacity. According to Business Developer 1 (xiv), firms lack the internal knowledge, after their start-up, to sufficiently know about what they actually need and about the products and capacities of partners or suppliers. A lack of absorptive capacity and experience causes a heavier reliance on trust and credibility in a relationship. Therefore, Business Developer 1 (xiv) highlighted the importance of meeting with partners: “…Generally, meeting with and seeing partners with whom you collaborate is very important.”

Finally, in literature it was seen that particularly small firms benefit from open innovation. All the interviewed firms were growing, but were still small; therefore, it was asked if being small provided them advantages with respect to open innovation. Regarding this question, Business Developer 1 (xiv) noticed the following: “It is good to be small for the collaboration within your company, and in large companies it is better to divide the employees in smaller units, because it is easier to cooperate in smaller units. Then, knowledge is automatically shared within the company, while in large companies which are not divided in smaller units everybody works separate as an individual.” So, it was experienced that being small was an advantage for intra-firm collaboration. In small firms or units knowledge is automatically shared, while in big firms which are not divided, employees work much more as individuals. Hence, according to Business Developer 1 (xiv) can optimal firm consists of both specialists and generalists. The specialists focus on the control points of the firm, and in this way they ensure the absorptive capacity for a firm. While the generalists have capabilities in several areas, so they can ensure an efficient intra-firm collaboration. In case 1, the mix of specialists and generalists was identified as critical for its success. In a firm that only consists of specialists everybody would work much more as an individual.

5.4 Case study evidence: Empirical analysis of case 2

Table 4 on the next page shows the general characteristics of the spin-off compared to the characteristics of a Type I USO. Below first will be elaborated on these characteristics. Then, from section 5.4.1 on, the case study evidence will be compared to the conceptual model.

To start with ‘the business opportunity’, it was explained by the business developer that currently the USO is engaged with both codified and tacit knowledge. With the next answer Business Developer 2 (vi) confirmed this: “The protection strategy we apply is a bit based on IPs, but mainly on design choices. So, by keeping some things secret.” As can be seen in table 2, the USO is concerned with the design and manufacture of measurement equipment, which means that they are mainly engaged with technological activities. As OEM, though, they sell their technology to other OEMs that implement the technology in their production process. Hence, the activities of case 2 are also industrial. Third, the USO serves an international customer market; because its technology has several important implications they serve customers in Europe, Asia, and the US (xi). Consequently, the export potential is considered to be high. Furthermore, at the moment the USO is experiencing significant growth. It even expects to grow much more and on a faster rate the next year(s), so the expected growth is high (vi). Also the further R&D
expenditures are considered to be high. The spin-off identifies R&D as one of its main focuses; with about sixty percent of its staff working on R&D, it tends to remain a developer of state-of-the-art equipment in its field (xii). Finally, just as in the first case, hardly any evidence was found about the barriers of entry.

Table 4. Type I university spin-off based on the findings of Pirnay et al. (2003) compared to case 2.

<table>
<thead>
<tr>
<th>The business opportunity</th>
<th>Type 1</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kind of knowledge involved</td>
<td>Both codified and tacit</td>
<td>Both codified and tacit</td>
</tr>
<tr>
<td>Type of activities</td>
<td>Technological, industrial</td>
<td>Technological and industrial</td>
</tr>
<tr>
<td>Barriers to entry</td>
<td>Moderate to high</td>
<td>?</td>
</tr>
<tr>
<td>Potential customer market</td>
<td>International</td>
<td>International</td>
</tr>
<tr>
<td>Export potential</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Expected growth rate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Further R&amp;D expenditures</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The entrepreneur</th>
<th>Type 1</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiator(s) of the idea</td>
<td>A team of researchers</td>
<td>A sole researcher</td>
</tr>
<tr>
<td>Pursuing</td>
<td>Sometimes</td>
<td>Yes</td>
</tr>
<tr>
<td>“Idea-bearer”=“idea-explorer”</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Level of dependency on founders</td>
<td>Moderate to high</td>
<td>High</td>
</tr>
<tr>
<td>Open-minded to external stakeholders</td>
<td>Growth</td>
<td>Growth</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The required resources</th>
<th>Type 1</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial needs (seed capital, funding capitals, …)</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Material needs (equipment, incubating facilities, …)</td>
<td>Moderate to high</td>
<td>Moderate</td>
</tr>
<tr>
<td>Intangible needs (networking, advice, information, …)</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Second, ‘the entrepreneur’ in this case again is a sole researcher. Just as in the first case, the technology originator is both the idea-bearer and the idea-explorer. Moreover, again some questions were asked about the current state of the USO. For instance, about its dependence on its founders and current employees. Business Developer 2 (vi) answered: “The current employees are important. Everybody, though, can be replaced within the firm. Of course, if everybody is removed it gets hard, but to remove or change one employee is possible. Cooperating within the firm is often done with people from different disciplines which focus on a problem. Furthermore, everybody now knows what others are concerned with. So, if someone is replaced the new person, of course, has to get acquainted with everything that has taken place within the firm, but in my opinion this is possible. In the past, this was much harder; we were with less people and then when somebody drops out, it would have been much more troublesome. Nowadays, also much more is documented. It does, though, still have a big impact, I think, and it would
provide us a delay of some months, but now it is less critical as in the past.” The answer makes clear that the firm is less dependent on its founders and current employees than case 1. However, still they cannot be easily replaced. The level of dependency on its founders is therefore, moderate. Business Developer 2 (vi) did, however, indicate that this was more critical in the past. Regarding external stakeholders then, Business Developer 2 (vi) explained: “Open innovation is indeed important for us. Especially within the region, open innovation is a nice example of how it works…. However, also when you are searching for specific knowledge you can gain it yourself, which is more common in other regions, or you can hire another company for this.” This answer shows that the USO realizes that it can use the help of external partners. It also cooperates with several partners. Therefore, it can be argued that the USO is highly open-minded to external stakeholders. Finally, the goal pursued by the spin-off for now is growth; as already stated it is significantly growing at the moment. According to Business Developer 2 (vi) this is also the goal for the next year(s). After the introduction of its latest product the entrepreneurial team aspires to make significant steps next year. The firm also expects, for instance, it to be necessary to expand the group of employees it employs.

Finally, with regard to ‘the required resources’ first the financial needs can be considered as moderate. Finding sufficient financial resources is not critical anymore; they have already passed the credibility threshold. Moreover, Business Developer 2 (vi) argued that they are quite good able to provide for their own funding. However, besides the public and private instances that already provide funding they are still searching for some investors to fund their project (x). Considering the material needs then, still the facility at the campus of the university is sufficient. They are, however, rapidly growing at the moment and therefore their material needs are also increasing. However, comparing with the material needs in their research phase and with the material needs of case 1, the current material needs of case 2 are relatively moderate. Last, its intangible needs are high. It was, for instance, argued that the relation with customers is critical for their success. Together, they strive to improve the products of the firm. They, therefore, need the advice and knowledge of their customers. Moreover, it was argued by Business Developer 2 (vi) as just has been shown that open innovation is very important for the firm.

5.4.1 Research phase

Already in 1996 research and product development on precision measurement equipment started. By 2001 the first series of prototypes of the technology were manufactured. In a second Ph.D. study based on these results, the technology originator of the USO started research at the TU/e to improve the results of the first research. Subsequently, to support the ongoing research the cooperation with local manufacturers was facilitated. This shows that the technology originator, already in this phase, was highly open-minded to external stakeholders; he stimulated early cooperation. It also shows that the intangible needs were already moderate during the research phase. Finally, encouraged by the improved results business development was started in 2006 (xii). Hence, an opportunity was recognized and the USO moved to the phase of opportunity framing. The opportunity thus, more or less followed from the research, while research was a clear goal in this phase. During this research, the technology originator already started with the development of the technology. This implies that the knowledge that was involved was both codified and tacit, because on the one hand, the technology originator had the know-how to develop such a technology. The documentation of the technology, on the other hand, can be classified as codified knowledge. Finally, it is hard to describe the required resources in the early phases before the start-up of the firm, because not much evidence was found for these phases. Nevertheless, there
are some hints that should enable the estimation of the required resources. The financial resources, for example, in this phase were still low, because as the technology originator took a Ph.D. at the TU/e, the research was paid for by the university; the technology originator was an employee of the university. Also the material needs for the USO were quite low in this phase; the research was mainly executed by one person and so, the most important material needs in this phase were the components of the technology. There were not yet, any facilities needed to accommodate a firm, its employees or other equipment. As employee of the university, mainly general facilities of the university could be used. This does not change much in the next phase; for business development no extra material needs were required.

5.4.2 Opportunity framing phase

In 2006 thus, business development started with the goal, of course, to transform the ideas into a project or spin-off. Clear evidence for this phase was found in the interview (vi): “We started in December 2007. However, we already started with the pre-start-up the year before. This means we already elaborated the business plan, we tried to find our first customers, we searched for some funding, etc.” This last part clearly confirms literature with respect to the opportunity framing phase. According to the business developer they entered this phase in 2006; he called it the pre-start-up. During this phase they started to create the venture around their technology. So, a business plan was made, and already some customers and initial funding were searched for. This also shows that they already had relatively moderate intangible needs in the form of a network with some investors and customers. Moreover, the financial needs had grown to moderate financial needs. This also confirms literature with respect to the early network dynamics. Pérez & Sánchez (2003) found that USOs in their early years need to replace their academic-oriented personal network with a more market-oriented network. As they argue, customers become an increasingly important partner instead of the university and technology centers. Business Developer 2 confirmed this, he also argued, though, that the university was still an important research partner. So, actually they did not completely replace their academic-oriented network for a more market-oriented network, but they expanded it. Contrary to literature this happened already before the spin-off was actually created, because only at the end of 2007 the USO was created and they entered the next phase. Consequently, they overcame the critical juncture of entrepreneurial commitment, as it seems quite easily.

5.4.3 Pre-organization phase

At the start of this phase, the spin-off was created. Hence, a work space for the employees and the equipment and products was needed and provided, as has been explained, by the university. The material needs of the spin-off had herewith grown to moderate. Then, in the previous phase they already started to find some customers and funding, in this phase according to literature, it becomes a top priority. Not much evidence, however, was found that this was a big problem for this USO. It is, therefore, hard to say anything about the financial needs of the spin-off in this phase. It was only said once that as start-up one has limited financial resources. Hence, the financial resources in this case are estimated to be moderate. The intangible needs of the USO, however, increased. Since, the start up the spin-off almost immediately expanded its network with suppliers. Moreover, the university was still a research partner, just as some other foreign universities. Business Developer 2 (vi) described how they started an interactive learning process mainly with suppliers just after their spin-off launch: “Quite early we cooperated with some partners, particularly suppliers of technology. With these partners we cooperated to improve the technology. In turn, they also learned about their own services and products which they could apply in a
different way on different customers. This was also agreed on; as a production process was learned, they could use it, but not for similar technologies as ours.” The answer shows among others that improving the technology, especially in the beginning, was still a main objective. Its network, more precisely its suppliers, should have helped the spin-off with this. Subsequently, on the question how these partners were found, Business Developer 2 (vi) partly confirmed the findings of case 1: “Partly, we find partners at network events, but also in the region are a lot of networks. Moreover, we are affiliated with some industry associations, which regularly organize events, conferences, and fairs. So, because of these industry associations we are concerned with building networks.” Network events, thus, seem to be an important source for finding partners and provide a firm with access to networks. This USO shows, though, that industry associations also can provide important support in the networking process. Moreover, it was explained that, when starting the relationships, trust was an important factor according to Business Developer 2 (vi). This was also already argued by Business Developer 1 (xiv), who said that experience was an important factor in judging about the credibility of partners. During the interview Business Developer 2 (vi) confirmed this and he emphasized the role of trust in the next quote Business Developer 2 (vi): “… For us it is, therefore, very important not only to start a partnership, but also to make it a successful one. This is also our focus with suppliers. I do not like a change of suppliers, so our focus is on long term partnerships. Subsequently, we also expect a certain quality level to be reached.” The role of trust in a relationship is again indicated in the next answer. It is argued that normally there were strict agreements before a partnership. Only when a partnership already lasted for some years, and thus partners completely trusted each other, the relationship loosened. The next answer also confirms the findings of Bogers (2011) regarding the size of the collaboration, the duration of it and the presence of IP influencing whether knowledge is shared or protected. Business Developer 2 (xiv): “Mostly, we start with a non-disclosure agreement en then we start sharing specifications that we want or are able to share. Depending on the size of the collaboration a contract is made, which addresses, for instance, what happens with the IP and what happens when one party decides to quit…. There are a few partners with whom we cooperate more often; these relationships are more loosen. However, these partnerships already last for a few years.”

Finally, the firm entered the re-orientation phase. The transition from this phase to the next phase is in this case rather vague, since no evidence was found that they had trouble acquiring sufficient financial resources. It was only mentioned once that they had not much trouble with acquiring sufficient financial resources. So, it seems like they quite easily overcame the credibility threshold and moved to the re-orientation phase. A reason might be their product, which was at that moment in their field the most accurate commercially available technology in the world (xii).

5.4.4 Re-orientation phase

So far, the USO has managed to make it to the re-orientation phase. From the interview it seems like the spin-off was already quite some time in this phase compared to case 1. Now, however, they were on the threshold of the next phase. According to the business developer, with the launch of a new product, they expected to grow and to make a significant step next year. Nevertheless, open innovation stayed important for the firm, as it was asked what open innovation means for the spin-off. According to Business Developer 2 (vi), open innovation: “… As I see it, means that one cooperates with partners on developments while the partners bring in specific knowledge, for example software or knowledge about the manufacturing process of some products. The partners bring in this knowledge, and while we are the
owner of the product, they can also learn from us, from our mentality. In this way, everyone benefits. ... Daring to outsource important parts of a development to someone else.” A pitfall recognized by Business Developer 2 (vi), though, with respect to this is a difference between the interests and beliefs of two collaborating partners (i.e. individuals or firms). Nevertheless, in this case these partnerships were identified as critical for the success of the firm. It was already said before that the firm aims to collaborate so that both parties could benefit from the partnership. A condition, of course, is not only to start the collaboration, but also to make it successful. So, preferably the spin-off only enters into long term relationships, with a guaranteed quality level, in which partners could fully trust and rely on each other. Sometimes, though, parties cannot supply what they initially proposed to supply. This may harm the relationship, as Business Developer 2 indicated. Moreover, expectations of a partnership can change. So, if two firms are in a long term relationship, their expectations after several years may have been changed with respect to their initial expectations. If the firms do not recognize this and therefore retain their relationship, in time problems can occur. This is a pitfall that should be avoided. Business Developer 2 (vi) elaborated on this problem with the next example: “In the course of time, the expectations of collaboration partners can change, because of the growth of your company, but also because the other party, for instance, repels a business unit. Your trajectory changes, moreover as company you also change. This change can happen without being noticed. In this way, you might always have collaborated nicely, but at a certain moment a company gets less eager to help you as it usually did. ... If you do not keep an eye on this, it could, eventually, bring you in trouble. It is better in this case to just find another partner, because it may prevent you from these problems....” He explained, however, that this was not a problem that is specifically connected to a certain stage in a spin-off’s lifetime: “…In our first year we had a very important collaboration partner, which suddenly decided to change its activities for several reasons. For us this was for a moment quite hard to overcome. So, also when you have just started, your partners may be busy for a while.” This last quote indicates that it is not a matter of working together for years with a specific partner before its expectations or yours could change. This problem can also occur in the beginning, and it can then be hard to overcome. Although not mentioned specifically, experience probably made it easier to overcome such problems in the early years. Subsequently, on another question Business Developer 2 (vi) indeed confirmed the importance of experience. He argued that the collaboration with some partners ended, because the firm was not satisfied with the quality of the supplied products. One cannot know this at the start, but it is noticeable after a supplier delivered its product a few times.

Now, partners with whom the USO cooperated were amongst others the TU/e and some other universities, technology suppliers, research institutes, and manufacturers (xii). Also its network consisted of investors, public and personal; customers, which were machine manufacturers of high-accuracy coordinate measuring machines; and a governmental organization which helped the spin-off with accessing networks and finding new partners (x; vi). Finally, a board of advisors provided the firm with advice on the policy and strategy to adopt, and it supported the firm with technical and business expertise (xiii). On the question what this network exactly provided the USO with, Business Developer 2 (vi) answered: “…New products, knowledge, new customers, and sometimes even employees. Such a network, of course, provides lots of new opportunities.” The network did, thus, indeed provide the spin-off with important resources. Earlier it was seen, that according to Business Developer 2 (vi) open innovation with respect to knowledge sharing within the network works twofold: (1) very specific knowledge acquired during the development process of its own products, which can be used for other products and markets, is
shared and sold. (2) Furthermore, if it is looking for specific knowledge another firm can also be hired to do this for you. He also argued that in other regions it is more common to do this in-house, which is also much easier, because a firm cannot blindly assume a partner is doing well; if something goes wrong, it does not have any control. Open innovation was, therefore, recognized as not easy. The fact that the firm was still small was experienced as a disadvantage, because a small firm only has limited financial resources, which is a disadvantage for open innovation. However, the existence of open innovation itself, again, was identified as an advantage for small firms, because they are not obligate to hire people if they want to explore a field the firm is unknown with.

To keep control during the cooperation with partners and thus, to benefit from open innovation, absorptive capacity on the side of the USO was already identified as critical in the first case; especially in the beginning. According to Business Developer 2 (vi), firms may indeed lack the internal knowledge to sufficiently know about what they actually need and about what partners or suppliers could offer. It is much easier if a firm knows exactly what it needs and can describe this in a ‘language’ the partner understands. Although this seems like something typically for the early years of a USO, later in its lifetime this can still happen, because the more complex a technology, the harder it is to collaborate. The next story of Business Developer 2 (vi) confirms the important role of absorptive capacity and experience in partnerships.

“At a certain moment we wanted to produce something, but we did not know anything about it and we actually did not know what we exactly wanted. Then, a party with experience presented itself and claimed it could produce our demand, but that collaboration did not go well. At the time, I did not know if the collaboration failed because of us or if they simply could not produce what they claimed. Therefore, it is much easier if you know exactly what you want and if you can describe this in the language of the other party….”

He added:

“…This is mainly applicable if you are starting to work on a problem which is new for you. In a large company, you will encounter fewer new problems, because as time goes by you learn more and more. On the other hand, these are the moments to collaborate, when you are looking for something new….”

Business Developer 2 argued here, that a firm learns as time goes by; its experience increases. Subsequently, it also learns how to deal with new questions or problems. The problem in this case was a lack of knowledge of what they exactly needed; a lack of absorptive capacity. In this case, the USO lacked absorptive capacity for two reasons: (1) internally, it did not have sufficient knowledge about the product which it needed; (2) it was not able to judge about the appropriateness for its purposes of the partner. Hence, a lack of absorptive capacity caused a heavier reliance on trust and credibility in a relationship.

With respect to the research context then, Business Developer 2 (vi) already indicated a difference between regions in one of his previous answers. He argued, as also was argued in literature, that open innovation is typical for the Dutch high tech sector. He specifically pointed to the Brainport region. Other regions, although no were specifically mentioned, are more characterized by closed innovation. So, the environment and its culture are important as background in which open innovation activities take place. In the next story Business Developer 2 (vi) confirmed these cultural differences and
he explained how trust, which has just again been identified as a very important factor, might be embedded in different cultures.

“Trust is important. Particularly, because you are cooperating, and when you make someone responsible for a big assignment, you have to trust that it will be alright. Of course, culture is also important; collaborating with some countries is easier as with other countries. … For example, once we sold a product to a former client of us at an Asian company, and we sent some product engineers to integrate the product…. So, we arrived there after a long journey, and we were immediately invited in the meeting room. Our products, which already were shipped, were brought in and, then, they asked us to explain how to install them. We were, of course, impressed to be there and to build it on the machine, and therefore it would have been easier if we were able to actually see and access the machine. However, this was impossible; there was no such trust that we were granted access to their core technology. Afterwards, we should have adjusted our process and the collaboration on this. With respect to this, Americans are easier; access to their technologies is granted easier, but they are a bit messier and they have fewer eyes for details. Germans, on the other hand, work slower; which makes them more precise. It depends on the kind of collaboration whether this is nice or not.”

Besides cultural differences, Bogers (2011) also indicated that geographical distance could influence knowledge transfers. Business Developer 2 (vi) emphasized this. He also confirmed that it is important to visit a partner at least once. When collaborating on distance communication becomes very important. Nevertheless, when the distance increases, the communication also changes after a while. So, geographical distance might be a barrier for cooperating. Business Developer 2 argued: “We also cooperate with other universities in other countries, and then distance can be a barrier. Partners within Eindhoven you just pass by once in a while, also you see these people more often and therefore, the relationship is better. Culture can be overcome when both parties have something to gain from the business deal or the collaboration. Geographical distance is much harder to overcome, in my opinion.” According to Business Developer 2 (vi), thus, geographical distance can even be a much harder barrier to overcome than cultural distance.

**5.5 Case study evidence: Empirical analysis of case 3**

Next, the current characteristics of this USO will be described and compared to the Type I USO of Pirnay et al. (2003), as is shown in table 5 on the next page. Then, again the conceptual model will be compared to the empirical evidence.

To begin with, R&D Manager 3 (ii) gave the next answer on the question how knowledge is embedded in the firm: “In all of these; the most important knowledge is embedded in the team. Moreover, you have to buy patents and the research group of the university also contains a lot of knowledge about the development of such a system.” This confirms that the USO is engaged with both codified and tacit knowledge. Second, ‘the business opportunity’ that is being developed is a technology: the design and manufacture of medical robotics. Next, as R&D Manager 3 (ii) argued, the potential customer market is mainly international and the export potential is high: “The hardest for all these projects is that one cannot start small. You cannot start with one product locally. You can start with two or three products in the Netherlands, but then you have to cross the borders.” The fact thus, that one cannot start small, plus the fact that the firm needs a very high and risky investment before it even can start to sell its product, results in a high barrier of entry for the USO. Nevertheless, the expected growth rate is very high, since the spin-
off is acting in an emergent market (i). Finally, the further R&D expenditures are, because the USO is considered with a high tech product, by definition high. In the interview, however, it was also multiple times argued that they still need a lot of money to improve the technology and make it available for the market. So, evidence confirms that further R&D expenditures are high for this USO.

Table 5. Type I university spin-off based on the findings of Pirnay et al. (2003) compared to case 3.

<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>The business opportunity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kind of knowledge involved</td>
<td>Both codified and tacit</td>
<td>Both codified and tacit</td>
</tr>
<tr>
<td>Type of activities</td>
<td>Technological, industrial</td>
<td>Technological</td>
</tr>
<tr>
<td>Barriers to entry</td>
<td>Moderate to high</td>
<td>High</td>
</tr>
<tr>
<td>Potential customer market</td>
<td>International</td>
<td>International</td>
</tr>
<tr>
<td>Expected growth rate</td>
<td>High (emergent market)</td>
<td>High (emergent market)</td>
</tr>
<tr>
<td>Export potential</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Further R&amp;D expenditures</td>
<td>Moderate to high</td>
<td>High</td>
</tr>
<tr>
<td>The entrepreneur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiator(s) of the idea</td>
<td>A team of researchers</td>
<td>A team of researchers</td>
</tr>
<tr>
<td>“Idea-bearer”=“idea-explorer”</td>
<td>Sometimes</td>
<td>No</td>
</tr>
<tr>
<td>Level of dependency on founders</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Open-minded to external</td>
<td>Moderate to high</td>
<td>High</td>
</tr>
<tr>
<td>stakeholders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goal pursued</td>
<td>Growth</td>
<td>Optimize product</td>
</tr>
<tr>
<td>The required resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial needs (seed capital,</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>funding capitals, ...)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material needs (equipment,</td>
<td>Moderate to high</td>
<td>Moderate</td>
</tr>
<tr>
<td>incubating facilities, ...)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intangible needs (networking,</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>advice, information, ...)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‘The entrepreneur’ is the part where this Type I USO distinguishes itself from the other cases. First, in this case there were three technology originators. Hence, the initiators of the idea are a team of researchers. The initiators in this case, however, are only the idea-explorers; the idea of medical robotics did originate already much earlier. The researchers in this case only improved the technology in a specific field and, therefore, are only the idea-explorers and not the idea-bearers (i). Meanwhile, the ties with the university are still quite strong, because it is argued that still a lot of knowledge is embedded in the research group of the university. So, if one wants to make its own system, it needs to consult the research group. Subsequently, on the question if the USO is still dependent on its founders it is argued that they still are necessary to build and improve the system. Just as the research group is important. So, the dependency on the founders is still quite high. To copy the system, however, is getting easier over time, as R&D Manager 3 (ii) explains: “It gets increasingly easy to transfer the technology. More and more is
documented. First, you start with a research project, but after a while you are working on a product, which changes the documentation.” Then, with respect to external partners also this case is very open-minded. Already in the research phase they collaborated with some surgeons and they expanded this group as soon as the USO was created. Now, their biggest obstacle is to acquire sufficient financial resources; they need investors to fund their project and they are very busy looking for them. So, the open-mindedness to external stakeholders is high. Finally, the goal that they pursue is for now that they first want to improve their technology; make it cheaper and more efficient to eventually get it to be used in the operation room. (vii; ix).

Finally, with respect to ‘the required resources’ it is for this USO very clear that the financial needs are very high. As will be explained in the next sections, this is a major problem for this USO. There is not much evidence for the material needs of this firm. The firm is, however, still very young and located at the campus of the university. Moreover, the product they are manufacturing is a complex high tech product, which requires a lot of components. Therefore, material needs are probably not low, and compared to case 1 they are moderate. Last, the intangible needs for this USO are high. As explained, already since the research phase surgeons are involved to provide the researchers with their field-expertise. According to R&D Manager 3 (ii) they are very important, because they know everything in their field, while the researchers only have knowledge about the technology. When launching the spin-off they even expanded this group of surgeons. Also they need their network to find potential investors.

5.5.1 Research phase

The research that eventually led to the technology of the spin-off was initiated by a surgeon; he started a Ph.D. project in which also TNO was involved that had to result in a medical robot. Subsequently, based on earlier research findings one of the three technology originators took responsibility for this project. Contrary to literature, where Vohora et al. (2004) argued that due to an academic culture the open mindedness to external stakeholders is quite low, this shows that external stakeholders were already early involved in the research; they even initiated the research. So, the pre-USO was already in this phase highly open-minded to external stakeholders. Also because it was recognized that technology suppliers needed to provide the components for the technology. Eventually, after his promotion, the technology originator stayed at the university to do research and further test his technology in the robotics group (ix). R&D Manager 3 (ii) looked back at this period and confirmed the early involvement of the surgeons: “The spin-off was created from research which was done during the last five to six years. The surgeons are involved in the research from day one.” At the end of the research one of the technology-originators already intended to look for market opportunities for the technology. At that moment, no such systems were available at the market (vii). With the opportunity being recognized, the critical juncture of opportunity recognition was overcome, and the technology originators proceeded to the next phase.

Since in this phase the development of a technology was intended to be the result, it stands out that the kind of knowledge that was involved was both codified as tacit. The tacit knowledge was represented in the know-how of the researcher to develop such a system and in the field-expertise of the surgeons. The documentation of the technology, of course, was codified knowledge. Moreover, it seems clear that of the activities in this phase were besides research also already technological. Finally, with respect to the financial resources it was earlier explained that Ph.D. researchers are employees of the university. So, the financial needs of the spin-off were still very low. In the perspective of the research
activities, which are technological and thus several components were required, and considering the fact that in this case three researchers were involved the material needs are considered to be relatively low to moderate.

5.5.2 Opportunity framing phase

The opportunity, thus, had been recognized quite easily; it was a logical next step for the team of researchers. Subsequently, it was also recognized by the academic entrepreneurs that they needed a surrogate entrepreneur to create the spin-off around their technology. Therefore, they addressed a business developer, which helped them with this process. The next quote by R&D Manager 3 (ii) confirms this: “We are all mechanical engineers and we added a business developer to the team with a background ‘Sales & Marketing’ from Philips. Moreover, we collaborate with surgeons, which are also in the team. ... The entrepreneurial team consists of three mechanical engineers, a business developer, and some surgeons.” The academic entrepreneurs, thus, realized their need for a more commercially minded person in the entrepreneurial team. Subsequently, on the question how hard it was to find the business developer it was argued that this was actually quite easy R&D Manager 3 (ii): “Generally, there are lots of people that are eager to fulfill the role of business developer, particularly if you offer some money. As firm, you just have to choose one of those people; the one that connects best to your entrepreneurial team.”

Since the original entrepreneurial team thus, which already originated in the research phase, consisted of only researchers with a technical background and some surgeons, literature is confirmed considering the early network dynamics; the academic-oriented network needed to shift more towards a market-oriented network. The employment of the business developer was the start of this. At the end of this phase, then, the spin-off was created. R&D Manager 3 (ii) explained how this happened: “In this field there are many different application areas. All these areas cannot be covered in one firm. Therefore, an ‘incubator’ firm was started. Within this incubator all these separate projects can develop in order to eventually, commercialize the technology. The hardest for all these projects is that one cannot start small. You cannot start with one product locally. You can start with two or three products in the Netherlands, but then you have to cross the borders. So, in this field you have to immediately start big. This requires a lot time and money.” This confirms the finding of Pirnay et al. (2003), who argue that Type I USOs often are concerned with incubator firms. R&D Manager 3 (ii) also commented to the commercialization: “The moment we were commercializing our research findings, we expanded the group of surgeons which we talked with. Just to sharpen the questions commercially. First, we collaborated with some surgeons since the research. These are still involved in the entrepreneurial team. Moreover, we expanded our network with local, but also international surgeons.” As the answer shows, already at the end of this phase, they started to build their network to seek for advice regarding the opportunity and the commercialization of it. The answer also again confirms Pérez & Sánchez (2003) about the early network dynamics. Especially the quote about sharpening their questions commercially shows that they partly needed to replace their academic-oriented personal network with a more market-oriented network. In their early years they mainly cooperated with the university, which is still an important partner, and a technology center. Now, they increase their networking with potential customers; the surgeons. In other words, marketing competences become increasingly important. Moreover, it also shows that the USO already in this phase was very open-minded to external actors.
Regarding the required resources, besides the intangible needs, not much evidence is found for this phase. It was, though, confirmed that next to research the entrepreneurial team in this phase was mainly engaged with business development. Therefore, again, it is argued that the material needs did not increase with respect to the previous phase. The financial needs, however, did most certainly increase. It was said that a business developer was approached and they had to offer him a salary. This shows that the USO from this stage on needed to provide for its own funding. Therefore, the financial needs in this phase had grown from low to moderate. Finally, these answers have shown that this USO is assigned to an international customer market. As can be seen, this requires high financial resources. Therefore, the shift from an academic-oriented network to a more market-oriented network became a top priority for this USO. It will be shown in the next phase that this causes quite some troubles for the USO. Nevertheless, with the creation of the spin-off the critical juncture of entrepreneurial commitment had been overcome.

5.5.3 Pre-organization phase

So far, it has been seen that this case overcame the first critical junctures without major problems. Subsequently, now it is in the pre-organization phase. This means according to literature that the spin-off has to pass the credibility threshold. The key imperative of the pre-organization phase is raising sufficient financial resources. These financial resources are needed in order to acquire other necessary resources. It was confirmed that this was indeed the objective for this USO; besides improving its technology it was mainly searching for partners that are willing to fund their activities. The firm did not yet sell anything. First they needed to acquire enough financial resources to make the next step and proceed to the next phase. Hence, in 2012 the USO was created and, as just has been indicated, the shift from an academic-oriented network towards a market-oriented network was top priority for this USO. Now, its network consisted of many international surgeons, which were also potential customers. Furthermore, the USO was dealing with the biggest international parties in the field, such as suppliers of different components and systems, but also with many local suppliers. Those international parties were considered to be potential investors. Of course, the TU/e was also still a research partner. Finally, governmental organizations did not support the USO very much, except for a loan that was provided by the region R&D Manager 3 (ii).

Contrary to the other cases, this spin-off had much more problems overcoming the credibility threshold and, thus, acquiring sufficient financial resources. Nevertheless, this USO clearly confirmed literature considering the pre-organization phase; the main objective and biggest problem in this phase was acquiring sufficient financial resources, accompanied with finding some key customers. R&D Manager 3 (ii) confirmed this in the story below.

“We talk with the biggest international parties in this field. These are suppliers for different technologies concerning our product. We talk with those firms to look how interested they are and how they perceive the development of the technology. Moreover, we ask if they want to cooperate and if they would want to fund our project. The main objective is to find funding to finance our technology.”

He added to this:

“The biggest problems here are that the product is a high tech medical product. Both words (high tech and medical) indicate that it is about a device for which a lot of money is required. Besides a lot of money, it also takes lots of time. This means that high risk capital in requires to move forward one step.
We are confronted with amounts that are too high. We really need investors, which in turn, also take a big risk, because it takes a long time before they are refunded. The Dutch business environment is not very suitable for this. It is better if you can start something with two hundred thousand euro and pay it back in two years. However, if we are able to manufacture a product, then it takes about five years before we can enter the market and, then it takes still some time before the investors can be repaid. So, it takes a lot of time and it involves a high risk. Moreover, it is a complex system, so a lot of parties are involved in the process, which also costs a lot of money.”

It becomes clear from this story that the environment also played an important role. R&D Manager 3 (ii) argued that the Dutch business environment is not suitable for high investments. Moreover, it is much better if one can assure a short payback-time. Contrary to the US, where according to Business Developer 1 (xiv) high investments are much more normal. He argued that there is a cultural difference between the Dutch high tech sector and the US high tech sector; in the US a good idea gets in no time a lot of attention and acquires big investments. However, in the US money also moves significantly faster. An idea with potential will soon attract big investors. Nevertheless, just as quickly as the idea arose, the plug may already be removed for several reasons. A possible cause for this difference is that in the Netherlands it is much more important, contrary to the US, to bring a technology in the world or to make it accessible. This was also emphasized by Business Developer 1 as difference in culture between the Dutch high tech sector and that of the US. In the Dutch high tech sector it is not as fast invested in small firms with an idea with potential.

Finally, a question was asked about how the USO deals with partners. R&D Manager 3 (ii) answered the following: “For different parties, different ways are used. For instance, looking at a local supplier, we visit them and they visit us to look with complete teams how to build their device. This involves also drawings that are exchanged. These are looked at in detail on the computer. Regarding a possible investor, you visit them and present your product. Afterwards everything is then discussed by telephone. If you focus at other parties that are developing similar devices, then you visit them to look at the device to ‘experience the atmosphere’. A telephone call is not very helpful; you just have to visit them. Finally, surgeons have also to be visited; you have to talk with those people. You meet them at conferences. So eventually, personal contact is very important.” The answer shows that, generally, meeting with partners is very important. This was also already indicated by the first two cases. Geographical distance can, thus, be a barrier if the partners are located at large distances. Nevertheless, R&D Manager 3 argued that there were not many differences between different partners with respect to collaborating. He did, however, explain that it depends on the phase a spin-off is in whether contractual agreements are made. R&D Manager 3 (ii) told that for them it was particularly important to capture every agreement, where knowledge or IP arises from, contractually, because they were not yet able to produce a product. Therefore, IPs were the only thing they can sell. Subsequently, all information and ideas they possessed, which could result in an IP was contractually agreed on to be theirs. Of course, contractual agreements and thus the presence of IPs could limit the potential of a knowledge sharing collaboration, as Bogers (2011) indentified.

All in all, the most important conclusion for this section is that the USO in this case clearly confirmed literature with respect to the pre-organization phase. Acquiring sufficient financial resources was the most important thing in this phase and at the same time a major problem. For this they were talking with many potential customers and investors both national and international. The investment was,
however, big and risky. Moreover, they were not yet selling their product. First, they needed to improve their technology to make it cheap and efficient enough to use in an operation room. The credibility threshold had therefore, not yet overcome.

5.6 Case study evidence: Opportunities

The cases provided also some direct input for opportunities with respect to USOs and how they can be supported in order for them to overcome the major problems and pitfalls, because all cases agree on this point; although the university tried to help, it was barely able to really help the spin-offs. Business Developer 1 (xiv) explained: “The university did not help finding appropriate partners. Besides facilitating the work space and the innovation-lab the TU/e did not help. Hence, this provides the university with an opportunity. The university could be a good partner to help spin-offs finding appropriate partners. Now, the policy of the university is too much focused on the short term. The policy is focused on facilitating the spin-off rather than really supporting spin-offs to succeed on the long term. ...” It was, though, recognized that the university did help indirectly by connecting the spin-offs with graduates and grant projects. Moreover, the university helped financing patent applications. Directly, however, besides facilitating the USO, the university did not support the spin-off. Therefore, because of a lack of a long term policy the university was not recognized as an essential partner for case 1. Also Business Developer 2 (vi) expressed the feeling that the TU/e is nowadays less active in supporting its USOs with respect to finding appropriate partners. Business Developer 1 (xiv), therefore, described the following opportunity: “When the university would better support its spin-offs in finding appropriate partners it would be beneficial for both the spin-offs and the university; the university becomes much more attractive for researchers as well as students. Of course, also an independent agency could fulfill this function in the market. So, an independent agency that gives advice and could help in finding appropriate partners for USOs or start-ups.”

All in all, it was argued that universities could be more engaged in supporting their USOs by helping to find appropriate partners. Earlier in this chapter it was confirmed that USOs often lack the experience to find appropriate partners. Now, their judgment about (potential) partners is mostly based on trustworthiness and credibility. According to the participants, this is where universities could help, for instance by building their own network of (appropriate) partners. In this way a university can easily connect its spin-offs with trustful partners, which seem to be appropriate and match the beliefs and needs of a certain USO. A second example is to assemble a board of advisors which consists of people with an entrepreneurial background, a big network, and lots of experience in the business world that could personally help connecting the spin-offs to appropriate partners and help them dealing with major problems.

5.7 Summary

The context of this research is the Dutch HTSM sector, which is characterized by open innovation. The Dutch HTSM sector is one of nine top sectors of the Netherlands and is divided in several smaller regions. Initially, this study focused on three regions specific, since technical universities are established in these regions. Unfortunately, only USOs of the TU/e responded and therefore, only USOs from the Brainport region were analyzed.

Overall, the empirical evidence mainly confirmed the findings of literature. First, it was described in literature by Pérez & Sánchez (2003) that typically four actors are involved in the creation of a USO:
(1) the technology originator, (2) the parent organization, (3) the surrogate entrepreneur(s), and last (4) the venture investor. When looking for these actors in the cases they were all confirmed to play a role in the creation of the spin-offs. The research phase, for instance, started in all cases with the development of a technology, which involved both codified knowledge, in the form of the technology and its documentation, and tacit knowledge embedded in the know-how of the technology originator(s). Moreover, in all three cases it was seen that the research which eventually led to the creation of the spin-off was executed for a Ph.D. study done at the university in cooperation with other parties, such as corporate firms, research institutes, or specialists in a certain field. Hence, it was seen in all the cases that, already in the research phase, the technology originators were highly open-minded to external stakeholders. In literature, though, it was explained that an academic culture would be a barrier for the open-mindedness to external stakeholders. Nevertheless, during the interviews nowhere such a mentality was noticed among the interviewees. Especially the individuals with field expertise were identified to provide a USO with the necessary intangible resources in this first phase, such as commercial awareness and prior business experience. In no cases, however, there seemed to be a problem with recognizing the business opportunity and then, moving to the phase of opportunity framing.

In the opportunity framing phase, further focus was, then, on improving the core technology. This still involved codified and tacit knowledge as was explained for the previous phase. Consequently, also the main objective in this phase, according to literature was, changed from research to transforming the opportunity and ideas into a business project. This was confirmed in all three cases: in all cases a business developer was added to the firm. The business developer, of course, was set responsible for the commercial part of the USOs and his knowledge and personal resources (i.e. prior business experience, commercial awareness, human entrepreneurial capital, and social capital) were recognized as necessary to create the spin-off. Moreover, it was confirmed in the cases that this phase was clearly used to frame the opportunity and set up the spin-off. That means that during this phase, with the help and advice of the business developer, a business plan was developed and already some early customers and investors were searched. Literature is, therewith, confirmed. However, contrary to literature in all cases it was not hard to find such partners. It was recognized that if a firm needed to find partners, there were a few different ways. First, sometimes a firm did not need a new partner, because some relationships did go back far before the USO. In case 1, for instance, the entrepreneur took a partner from his business life before the spin-off (social capital of the entrepreneur) with him. Moreover, in case 3 some partners were already involved in the research before the spin-off was launched. Case 2, identified industry associations and a governmental agency as an important partner for its networking process. Also the ‘Brainport’ region was recognized as an important place to find networks. Network and carrier events were recognized as a last way to find partners. During these events it is important to connect experience to the spin-off.

After the spin-off, then, was created and the critical juncture of entrepreneurial commitment was overcome, in the pre-organization phase, the university provided all the cases a work space at the campus. Moreover, it was found that the cases were not immediately after the start up able to sell their technology, therefore optimizing the product and preparing it for market launch was a main objective rather than growth. The reason for this was also recognized in literature as the biggest obstacle in this phase; to acquire sufficient financial resources. Hence, it was argued that a spin-off needs to find some key customers to gain credibility and subsequently, some investors to provide for the financial resources. Considering this problem, it was also found that for a big investment a USO is mainly designated to private investors instead of public investors; in the three cases the university contributed only a little to
the funding of its spin-offs, just as governmental organizations (i.e. the EU, the Dutch government, and the Brainport region). The main problem here was that a big investment also brings a big risk. Regarding this, it was explained that the Dutch business environment does not suit such big and risky investments. In contrast to other environments were such investments are much more common. Finally, it was shown in all cases that the intangible needs were very high in this phase. Their network was in all cases recognized as very important, for some even critical for their success. It was argued that a firm can get exposure everywhere with help of the right contacts. In these cases, the network provided the USOs with the necessary knowledge, customers, products/components, financial resources and even employees. With respect to open innovation as network activity, it was therefore argued that firms have to realize they cannot do everything on their own. They should dare to outsource some responsibilities.

When eventually, the threshold of credibility was overcome, USOs entered the re-orientation phase. This phase had the least clear characteristics and it was only vaguely recognized in the cases. The re-orientation phase in the analyzed cases seemed to be a transition phase between the pre-organization phase, which was clearly recognized and the phase of sustainable returns. Growth has been recognized as the main objective during this phase. Consequently, a characteristic of the sustainable returns phase was that USOs outgrow the facilities at the university and move into the commercial environment. This is also a sign that the critical juncture of attaining sustainable returns has been overcome. In this study only the first case had managed to overcome this juncture yet. Subsequently, the main objective during the sustainable returns phase was still growth. This also seemed to be a common characteristic for high tech USOs; eventually, in all cases it was recognized that their main ambition was, to make their technology accessible for the whole world. This confirms literature on high tech USOs. With respect to network activities it was recognized in these last phases that the intangible needs were unchanged high. However, since the USOs had gained experience, it was argued that it was much easier to optimally profit from the network; they had acquired the necessary absorptive capacity and network capabilities.

Finally, this chapter aimed to answer the question: In what way are university spin-offs in the Dutch HTSM sector engaged with network activities? In order to answer this question, this chapter presented the main findings of the multiple-case study that was done. In this chapter the analyzed patterns with respect to network activities were matched to the earlier developed conceptual model. Appendix G then, shows the conceptual model after data analysis. In this model changes with respect to the original model are shown. The main differences are, obviously, seen in the ‘open-mindedness to external stakeholders’. Regarding this it can be argued that this is typical for the Dutch HTSM sector. Subsequently, from the empirical evidence it stands out that the network and intangible resources were very important for the USOs. First, it was explained that the Dutch HTSM sector is characterized by open innovation, which was in the cases simply described as cooperating with partners on developments. During the process of open innovation then, those partners bring in specific knowledge that corresponds to their own capabilities and competences. Eventually, the purpose of open innovation was to learn from each other in order for both to benefit from the collaboration. Second, the network provided the USOs with intangible resources, for instance embedded in a business developer, which were necessary for framing the opportunity and creating the spin-off. Finally, literature was confirmed in the fact that, one needed absorptive capacity and credibility, which the USOs often lacked in their early years. Especially, a lack of absorptive capacity caused a heavier reliance on trust and credibility on the side of the source of knowledge in a relationship. Moreover, when it came to estimating partners and open innovation, USOs also needed network capabilities, of which experience was recognized as an important factor.
6. Summary and Conclusions

In this final chapter, first a summary will be provided of the different chapters of this report. Subsequently, conclusions will be drawn and an answer will be given on the research question: *How do networks come into existence, and how do they influence success and performance in terms of growth of university spin-offs in the Dutch HTSM sector?* After the conclusion then, some implications for a parent university of high tech spin-offs will be explained. Eventually, this chapter ends with the limitations of this study and some suggestions for further research.

6.1 Summary

This study focused on USOs and their network activities. Regarding these concepts, USOs followed the next definition in this study: “new firms created to exploit commercially some knowledge, technology or research results developed within a university”. Four types of USOs were distinguished. These distinctions were made along two dimensions: (1) the status of individuals involved in the spin-off, (2) the nature of knowledge transferred. Subsequently, Type I USOs were described in literature as high tech. This type of USO is product-oriented and mainly based on codified knowledge (e.g. technology). However, also tacit knowledge is involved. These spin-offs are created by researchers coming from the scientific community to exploit commercially-viable research findings. It was recognized in literature that the establishment of close links, although hard for USOs, with a variety of partners is critical especially for these high tech USOs to survive. Subsequently, based on literature networks were defined as “a set of inter-organizational links and relationships that are needed to create a product or service.” These relationships can provide the USOs with several important resources, such as material resources (i.e. components) and two kinds of intangible resources; to directly create a product (i.e. development know-how) and to indirectly create a product (i.e. commercial awareness, prior business experience, etc.) by means of shaping the direct context (i.e. creating the spin-off). Subsequently, the unit of analysis of this study (‘network activities’) was defined as activities that involve this network. Obviously, a clear example of such a network activity is open innovation.

The aim of the second chapter then, was to find an answer on the following question: To what extent takes literature about university spin-offs their network activities into account? Considering this question it was seen that literature indeed recognized ‘network activities’ as important for USOs; a positive relationship was found between network activities and the performance and growth of a USO. For example, open innovation has been recognized as an important means by which specific tangible (e.g. components) and intangible resources (e.g. development know-how) can be acquired. Other necessary intangible resources (e.g. commercial awareness and prior business experience) can also be provided by partners in the network. These are, though, not accessed by means of open innovation. Nevertheless, although it was emphasized that USOs struggle to establish successful relationships with partners, literature does not go into much detail about how these processes specifically work for USOs. Only recently Lubik et al. (2013) focused in more detail on the network and partnerships of USOs. They showed that the network of a USO typically consists of corporate partners, the parent university, governmental organizations, other universities and sometimes other USOs. However, based on the literature review, a research opportunity was found to explain the common held assumptions about networking activities for (high tech) USOs. Subsequently, based on literature, one would expect that there are a few important reasons that could explain why USOs struggle with establishing successful relationships within the network; a weak credibility, a lack of absorptive capacity, a lack of experience and thus also a lack of network capabilities, may, based on literature about network activities, be the most
important causes that hinder the USO from acquiring several necessary tangible and intangible resources to enable the technology transfer and create the spin-off.

To answer then, the research question it was first important to define how success and performance of high tech USOs can be measured. This was explained in the third chapter with the help of a conceptual model that also served as literal replication for the multiple-case study. Subsequently, within the perspective of this study and the challenges that USOs mostly face before they are able to become established players in the market, it was argued that success and performance could best be described in terms of growth. Based on literature then, the conceptual model described the growth of a high tech USO in five growth phases; for every phase the characteristics were described. Regarding the success and performance, it was shown in literature that during their growth high tech USOs have to overcome major challenges, which are called critical junctures. Consequently, it was explained that successful USOs have less problems to identify, acquire, integrate, and re-configuring the necessary resources and capabilities during these growth phases to overcome these critical junctures. Hence, spin-offs that perform better have less trouble overcoming the problems and making it to the final sustainable returns phase. All in all, success and performance of high tech USOs can be measured in terms of growth by means of the conceptual model in figure 6 that shows the different growth phases of high tech USOs and the major challenges that need to be overcome.

To analyze the network activities of Dutch high tech university spin-offs, chapter four described the methodology that was used for the multiple-case study. It was shown that only few Dutch USOs are truly high tech. Subsequently, not many appropriate cases were available and only three responded; all of the TU/e. Therefore, it was chosen for a literal replication design which perfectly fitted in the explanatory nature of this study. The conceptual model was then, used as literal replication which was confirmed by the cases. Cases thus, confirmed that they did not differ from other high tech USOs as they were described in literature. This was shown in chapter five which aimed to explain in what way USOs in the Dutch HTSM sector are engaged with network activities. The main difference between high tech USOs in literature and Dutch high tech USOs was seen in the ‘open-mindedness to external stakeholders’. Regarding this, it can be argued that this is typical for the Dutch HTSM sector, which is characterized by open innovation and intensive cooperation. Subsequently, from the empirical evidence it stands out that the network and intangible resources were indeed very important for the USOs. It was seen that especially in the Brainport region, open innovation is how the innovation process works. This can also be seen in appendix A, which shows the open supply chain of the Dutch HTSM sector. During the process of open innovation partners bring in specific knowledge that corresponds to their own capabilities and competences. Eventually, the purpose of open innovation is to learn from each other in order for both to benefit from the collaboration. With respect to network activities of high tech USOs, though, the main findings of literature were indeed confirmed. For open innovation one needs absorptive capacity, which USOs often lacked in their early years. A lack of absorptive capacity caused a heavier reliance on trust and credibility in a relationship. Moreover, when it came to estimating partners and open innovation, USOs, besides absorptive capacity, also needed network capabilities, of which experience is an important factor. Last, literature was confirmed with regard to a weak credibility on the side of USOs being a problem for acquiring resources from the network. This was mainly found to be a problem in the pre-organization phase, which was found to be the most critical phase in the development of high tech USOs.
6.2 Conclusions

Overall, literature concerning high tech USOs was confirmed. So, high tech USOs in the Dutch HTSM sector seem to be no different from other high tech USOs. Also the same typical problems need to be overcome. Concerning the first part of the research question then, - How do networks come into existence, and how do they influence success and performance in terms of growth of university spin-offs in the Dutch HTSM sector? - it can be argued that partners are found in several ways. First, network and carrier events are recognized as important sources that provide access to networks. These events might also provide USOs with necessary intangible resources, e.g. embedded in a business developer, which was recognized as an important knowledge source for creating the spin-off in all cases. Generally, it was said that such events are an easy way to build a network. Another way to access networks or to connect to partners is through the social capital of the academic or surrogate entrepreneur. Finally, some industry and governmental organizations can provide services to help with the networking process. So, basically the network of a high tech USO arises or evolves in three different ways: by actively seeking from the side of the USO, by means of social capital, or by using a third-party. So, some networks or parts of networks arise naturally, while others arise forced. The creation of a network does, though, not per se mean success. It was recognized in literature and in the cases that USOs need the right (appropriate) partners in order to profit from the network. The finding of these partners is not straightforward. It was explained in literature and confirmed in the cases that a weak credibility on the side of the USO, a lack of absorptive capacity, and a lack of experience, and thus network capabilities, make the process of finding appropriate partners much harder for the USOs. However, it was argued in the cases that this problem is typical for the early years of a USO and subsequently, the process gets easier as the spin-off ages. Therefore, in the beginning it is particularly important to link experience to the USOs. This can be done with the help of the network; more specifically it can, for instance, be found in entrepreneurs from the business environment; someone with experience in the relevant business field.

Regarding success and performance then, the cases confirmed literature and networks were recognized as very important, sometimes even critical, for the performance of USOs in the Dutch HTSM sector. The network provides the USOs with important knowledge and resources to create the spin-off and enable the technology transfer, such as intangible resources, e.g. commercial awareness and prior business experience embedded in a surrogate entrepreneur; financial resources, like seed capital; tangible resources, which include the components delivered by the technology suppliers; etcetera. Moreover, it can be concluded that, especially in the Dutch HTSM sector, which is characterized by open innovation, co-development with technology suppliers is the only way in which small firms, such as the analyzed USOs, are able to survive. Because of limited financial resources in their early years, these firms are obligated to outsource important parts of their process and to share their knowledge. The network and open innovation were recognized to be important factors for the analyzed USOs in overcoming the most critical problems that could hinder the spin-off from reaching the sustainable returns phase and thus from becoming an established player. Hence, on the question how networks influence the performance and success in terms of growth of USOs in the Dutch HTSM sector, it can be concluded that the networks provide the USOs with the required resources and knowledge to overcome the main barriers that are experienced by high tech USOs during their growth.

6.3 Managerial implications

It was explained that high tech USOs face several challenges during their development before they are able to become established players in the market beyond those faced by other high tech firms. In
order to help USOs overcoming these problems some parent universities actively try to help finding solutions, while other parent universities consider those problems as beyond their mission. Hence, a contribution of this report is to emphasize the problems that have to be taken into account by the parent university or other policy makers considering the ambitions in the HTSM sector. This report could guide them in better supporting Dutch high tech USOs. Consequently, an opportunity for universities is recognized by Lee & Tsang (2001); they explain that entrepreneurial skills can be learned-by-doing. So, universities should increase their focus on entrepreneurial skills in order for their students and researchers to benefit from this, because it is elaborated in literature that academic entrepreneurs often lack these skills. Moreover, considering this an opportunity was recognized in the cases. It was argued that the university should actively help its USO by making entrepreneurs available which possess these entrepreneurial skills and among others also prior business experience and social capital in several fields. In this way those entrepreneurs can help the USOs with their expertise to connect them with appropriate partners and help them overcoming some common problems. Moreover, they can provide the USOs with some commercial awareness which academic entrepreneurs often lack. These entrepreneurs could, for instance, be hired by parent universities of high tech USOs and take place in a general advisory board which can be accessed by all its USOs. Both the USOs and the university could profit from this. Obviously, USOs have better support in their early years and the entrepreneurs could help the USOs with finding appropriate partners and fill up the lack of experience. From these measures also the university will benefit, because it becomes more attractive for students and researchers, who eventually have the ambition to commercialize their research findings.

All in all, an advisory board of careful selected entrepreneurs with a background in several fields, could actively support the USOs of the parent university in several ways: they could provide the USOs with commercial awareness and thus help them with recognizing opportunities; their social capital could provide the USOs with some appropriate partners to start working with in their early years; they could give the USOs advice, e.g. with respect to policy to implement and trajectory to follow; etcetera.

6.4 Limitations
For the scientific value of this study and the strength of the managerial implications it is important that this study can provide some general findings which reflect more than only the USOs that are studied. The small population of USOs that meet the criteria for this study and thus, the use of a qualitative explanatory multiple-case study decreases, however, the generalizability or external validity of the findings. Subsequently, in order to improve the external validity of this study and drawn on previous literature a literal replication logic was applied. In short, this implies that first the conditions of the replication should be mentioned. Those were in this study the conceptual model based on literature of mainly Vohora et al. (2004), Ndonzuau et al. (2002) and Pirnay et al. (2003). Secondly, a few cases are carefully chosen, in this study three, which meet with the criteria of this study. If theory then is replicated, the analyzed cases confirm theory and can be argued to be similar to those mentioned in literature (Yin, 2009). As has been seen in the results and can be seen in appendix G, the cases mostly confirmed the replication. Unfortunately, analyzed USOs were all TU/e spin-offs, and as has been shown in the fifth chapter, the Dutch HTSM sector consists of more separate regions. Here, only high tech USOs from the Brainport region were analyzed. Therefore, generalization cannot go as far as the whole Dutch HTSM sector, instead the conclusions of this study only hold for the Brainport region. Hence, to generalize the findings to a broader context, high tech USOs from the Brainport region generally seem to be similar to other high tech USOs, as described in literature. With the help of figure 7, abstraction and thus,
generalization cannot even go as far as the inner nest: USOs in the Dutch HTSM sector. Within the perspective of the findings of Lee & Tsang (2001), who argue against generalization of cultural embedded phenomena to other regions or countries, and because no cases from other regions were analyzed, the generalization of the conceptual model cannot go as far so that it holds for all high tech USOs. This may, though, be a possible future research direction.

With respect to other qualitative criteria, it was already explained in the methodology that during analysis with the use of ‘pattern matching’ the reliability should be increased. Tellis (1997) explained that if the empirically pattern matches the predicted pattern, then the reliability of the case study is enhanced. Considering this, the conceptual model guided the data analysis. The pattern of what was observed in the cases thus, matches quite well with the patterns observed in literature; similar results as were found by Pirnay et al. (2003), Vohora et al. (2004) and Ndonzuaau et al. (2002) were found in the cases. Moreover, the use of a protocol, which is shown in appendix C, should make it possible to repeat the exact same research in a similar or different context and get mainly the same results. Therefore, it is argued that the qualitative reliability of this study is quite good. In contrast, the qualitative validity may be more of a problem. This refers to whether the findings are believable. In this perspective it should be noted that the results are mainly based on the truth as known by the interviewees. To improve the qualitative validity it was tried to triangulate the evidence as much as possible by referring to public documents. Mostly, the sources confirmed each other. Moreover, all the elaborated interviews were approved by the participants. These tactics were basically also used to improve the construct validity of this study. Hence, regarding this criteria not much problems are expected. However, considering the qualitative validity the most important problem is the bias that the researcher may have brought to this study; all the findings are based on the interpretation of the researcher. The findings are not based on exact facts, but on relative interpretations of the interviews and documents, just as in the study of Pirnay et al. (2003). Some findings are, therefore, more trustworthy than other findings.

Finally, the specific focus on network activities may decrease the internal validity of this study. Since the research question addresses how networks influence the success and performance of high tech USOs the study kind of fails to search for other reasons to explain the success of those USOs. It is therefore, hard to say if the access and optimal use of networks are truly the cause of the success of the USOs. It was indeed recognized in the cases that networks are critical for their success. However, it cannot be argued with a hundred percent probability that network activities are the exact reason for the success of the USOs. Other reasons might be the kind of product, which is particularly good, or an above average business developer. Within the perspective of how networks influence the success, it can at least be explained that they are very important, maybe even necessary, particularly in this specific context: the Brainport region. It can, however, not be excluded that other factors are a more important reason for the success of the analyzed high tech USOs.

All in all, the method that was used has some clear shortcomings, which are dealt with as good as possible. Some problems, though, could not have been prevented. Still, it can be argued, that because of the use of a literal replication design and subsequently, because the cases mainly confirmed theory, theory about high tech USOs can be transferred to the Brainport region. The biggest problems are the qualitative validity and the internal validity of this study. The first could best be solved with a quantitative follow-up study which exactly sets up some standards for the labels low, moderate, and high and, again, tests the
conceptual model. With respect to the internal validity, as already explained, other factors that have a bigger influence cannot be excluded.

6.5 Future research

First, as was identified with respect to the qualitative validity future research could be a quantitative study that exactly defines the labels low, moderate, and high; also with respect to the typology of Pirnay et al. (2003). In this way USOs could be more accurately described, and research on this topic does not suffer anymore from bad interpretations of the researcher. However, this is probably hard to realize since some characteristics of USOs, as they were described in this study, are hard to define by means of quantitative data.

Second, it has been seen in this research that USOs in the Brainport region basically do not differ from high tech USOs, as they are described in literature. Contrary to literature though, the open-mindedness to external stakeholders was found to be quite high in an early stage. This might originate from the context in which the analyzed USOs are located: the HTSM sector, which is characterized by open innovation and intensive cooperation. It was however, shown by Lee & Tsang (2001) that the results of such a study cannot easily be generalized to other cultures. Therefore, future research might compare high tech USOs of several regions with literature and with each other. Are there any differences? And how could these be explained.

A third problem that was identified earlier in this study was that it is hard to test the problems of the phases before the spin-off was created, because the spin-offs that were interviewed all have overcome these first problems. Actually, all spin-offs have overcome these problems, because they are created. Future research could focus on academic entrepreneurs who are still in the research phase or in the opportunity framing phase. Obviously these cases are much harder to find than spin-offs that have past these phases. It might, though, be interesting to find out in more detail how networks and intangible resources influence the success or failure of spin-offs in those early phases.

Finally, besides further exploring the results of this study, also a bridge can be made with normal firms or corporate spin-offs in the high tech sector. For the research of this study a pilot interview with someone from a normal high tech firm was done, and it looked like there is a difference in the way they perceive partners compared to how they are perceived in USOs. It seemed like in a normal high tech firm they are much more market-oriented and focused on making money. While in USOs the ambition often is to show their product to the world instead of making money of it. This distinction is also identified by Ndzonzuau et al. (2002) who argue that most academic researchers consider money as a means of scientific research, while businessmen consider it as an end itself and science only as a means to that end. Furthermore, it was recognized by Vohora et al. (2004) that the problem of a weak credibility in the pre-organization phase seems to be more significant for USOs than other business start-ups. These differences could be further explored in future research. For example, a likewise typology can be made as that of Pirnay et al. (2003) or as the conceptual model that was proposed in this report for normal firms or corporate spin-offs. Then these typologies should be compared with each other; how do networks influence the performance of those other kinds of firms? Which differences are there with USOs? And why or how do these differences emerge?
Bibliography


Appendix A. The evolvement of the value chain in the HTSM sector

1. 1980: Closed OEM value chain: only the component production is outsourced to different suppliers (1980).
2. 2000: Parts of the value chain are outsourced: i.e. core processes, including process development; and support processes, like supply chain management and sourcing & life cycle management.
3. 2020: The open supply chain, as it should look like in a few years (Hendrikse, 2011). In these schemes, the OEM is engaged with activities in the dark areas (Topteam High Tech Systemen en Materialen, 2011).
Appendix B. Applied qualitative data collection types

Qualitative data collection types: documents and interviews. Options, strengths and weaknesses (Creswell, 2009; Tellis, 1997).

<table>
<thead>
<tr>
<th>Source of evidence</th>
<th>Options</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documentation</td>
<td>• Public documents, such as minutes of meetings, or newspapers</td>
<td>• Stable – repeated review</td>
<td>• Retrievability – difficult</td>
</tr>
<tr>
<td></td>
<td>• Private documents, such as journals, diaries, or letters</td>
<td>• Exact – names etc.</td>
<td>• Biased selectivity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Broad coverage – extended time span</td>
<td>• Reporting bias – reflects author bias</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Enables a researcher to obtain the language and words of participants</td>
<td>• Access – may be blocked</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Unobtrusive - can be accessed at a time convenient to researcher</td>
<td>• Not all people are equally articulate and perceptive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Represents data which are thoughtful in that participants have given</td>
<td>• Requires the researcher to search out the information in hard-to-find</td>
</tr>
<tr>
<td></td>
<td></td>
<td>attention to compiling them</td>
<td>places</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• As written evidence, it saves a researcher the time and expense of</td>
<td>• Requires transcribing or optically scanning for computer entry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>transcribing</td>
<td>• Materials may be incomplete</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• The documents may not be authentic or accurate</td>
</tr>
<tr>
<td>Interviews</td>
<td>• Face-to-face – one-on-one, in-person interview</td>
<td>• Targeted – focuses on case study topic</td>
<td>• Bias due to poor questions</td>
</tr>
<tr>
<td></td>
<td>• Telephone – researcher interviews by phone</td>
<td>• Insightful – provides perceived causal inferences</td>
<td>• Incomplete recollection</td>
</tr>
<tr>
<td></td>
<td>• Focus group – researcher interviews participants in a group</td>
<td>• Useful when participants cannot be directly observed</td>
<td>• Provides indirect information filtered through views of interviewees</td>
</tr>
<tr>
<td></td>
<td>• E-mail internet interview</td>
<td>• Participants can provide historical information</td>
<td>• Provides information in a designated place rather than the natural field</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Allows researcher control over the line of questioning</td>
<td>setting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Researcher’s presence may bias responses</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Not all people are equally articulate and perceptive</td>
</tr>
</tbody>
</table>
Appendix C. Protocol

[Company]

A. Introduction to the case study and purpose of protocol

1. Project objectives

Why are many high tech USOs with potential unable to become an established player in the market? It is an important question, because these firms are among others critical for the High Tech Systems and Materials (HTSM) sector to maintain their international top position and to achieve the ambitions of the sector. These ambitions are for the sector to return in the top five of the world and double its export by 2020.

Within this perspective, the objective of the next OEM approach is to support young high tech firms with potential to make the final step and to bridge the ‘valley of death’. Their ambition is to grow the number of large OEMs by combining breakthrough technology with inspiring entrepreneurship and smart capital. The approach wants to stimulate the business of young high tech industrial firms by professional industrialisation, internationalisation, business planning, intellectual property protection and financing. This should bring the best out of these firms and make them grow to become the future technology leaders (NextOEM, n.d.).

The conclusions of this study might, eventually, provide important insights in how such young high tech USOs can be supported in order for them to overcome the main problems during their growth and eventually become a large OEM. Special attention is given to the role of networks and how their influence can help high tech USOs overcoming the main problems.

2. Case study questions

Research question: How do networks come into existence, and how do they influence success and performance of university spin-offs in the Dutch HTSM sector?

Question to be answered by the cases: In what way are university spin-offs in the Dutch HTSM sector engaged with network activities?

3. Theoretical framework for the case study

A USO is described as a new firm created to exploit commercially some knowledge, technology or research result developed within a university. So, they transfer knowledge created on a university to the market. USOs face several challenges before they are able to become established players in the market beyond those faced by other firms. Therefore, USOs need to start finding partners right after their launch, because other actors typically possess the necessary tangible and intangible resources that USOs need to enable the technology transfer and to create the spin-off. Hence, it is shown in literature that the level of access of USOs to resources of partners is positively related to their value creation. Unfortunately, acquiring access to a network and finding partners is not as straightforward as it seems. Many USOs struggle to establish successful relationships (Pirnay et al., 2003). This study therefore, focuses in more detail on the network activities of high tech USOs.
Based on previous literature on USOs and network activities, the role of networks should be explained for USOs in the Dutch HTSM sector. The important questions are how those networks come into existence and how they influence the performance of USOs in the Dutch HTSM sector. Which role do they play in overcoming the main problems for start-up USOs? In order to answer this question, based on findings of Pirnay et al. (2003), Vohora et al. (2004) and Ndonzuau et al. (2003) a conceptual model was developed, which should guide the research. From their findings it is pointed out that success and performance of high tech USOs can be expressed in a five-stage growth model. Networks might play a critical role for USOs in order for them to overcome the main challenges during their growth. Obviously, successful USOs overcome these barriers more easily than less successful USOs.

**B. Data collection procedures**

1. **Names of sites to be visited, including contact persons**

   **Source:** Interview

   **Interviewee:** [person]

   **Company:** [company name]

   **Date and time:** [date, time]

   **How:** [face-to-face/ by telephone]

   **Location:** [address]

2. **Data collection plan**

   Two types of evidence will be used in this study: documents and interviews. The documents that are used are only public documents. These documents are all found on the internet and they vary from newspaper articles to interviews with founders of the firms. An important weakness of documents is that they may not be authentic or accurate (Creswell, 2009). This weakness is dealt with by referring to the documents during the interviews. In this way the plausibility of the documents is checked.

   The second source of evidence used in this case study is interviews. The interviews will be conducted face-to-face or through the telephone. The interviews are all semi-structured. That means they are non-standardized (Gray, 2004). However, a list of questions will be used which is basically the same for every interview. Depending on the answers of the interviewee some questions will be dealt with, while others will be left out. Important weaknesses of interviews are: The presence of the researcher may bias the responses of the participant; moreover, there may arise a bias due to poor questions on the side of the interviewer (Tellis, 1997). In order to minimize these biases this protocol is used during the interviews. This protocol should guide the interviewer through the interview and keep the focus on the study objectives (Creswell, 2009).

3. **(a) Expected preparation prior to site visits**

   Before every interview a background check should be done on every case. All the public documents that can be found on a case should be carefully reviewed in order to get a general impression about each
case. Moreover, notes about the documents should be made next to the interviews, in order to be able to refer to some of these documents during the interviews. This is important for the triangulation of the data.

(b) Reminders about procedures

• Unit of analysis: network activities

• Data is collected by means of semi-structured interviews.

• During all the interviews this protocol should be used.

• At the start of every interview the purpose should be explained and why the information is being collected. Moreover, interviewees should be told how long the interviews approximately will last.

• Also emphasize at the beginning of the interview that the interviewee always has the option not to answer a question.

• Next, permission should be asked to audiotape the interview. If the interviewee agrees, audiotape the interview and take notes during the interview.

• If the previous steps are executed, the interview can start. During the interview try to refer to the public documents about the firm. This is important for the triangulation of data.

• When the interview is finished, ask if the interviewee has any questions. Subsequently, thank him for his help and his valuable observations.

• Eventually, elaborate the interview using the notes and recordings. Afterwards the elaborated interview will be sent back to the interviewee in order to be verified by him.

• In the final version of this study all the firms and individuals will be treated anonymously. So, no names of firms or persons will be specifically addressed.

C. Case study questions

Level 1: Questions asked of specific interviewees

What is the interviewee’s background and how is he involved in (the start of) the firm?

What does the interviewee mean by open innovation?

Level 2: Questions asked of the individual case

Which authorities supported the firm in its start-up phase and how did they do this?

What does the firm’s network look like and how did it change over the years?

How did the firm build its network?

To which extent has the firm’s history been critical for its current state and what role did the network play?
What does the knowledge sharing process look like?

Which pitfalls did the firm encounter during its growth?

**Level 3: Questions asked of the pattern of finding across multiple cases** *

What does the networking process of a university spin-off look like?

What does the knowledge sharing process of a university spin-off look like?

Which pitfalls do university spin-offs encounter during its growth?

**Level 4: Questions asked of an entire study** *

To which extent do university spin-offs differ from or coincide with the literature regarding network activities?

**Level 5: Normative questions about policy recommendations and conclusions, going beyond the narrow scope of the study** *

How can university spin-offs be better supported in their process of becoming established players in the market, especially with respect to network activities?

**D. Outline of case study report**

1. Description of the growth of each university spin-offs based on the conceptual model

2. Description of the university spin-offs and their network activities

3. Exhibits to be developed: University spin-off typology table, and a table with the characteristics of university spin-offs per growth phase.

**E. Bibliography**

1. **Sources for composing the protocol**


2. **Sources for composing the theory**


* can only be answered when all the cases are analyzed.


3. **Sources for composing the methodology**


4. **Case specific sources**

[Case specific source 1]

[Case specific source 2]

...
<table>
<thead>
<tr>
<th>Type</th>
<th>Kind of knowledge involved</th>
<th>Type of activities</th>
<th>Barriers to entry</th>
<th>Potential customer market</th>
<th>Expected growth rate</th>
<th>Further R&amp;D expenditure</th>
<th>The entrepreneur</th>
<th>The required resources</th>
<th>Financial needs (seed capital, funding capitals, ...)</th>
<th>Material needs (equipment, incubating facilities, ...)</th>
<th>Intangible needs (networking, advice, information, ...)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type I</strong></td>
<td>Both codified and tacit</td>
<td>Technological, industrial</td>
<td>International</td>
<td>High</td>
<td>Low (emergent market)</td>
<td>High</td>
<td>A sole researcher</td>
<td>High (emergent market)</td>
<td>Low (emergent market)</td>
<td>Moderate to high</td>
<td>High</td>
</tr>
<tr>
<td><strong>Type II</strong></td>
<td>Merely tacit</td>
<td>Consultancy</td>
<td>Low to moderate</td>
<td>Low</td>
<td>Low (market niche)</td>
<td>Low to moderate</td>
<td>A sole individual</td>
<td>Always</td>
<td>Very high</td>
<td>Moderate to high</td>
<td>Moderate to high</td>
</tr>
<tr>
<td><strong>Type III</strong></td>
<td>Both codified and tacit</td>
<td>Technological, Industrial, National to International</td>
<td>Moderate to high</td>
<td>Moderate to high</td>
<td>Moderate to high</td>
<td>Moderate to high</td>
<td>Either a sole individual, or a team of students</td>
<td>Always</td>
<td>High</td>
<td>Moderate to high</td>
<td>Moderate to high</td>
</tr>
<tr>
<td><strong>Type IV</strong></td>
<td>Merely tacit</td>
<td>Service-provider</td>
<td>Low to moderate</td>
<td>Low</td>
<td>Low (market niche)</td>
<td>Low</td>
<td>A sole individual</td>
<td>Always</td>
<td>Low</td>
<td>Low to moderate</td>
<td>Low to moderate</td>
</tr>
</tbody>
</table>

---

**Appendix D. Case 1: complete table of Pirnay et al. (2003)**
<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The business opportunity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kind of knowledge involved</td>
<td>Both codified and tacit</td>
<td>Merely tacit</td>
<td>Both codified and tacit</td>
<td>Merely tacit</td>
</tr>
<tr>
<td>Type of activities</td>
<td>Technological, industrial</td>
<td>Consultancy</td>
<td>Technological</td>
<td>Service-provider</td>
</tr>
<tr>
<td>Barriers to entry</td>
<td>Moderate to high</td>
<td>Low to moderate</td>
<td>Moderate</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Potential customer market</td>
<td>International</td>
<td>Local to national</td>
<td>National to international</td>
<td>Local</td>
</tr>
<tr>
<td>Expected growth rate</td>
<td>High</td>
<td>Low (market niche)</td>
<td>Moderate to high</td>
<td>Low (market niche)</td>
</tr>
<tr>
<td>Export potential</td>
<td>High</td>
<td>Low</td>
<td>Moderate to high</td>
<td>Low</td>
</tr>
<tr>
<td>Further R&amp;D expenditures</td>
<td>Moderate to high</td>
<td>Low to moderate</td>
<td>Moderate to high</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>The entrepreneur</strong></td>
<td>A sole researcher</td>
<td>A team of researchers</td>
<td>Either a sole individual, or a team of students</td>
<td>A sole individual</td>
</tr>
<tr>
<td>Initiator(s) of the idea</td>
<td>Sometimes: yes</td>
<td>In most cases</td>
<td>Always: yes</td>
<td>Always</td>
</tr>
<tr>
<td>“Idea-bearer”=&quot;idea-explorer&quot;</td>
<td></td>
<td>High</td>
<td>Moderate to high</td>
<td>Very high</td>
</tr>
<tr>
<td>Level of dependency on founders</td>
<td>Low Moderate to high</td>
<td>High</td>
<td>Moderate to high</td>
<td>Low</td>
</tr>
<tr>
<td>Open-minded to external stakeholders</td>
<td>Moderate to high</td>
<td>Low to moderate</td>
<td>Moderate to high</td>
<td>Low</td>
</tr>
<tr>
<td>Goal pursued</td>
<td>Growth</td>
<td>Profitability</td>
<td>Growth / profitability</td>
<td>Profitability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>The required resources</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial needs (seed capital, funding capitals, ...)</td>
<td>High</td>
<td>Low to moderate</td>
<td>Moderate to high</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Material needs (equipment, incubating facilities, ...)</td>
<td>Moderate to high</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Intangible needs (networking, advice, information, ...)</td>
<td>High</td>
<td>Low to moderate</td>
<td>Moderate to high</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Type</td>
<td>Kind of knowledge involved</td>
<td>Type of activities</td>
<td>Barriers to entry</td>
<td>Potential customer market</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------</td>
<td>-------------------</td>
<td>------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Type I</td>
<td>Both codified and tacit</td>
<td>Technological, industrial</td>
<td>International</td>
<td>High (emergent market)</td>
</tr>
<tr>
<td></td>
<td>Merely tacit</td>
<td>Consultancy</td>
<td>Low to moderate</td>
<td>Low (market niche)</td>
</tr>
<tr>
<td>Type II</td>
<td>Both codified and tacit</td>
<td>Both codified and tacit</td>
<td>National to international</td>
<td>Moderate to high</td>
</tr>
<tr>
<td></td>
<td>Merely tacit</td>
<td>Consultancy</td>
<td>Low to moderate</td>
<td>Low (market niche)</td>
</tr>
<tr>
<td>Type III</td>
<td>Both codified and tacit</td>
<td>Technological, industrial</td>
<td>National to international</td>
<td>Moderate to high</td>
</tr>
<tr>
<td></td>
<td>Merely tacit</td>
<td>Consultancy</td>
<td>Low to moderate</td>
<td>Low (market niche)</td>
</tr>
<tr>
<td>Type IV</td>
<td>Merely tacit</td>
<td>Service-provider</td>
<td>Low to moderate</td>
<td>Low (market niche)</td>
</tr>
<tr>
<td></td>
<td>A sole individual</td>
<td>Always</td>
<td>Very high</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Either a sole individual, or a team of students</td>
<td>Always</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

Appendix F. Case 3: complete table of Pirnay et al. (2003)
### Appendix G. Growth characteristics of high tech university spin-offs

#### Type I

<table>
<thead>
<tr>
<th>The business opportunity</th>
<th>Type of activities</th>
<th>Barriers to entry</th>
<th>Potential customer market</th>
<th>Expected growth rate</th>
<th>Export potential</th>
<th>Further R&amp;D expenditures</th>
<th>Initiator(s) of the idea</th>
<th>Open-minded to external stakeholders</th>
<th>Goal pursued</th>
<th>The required resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kind of knowledge involved</td>
<td>Codified and tacit</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>High</td>
<td>Either a sole researcher, or a team of researchers</td>
<td>Low</td>
<td>Research</td>
<td>Financial needs (seed capital, funding capitals, ...)</td>
</tr>
<tr>
<td>Type of activities</td>
<td>Research and technological</td>
<td>Moderate to high</td>
<td>International</td>
<td>High</td>
<td>N/A</td>
<td>High</td>
<td>Most cases</td>
<td>Low</td>
<td>Moderate to high</td>
<td>Moderate to high</td>
</tr>
<tr>
<td>Barriers to entry</td>
<td>Both codified and tacit</td>
<td>Technological, industrial</td>
<td>International</td>
<td>High</td>
<td>N/A</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate to high</td>
<td>Moderate</td>
</tr>
<tr>
<td>Potential customer market</td>
<td>Both codified and tacit</td>
<td>Technological, industrial</td>
<td>International</td>
<td>High</td>
<td>N/A</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate to high</td>
<td>Moderate</td>
</tr>
<tr>
<td>Expected growth rate</td>
<td>Both codified and tacit</td>
<td>Technological, industrial</td>
<td>International</td>
<td>High</td>
<td>N/A</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate to high</td>
<td>Moderate</td>
</tr>
<tr>
<td>Export potential</td>
<td>Both codified and tacit</td>
<td>Technological, industrial</td>
<td>International</td>
<td>High</td>
<td>N/A</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate to high</td>
<td>Moderate</td>
</tr>
<tr>
<td>Further R&amp;D expenditures</td>
<td>Both codified and tacit</td>
<td>Technological, industrial</td>
<td>International</td>
<td>High</td>
<td>N/A</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate to high</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The entrepreneur</th>
<th>Level of dependency on founders</th>
<th>Open-minded to external stakeholders</th>
<th>Goal pursued</th>
<th>The required resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiator(s) of the idea</td>
<td>N/A</td>
<td>Low</td>
<td>Research</td>
<td>Financial needs (seed capital, funding capitals, ...)</td>
</tr>
<tr>
<td>“Idea-bearer”=“idea-explorer”</td>
<td>N/A</td>
<td>Low</td>
<td>Moderate to high</td>
<td>Material needs (equipment, incubating facilities, ...)</td>
</tr>
<tr>
<td>Level of dependency on founders</td>
<td>N/A</td>
<td>Low</td>
<td>High</td>
<td>Intangible needs (networking, advice, information, ...)</td>
</tr>
</tbody>
</table>

---

3 Questions Italic texts are added labels with respect to the original model, and strikethrough texts are removed labels with respect to the original model.
Remarks with respect to the literal replication of the conceptual model

Barriers to entry

It was identified in the chapter 5 that not much evidence was found on the barriers of entry of the firms. Only for the third case clearly a high entry barrier was found. Still it was also recognized in the other cases that they had some problems with their entry to the market, be it less significant as the problems for case 3. Since also the other cases then, noticed that they had limited financial resources in the beginning, it was interpreted that the barriers of entry were indeed moderate to high for the analyzed cases.

Level of dependency on founders

With respect to the level of dependency on the founders of the USOs it was recognized in the cases that this was in all cases still moderate to high. Nevertheless, it was clearly mentioned that more and more is being documented and therefore, it becomes increasingly easy to replace some of the key people of the USOs. Eventually, as the USOs age and grow, the level of dependency on the founders will decrease. The rate, at which this occurs though, differs per USO. This does also imply that the conceptual model with respect to the low dependency on the founders in the sustainable returns phase is not wrong. Case 2 confirmed this; being in the re-orientation phase, its dependency on the founders already decreased to moderate.

Open-minded to external stakeholders

It was recognized in literature that an academic culture at the parent university in the early phases ensures that academic researchers are not very open-minded to external stakeholders. In these cases, however, this was not observed and the open-mindedness seemed already in the beginning to be quite high. This might be the influence of the context in which the USO acts: the HTSM sector, which is characterized by open innovation and intensive cooperation. Hence, this is the only aspect in which the analyzed USOs clearly differ from literature.

The required resources

Finally, with respect to the required resources it was especially had to analyze the first phases before the spin-off creation. A reason for this is, that only cases were analyzed that passed the critical juncture of entrepreneurial commitment and thus, spin-offs that were created. Hence, these interpretations are mainly based on some general public documents of the TU/e. Therefore, not much conclusions can be drawn from these labels.