



**NTNU – Trondheim**  
Norwegian University of  
Science and Technology

# How does human capital affect the performance of academic spin-offs?

**Frøydis Folvik Bjerkholt**  
**Mari Haga Rimestad**  
**Ole Jørgen Seeland**

NTNU School of Entrepreneurship

Submission date: June 2014

Supervisor: Roger Sørheim, IØT

Co-supervisor: Marius Tuft Mathisen, IØT

Norwegian University of Science and Technology  
Department of Industrial Economics and Technology Management



# MASTERKONTRAKT

## - uttak av masteroppgave

### 1. Studentens personalia

Etternavn, fornavn <b>Rimestad, Mari Haga</b>	Fødselsdato <b>08. des 1987</b>
E-post <b>marihaga@stud.ntnu.no</b>	Telefon <b>45474874</b>

### 2. Studieopplysninger

Fakultet <b>Fakultet for samfunnsvitenskap og teknologiledelse</b>
Institutt <b>Institutt for industriell økonomi og teknologiledelse</b>
Studieprogram <b>NTNUs Entreprenørskole</b>

### 3. Masteroppgave

Oppstartsdato <b>15. jan 2014</b>	Innleveringsfrist <b>11. jun 2014</b>
Oppgavens (foreløpige) tittel <b>An empirical study: Human Capital needs in the processes of academic spin-off development</b>	
Oppgavetekst/Problembeskrivelse An empirical study of human capital's role on the processes of academic spin-off development.	
Hovedveileder ved institutt <b>Førsteamanuensis Roger Sørheim</b>	Medveileder(e) ved institutt <b>Marius Tuft Mathisen</b>
Merknader <b>1 uke ekstra p.g.a påske.</b>	

#### 4. Underskrift

**Student:** Jeg erklærer herved at jeg har satt meg inn i gjeldende bestemmelser for mastergradsstudiet og at jeg oppfyller kravene for adgang til å påbegynne oppgaven, herunder eventuelle praksiskrav.

Partene er gjort kjent med avtalens vilkår, samt kapitlene i studiehåndboken om generelle regler og aktuell studieplan for masterstudiet.

Trondheim, 15. 01. 2014

Sted og dato

  
Student

  
Hovedveileder

Originalen lagres i NTNUs elektroniske arkiv. Kopi av avtalen sendes til instituttet og studenten.

# MASTERKONTRAKT

## - uttak av masteroppgave

### 1. Studentens personalia

Etternavn, fornavn <b>Seeland, Ole Jørgen</b>	Fødselsdato <b>07. mar 1986</b>
E-post <b>seeland@stud.ntnu.no</b>	Telefon <b>93027481</b>

### 2. Studieopplysninger

Fakultet <b>Fakultet for samfunnsvitenskap og teknologiledelse</b>
Institutt <b>Institutt for industriell økonomi og teknologiledelse</b>
Studieprogram <b>NTNUs Entreprenørskole</b>

### 3. Masteroppgave

Oppstartsdato <b>15. jan 2014</b>	Innleveringsfrist <b>11. jun 2014</b>
Oppgavens (foreløpige) tittel <b>An empirical study: Human Capital needs in the processes of academic spin-off development</b>	
Oppgavetekst/Problembeskrivelse An empirical study of human capital's role on the processes of academic spin-off development.	
Hovedveileder ved institutt <b>Førsteamanuensis Roger Sørheim</b>	Medveileder(e) ved institutt <b>Marius Tuft Mathisen</b>
Merknader <b>1 uke ekstra p.g.a påske.</b>	

#### 4. Underskrift

**Student:** Jeg erklærer herved at jeg har satt meg inn i gjeldende bestemmelser for mastergradsstudiet og at jeg oppfyller kravene for adgang til å påbegynne oppgaven, herunder eventuelle praksiskrav.

Partene er gjort kjent med avtalens vilkår, samt kapitlene i studiehåndboken om generelle regler og aktuell studieplan for masterstudiet.

16/5/14

.....  
Sted og dato

oe froyen Sealand  
.....  
Student

.....  
Hovedveileder

Originalen lagres i NTNUs elektroniske arkiv. Kopi av avtalen sendes til instituttet og studenten.

# SAMARBEIDSKONTRAKT

## 1. Studenter i samarbeidsgruppen

Etternavn, fornavn <b>Bjerkholt, Frøydis Folvik</b>	Fødselsdato <b>09. nov 1987</b>
Etternavn, fornavn <b>Rimestad, Mari Haga</b>	Fødselsdato <b>08. des 1987</b>
Etternavn, fornavn <b>Seeland, Ole Jørgen</b>	Fødselsdato <b>07. mar 1986</b>

## 2. Hovedveileder

Etternavn, fornavn <b>Sørheim, Roger</b>	Institutt <b>Institutt for industriell økonomi og teknologiledelse</b>
---	---

## 3. Masteroppgave

Oppgavens (foreløpige) tittel <b>An empirical study: Human Capital needs in the processes of academic spin-off development</b>
---

## 4. Bedømmelse

Kandidatene skal ha *individuell* bedømmelse

Kandidatene skal ha *felles* bedømmelse



TRONDHEIM  
16. mai 2014  
Sted og dato  
  
Hovedveileder

  
Frøydis Folvik Bjerkholt  
  
Mari Haga Rimestad  
  
Ole Jørgen Seeland

Originalen oppbevares på instituttet.

#### 4. Underskrift

**Student:** Jeg erklærer herved at jeg har satt meg inn i gjeldende bestemmelser for mastergradsstudiet og at jeg oppfyller kravene for adgang til å påbegynne oppgaven, herunder eventuelle praksiskrav.

Partene er gjort kjent med avtalens vilkår, samt kapitlene i studiehåndboken om generelle regler og aktuell studieplan for masterstudiet.

TRONDHEIM 16 MAI 2014  
.....  
Sted og dato

Frederik Børseth  
.....  
Student

.....  
Hovedveileder



# MASTERKONTRAKT

## - uttak av masteroppgave

### 1. Studentens personalia

Etternavn, fornavn <b>Bjerkholt, Frøydis Folvik</b>	Fødselsdato <b>09. nov 1987</b>
E-post <b>froydisbjerkholt@gmail.com</b>	Telefon <b>90673050</b>

### 2. Studieopplysninger

Fakultet <b>Fakultet for samfunnsvitenskap og teknologiledelse</b>
Institutt <b>Institutt for industriell økonomi og teknologiledelse</b>
Studieprogram <b>NTNUs Entreprenørskole</b>

### 3. Masteroppgave

Oppstartsdato <b>15. jan 2014</b>	Innleveringsfrist <b>11. jun 2014</b>
Oppgavens (foreløpige) tittel <b>An empirical study: Human Capital needs in the processes of academic spin-off development</b>	
Oppgavetekst/Problembeskrivelse <b>An empirical study of human capital's role on the processes of academic spin-off development.</b>	
Hovedveileder ved institutt <b>Førsteamanuensis Roger Sørheim</b>	Medveileder(e) ved institutt <b>Marius Tuft Mathisen</b>
Merknader <b>1 uke ekstra p.g.a påske.</b>	

# SAMARBEIDSKONTRAKT

## 1. Studenter i samarbeidsgruppen

Etternavn, fornavn <b>Bjerkholt, Frøydis Folvik</b>	Fødselsdato <b>09. nov 1987</b>
Etternavn, fornavn <b>Rimestad, Mari Haga</b>	Fødselsdato <b>08. des 1987</b>
Etternavn, fornavn <b>Seeland, Ole Jørgen</b>	Fødselsdato <b>07. mar 1986</b>

## 2. Hovedveileder

Etternavn, fornavn <b>Sørheim, Roger</b>	Institutt <b>Institutt for industriell økonomi og teknologiledelse</b>
---	---

## 3. Masteroppgave

Oppgavens (foreløpige) tittel <b>An empirical study: Human Capital needs in the processes of academic spin-off development</b>
---

## 4. Bedømmelse

Kandidatene skal ha *individuell* bedømmelse  
Kandidatene skal ha *felles* bedømmelse

<input type="checkbox"/>
<input checked="" type="checkbox"/>

TRONDHEIM 19.05.17  
.....  
Sted og dato

.....  
Hovedveileder

Frøydis F. Bjerkholt  
.....  
Frøydis Folvik Bjerkholt

Mari H. Rimestad  
.....  
Mari Haga Rimestad

Ole Jørgen Seeland  
.....  
Ole Jørgen Seeland

Originalen oppbevares på instituttet.

## SAMMENDRAG

Gjennom vår masteroppgave har vi utforsket fenomenet *akademiske spin-offs* (ASOer) gjennom å skrive to artikler. ASOer er nyetableringer som er basert på forskning fra ulike forskningsinstitusjoner, som for eksempel universiteter. Å forske på ASOer er nyttig ettersom de utgjør en måte å kommersialisere teknologi og andre forskningsresultater. ASOer skiller seg fra andre typer startups ved at de har høye overlevelsesrater, men de blir sjeldent høytytende. Ettersom de tidlige fasene av en ASOs utvikling er karakterisert av begrensede ressurser, så har det blitt indikert av *menneskelig kapital* er spesielt viktig i utviklingen av høytytende bedrifter. Det er nettopp menneskelig kapitalens betydning i forbindelse med ASOers ytelse som vi har utforsket i vår masteroppgave.

I den første artikkelen gjorde vi et strukturert litteraturstudie for å bli kjent med litteratur som omfatter ASOer og ytelse. Forskningsspørsmålet vårt gikk ut på å utforske hvordan forskjellige typer menneskelig kapital påvirker ytelsen til ASOer. Gjennom vårt søk endte vi opp med 39 artikler som var relevante for vårt forskningsspørsmål. Vi identifiserte fire ulike operasjonaliseringer av menneskelig kapital som er mye brukt i litteraturen: arbeidserfaring, utdanning, teamsammensetning og betydningen av akademiske gründeres tilstedeværelse. Ved å drøfte disse områdene kom vi fram til et sett med hypoteser.

I den andre artikkelen tok vi utgangspunkt i funnene fra den første artikkelen, og kom fram til revidert sett med hypoteser. Vi ønsket å finne ut av hvordan ulike tilstedeværelsen av ulike typer menneskelig kapital (i form av arbeidserfaring og utdanning) i ledelsesteamet påvirket ytelsen til ASOer. Vi ønsket også å utforske hvor viktig det er for ytelsen til disse bedriftene at de akademiske gründerne er med i ASOens ledelsesteam ved oppstart. Vi gjorde et omfattende empirisk studie for å få svar på dette. Med et utvalg på 100 bedrifter fra et program i regi av Forskningsrådet utførte vi regresjon, hvor vi operasjonaliserte ledelsesteamet ved å se på alle daglige ledere som hver enkelt bedrift har hatt, gjennom hele sin livstid. Våre funn indikerer, overraskende nok, at ledelsesutdanning er den type menneskelig kapital som har sterkest påvirkning på ytelsen til en ASO. Videre fant vi at ledelseserfaring også er positivt. Et annet funn som går delvis imot tidligere forskning er relatert til doktorgrader. Vi fant at tilstedeværelse av doktorgrader hos daglige leder har en positiv effekt på en ASOs ytelse. Når det gjelder den akademiske gründeren, bør akademikeren også ha kommersiell kunnskap for at det skal ha noe å si på ASOens ytelse.

## **PREFACE**

This master thesis was written by Mari Haga Rimestad, Ole Jørgen Seeland and Frøydis Folvik Bjerkholt during the spring of 2014. All students studied at the Norwegian School of Entrepreneurship which is part of the Department of Industrial Economics and Technology Management at NTNU.

As an extension to a literature review written autumn of 2013, this master thesis contains two articles; The first article is a synthesis of the mentioned literature review. It has also been adjusted for the purpose of the following article, which presents a quantitative empirical study of Academic spin offs. The latter study was performed using data from the Norwegian FORNY-database. While the two articles are written to stand independently of one another, the first article is more thorough in terms of descriptions and definitions. It is designed so that readers not familiar with academic spin-offs can have the pleasure of learning about the phenomenon.

We would like to express our deepest gratitude to our main supervisor, PhD-candidate Marius Tuft Mathisen for giving valuable feedback and for sharing his knowledge on the subject matter. He has greatly contributed to our understanding of the technical aspects on how to approach and evaluate academic literature. We would also like to thank Professor Roger Sørheim for guidance in the initial stages our work. Gratitude is also directed to our fellow students, Fredrik Bergflødt, Karen Skarbø, Halvor Langhoff, Eirik Sola Fischer and Andreas Våge for vigorous template coding, fruitful discussions and insights.

The process of writing this thesis has provided us with knowledge of academic spin-offs as well as knowledge on how to conduct literature reviews and quantitative empirical studies. As the latter was not a part of our curriculum, we spent a great deal of time and effort on understanding how such studies are conducted. Overall, the process of conducting a master thesis has been one of learning, meaning if we were to do this all over again, many things would have been done differently. This is reflected in the limitation chapters of both articles. Although one could argue that a master thesis is more about performing an academic exercise, we believe that some of our research results are indeed very interesting and should possibly be investigated in further research. Although none of us are pursuing academic spin-offs at the moment, we are certain that the insights gained throughout the spring will be valuable in future employments, and eventually future entrepreneurial endeavours.

Trondheim, June 11th 2014

# How does human capital affect the performance of academic spin-offs: A literature review

Mari Haga Rimestad

Tlf: +47 45474874

Email: [mari.h.rimestad@gmail.com](mailto:mari.h.rimestad@gmail.com)

Ole Jørgen Seeland

Tlf: +47 93027481

Email: [olesee@gmail.com](mailto:olesee@gmail.com)

Frøydis Folvik Bjerholt

Tlf: +47 90673050

Email: [froydisbjerholt@gmail.com](mailto:froydisbjerholt@gmail.com)

# ABSTRACT

*This article investigates the field of academic spin-offs. This type of spin-offs commercialize research results from research institutions and are believed to be a source of wealth creation. Even though academic spin-offs have high survival rates they rarely grow into high performing ventures. Furthermore, performance of young academic spin-offs is closely linked to their human capital as they often have limited resources. Through a structured literature search we investigated how different types of human capital affect the performance of ASOs. A synthesis of the articles from this search indicated that four different operationalizations of human capital are commonly used to investigate the performance of academic spin-offs, namely work experience, education, presence of an academic founder and team heterogeneity. We found indications that different types of human capital is needed in different stages of spin-off development. We provide a set of hypotheses that we encourage other researchers to test empirically.*

## 1. INTRODUCTION

Spin-off activity from universities and other research institutions has in the last decades seen a significant increase (Mustar et al., 2006, Wright et al., 2007a, Rothaermel et al., 2007). This is largely due to federal policy changes regarding patenting and funding as well as an emerging public debate about universities' roles in society, which has consequently induced a change in how university research and activities are conducted (Wright et al., 2007a, Shane, 2004). The creation of academic spin-offs (ASOs) is a mechanism to transfer and commercialize knowledge from research institutions (Wright et al., 2007a). Whereas traditional emphasis has been on the licensing of innovations, the latter years has seen a popularity in transferring technology and knowledge through the creation of spin-offs (Wright et al., 2007a). Interestingly, it is seen that they often commercialize embryonic, early stage and knowledge-intensive inventions where existing companies fail to commercialize the technology (Thursby et al., 2009). Thus, the commercialization of technology from a historically non-commercial environment, has become an increasingly interesting topic of debate and research (Djokovic and Souitaris, 2008, Shane, 2004).

Spin-offs from the academic environment are at the frontline of high-technology innovation and are believed to be a potential source of wealth and job creation. There is clear evidence that some spin-offs are highly successful (Shane, 2004). However, it is found that even though ASOs have high survival rates, they rarely grow into high performing ventures, and many do not generate substantial wealth (Nerkar and Shane, 2003, Wright et al., 2007a, Wright et al., 2012, Harrison and Leitch, 2010).

Due to the latter, there lies great value in understanding how these ventures are created and initiated. Furthermore, one needs to comprehend how they differentiate in terms of resources, activities and development paths, and why some

ASOs outperform others. This offers incentives to policy makers, as explaining the mechanisms leading to successful academic entrepreneurship is a crucial step in designing effective support mechanisms (Rasmussen, 2012, Wright et al., 2007a).

ASOs face distinct challenges that are related to characteristics of the university/research environment and the nature of the technology itself; ASOs are characterised by knowledge-intensive, novel and potentially disruptive technologies involving high levels of tacit knowledge residing within the academic founders (Ardichvili et al., 2003). They commonly operate in uncertain environments (Roure and Keeley, 1990, Vohora et al., 2004). Consequently, development paths are long and complex and requires a combination of competencies that are outside the scope of the research institutions' core activities (Vohora et al., 2004). Firms with technologies at such early stage often face difficulties gaining investments as capital providers find the business opportunity hard to evaluate (Wright et al., 2006). Furthermore, the non-commercial environment of universities and research institutions suggests that the academic entrepreneur(s) is unlikely to have experience or skills in commercialising business ideas (Mosey and Wright, 2007). Lastly, opposing interests between key stakeholders such as the university, the founders, management team and providers of finance are likely to hamper the spin-off development. Hence, there is a conflict between research and commercial activities (Mustar et al., 2006, Rasmussen, 2011).

The performance of spin-offs is among other things related to type and amount of human capital of the individuals involved. Human capital relates to skills and knowledge derived from education and experience and it is generally believed that higher levels of human capital is positively linked to enhanced performance of ASOs (Shane, 2004, Davidsson and Honig, 2003, Colombo and Grilli, 2005, Becker, 1964, Mosey

and Wright, 2007). Human capital criteria appears to be especially useful for predicting success and long term survival while spin-offs are young (Unger et al., 2011, Aspelund et al., 2005). Moreover, early strategic decisions have lasting effects and impacts the spin-offs long term performance (Bamford et al., 2000).

One major drawback of human capital studies is the lack of empirical and longitudinal data (Rothaermel et al., 2007, Hayter, 2013). As a consequence, most studies on performance are static, and overlook dynamic characteristics and their development over time (Vohora et al., 2004, Druilhe and Garnsey, 2004). This is argued to be a significant limitation as performance and success is dependent on several variables. Furthermore, looking at these variables by taking a snapshot at a particular point in time is a weakness (Hayter, 2011). In particular there is a need for literature emphasizing early development of spin-offs and how human capital influences this (Davidsson and Honig, 2003).

Furthermore, most studies on human capital and success draw on literature about new technology based firms (NTBF). Although NTBFs and ASOs are closely related, we would argue that the ASO context and its related challenges mentioned earlier is of particular interest when studying human capital measures.

In this literature review, we will attempt to uncover what types of human capital the founder(s) need in the development of a successful ASO. In particular we choose to focus on how investments of human capital; namely education and work experience of the academic entrepreneur(s) affects the performance of ASOs. We chose to focus on how human capital in earlier stages predict future success, as this is the time when human capital is the most influential in terms of which path the venture evolves (Clarysse and Moray, 2004). In other words, the initial base of human capital is valuable in determining the long term survival of spin-offs (Aspelund et al., 2005). By using process related theories we seek to find out what types of human capital are especially helpful in selected junctures, or critical waypoints of spin-off development. Unlike other studies which measure firm performance by taking a snapshot in time, we treat spin-off performance as a longitudinal process that develops over time. Consequently, when treating spin-off development as a range of different phases, the influence of the different kinds of human capital is expected to vary across the phases (Vohora et al., 2004). As follows, the research question in this study is:

*How do different types of human capital affect the performance of ASOs?*

Our study contributes to the understanding of the ASO phenomenon while suggesting what human capital needs are prominent through the different phases of ASO development. Awareness of what types of human capital an ASO needs in order to perform should be of interest to universities, technology transfer offices (TTOs), scholars, policymakers and academics themselves as it may increase the chances of successful spin-off development.

The article is structured as follows: First, we explore the theoretical foundation of our topic and provide definitions relevant for the research question. The Resource Based Theory (RBT) is chosen as theoretical lens as it is closely related to human capital and the performance of ASOs. The Knowledge Based View (KBV) is also presented as knowledge is a key component of human capital. Additionally we give a brief presentation of the ASO phenomenon as well as a theoretical perspective which looks at spin-off development as a process. Second, the method used in the structured literature review is thoroughly explained. Third, an analysis of the literature is performed providing descriptive statistics and demographic information. The following discussion extracts relevant theory on human capital and performance and a set of related hypothesis is put forward. Finally, implications, limitations, further research and a conclusion are provided.

## **2. THEORETICAL BACKGROUND**

In order understand why we arrived at our research question we believe it necessary to build a theoretical foundation which explains concepts closely related to human capital, success and process. There is also a need to establish some fundamental definitions so terms like ASOs, process, success and performance are not misinterpreted. The following section will first give a brief introduction to RBT and KBV. Secondly we will investigate the phenomenon of ASOs by defining the unit of analysis (ASO), outline research on performance as well as giving an introduction to a process view of ASOs.

### **2.1 Resource Based Theory**

The RBT has become a commonly used framework to explain why some firms perform better than others (Mustar et al., 2006). The

theory attributes a firm's superior performance to the firm's organisational resources and capabilities. Arguably it is a suitable framework to explain how human capital influences performance of ASOs and in understanding entrepreneurial processes (Aspelund et al., 2005).

RBT helps to evaluate all the different resources a firm possesses and contextualise how they can be used to achieve sustained competitive advantage and maximise rents (Grant, 1991, Barney, 1991). According to Barney (1991) the resources that will help a firm obtain a sustained competitive advantage needs to be: Valuable, rare, inimitable, and non-substitutable (*VRIN-framework*). A *valuable* resource enables the firm to improve its market position compared to its competitors (Peteraf, 1993). *Rare* resources enables the firm to keep a sustained competitive advantage and are difficult to obtain for competitors (Barney, 1991). Resources that are *inimitable* refers to resources that are immobile and costly to imitate or replicate (Barney, 1991). Finally, *non-substitutable* resources result in a sustained competitive advantage and cannot be substituted by other resources in order to implement the same strategy (Barney, 1991).

RBT also includes a description of the term *capabilities*, defined by Makadok and Barney (2001) as "an organizationally embedded non-transferable firm-specific resource whose purpose is to improve the productivity of the other resources possessed by the firm". There is an important distinction between resources and capabilities, where the former is the basic unit of analysis for the firm whereas the latter is the capacity of bundled resources to perform an organisational task or activity (Grant, 1991). Capabilities are what the firm does better and/or more efficiently compared to its competitors (Eisenhardt and Martin, 2000). Grant (1991) states that capabilities are not formed simply by bundling resources as the process of turning resources into capabilities includes coordination and complex interactions. This transformation from resources to capabilities is in itself a resource (Grant, 1991).

In 1997 Teece et al. made a distinction between different capabilities. They differentiated between current capabilities (referred to as substantive capabilities (Grant, 1991)) and dynamic capabilities. The dynamic capabilities of a firm explain how certain firms can stay competitive over time (Eisenhardt and Martin, 2000). Teece et al. (1997) defined dynamic capabilities as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing

environments". Dynamic capabilities are especially important in rapidly changing markets where the ability to create new resource configurations and capabilities are crucial to gaining and maintaining a competitive advantage (Eisenhardt and Martin, 2000). This is indeed the case of ASOs and other high tech firms, as they operate in such markets. Hence, dynamic capabilities are just as important to ASOs as other firms striving for competitive advantage (Ittner and Larcker, 1997).

### **2.1.1 Resource based theory and new ventures**

The RBT framework as defined in 1991 by Barney (1991) had some shortcomings when it came to explaining how entrepreneurs with limited resources and no organisation to speak of could build sustained competitive advantages. Alvarez and Busenitz (2001) used RBT to show how entrepreneurs use their unique awareness of opportunities, their ability to acquire the resources needed to exploit these opportunities, as well as the organizational ability to combine homogeneous resources into heterogeneous resources and thus obtain a sustained competitive advantage. Brush et al. (2001) explains this differently: "Initial focus must rest on the resources of the entrepreneur and not the firm". This serves to show that the construction of the initial resource base is the true entrepreneurial challenge (Brush et al., 2001). Gurdon and Samsom (2010) built on how RBT could be used to explain entrepreneurial traits. As they stated, using the VRIN-framework as well as the entrepreneurs' personal characteristics; their drive to achieve and sense of self-efficacy should be viewed as important resources and placed in the impossible to imitate category in the VRIN-framework (Gurdon and Samsom, 2010). This entails that the entrepreneurs personal traits, their ability to acquire resources and combine them are in themselves resources that can be the basis of a sustained competitive advantage (Alvarez and Busenitz, 2001).

Advocates of the resource based perspective describe a multitude of resource categories but there is a lack of consensus on how to classify them (Brush et al., 1997). Most of these typologies are suited well established firms, not considering the fact that resources of new firms are scarce and need to be acquired and developed before turning valuable (Rasmussen et al., 2011). To account for this, Brush et al. (2001) therefore defined six categories of resources suited for new ventures, namely technological, human, social, financial, physical and



organisational resources. Mustar et al. (2006) further developed these into categories suited for the context of ASOs, namely; technological, social, human, and financial.

*Technological resources*; defined as the firm-specific products and technology. For new ventures the degree of innovation, scope of their technology, legitimacy of the firms' research and development (R&D) and where they are in the product development cycle also impact their technological resources (Borch et al., 1999).

*Social resources*; consist of the firm's industry and financial contacts, in other words, the outcome of network relationships (Brush et al., 2001).

*Financial resources*; the type and amount of financing of the firm, meaning all the different types of financial resources that a firm can possess and use (Heirman and Clarysse, 2004).

*Human capital*; defined as the stock of knowledge and skills that resides within individuals (Becker, 1964). According to RBT human capital resources are a potential source of competitive advantage as they may be valuable, inimitable, rare and non-substitutable (Zhuang and Lederer, 2006). According to research, the initial competencies of new ventures basically coincide with the competencies or the human capital of the founders. Arguably, understanding human capital is paramount when trying to understand the performance of new firms (Mustar et al., 2006, Cooper and Bruno, 1977).

For this article it is important to note that because skills and knowledge are difficult to measure, most researchers use human capital investments, such as education and work experience, as proxies for human capital (Unger et al., 2011). This is a necessary, but also valid approach as there is a strong relationship between these human capital investments and their potential outcomes (skills and knowledge). Hence, having technical education or experience implies you have technical skills (Unger et al., 2011).

### **2.1.2 Knowledge Based View**

KBV is an extension to RBT and is based on the assumption that knowledge is the firm's key resource (Lockett et al., 2005). As spin-offs from universities often commercialize early stage and knowledge-intensive inventions (Thursby et al., 2009), the KBV is suited for studying spin-offs from an academic environment.

Knowledge is a particular type of resource with three important dynamic traits separating it from all other resources; (i) It can grow stronger when used, (ii) It is never lost when

shared, and (iii) It is independent of factors such as space and time (Widding, 2005). Lockett et al. (2005) suggest that spin-offs can potentially enhance their performance through accessing, developing, and integrating new and existing knowledge. Knowledge is closely related to skills/capabilities as it is seen as the key input into the development of these capabilities (Lockett et al., 2005). As seen previously, capabilities represent what a firm does better or more efficiently compared to competitors (Eisenhardt and Martin, 2000), which serves to illustrate the importance of knowledge and knowledge management in ASOs.

Furthermore, knowledge can be described as explicit or tacit. *Explicit knowledge*, or codifiable knowledge, can easily be stored or transferred between individuals. In entrepreneurial ventures it can be assumed that explicit knowledge is underdeveloped for several reasons: (i) There are few employees, which makes it difficult to specialize functions (ii) There is often a high pace of activity which may interfere with the documentation of tasks and routines (iii) There is a low level of formalization (Widding, 2003). *Tacit knowledge* is non-transferable and non-storable other than in the person it originated from. Thus, tacit knowledge is highly individual. However, Polanyi (1967) argues that all knowledge is either tacit or rooted in tacit knowledge, thus implying that all knowledge relies on the person or people where it originated from. Some of the most valuable aspects of an organization are embedded in its tacit knowledge, as such knowledge is hard to imitate and sell (Amit and Belcourt, 1999).

One of the challenges a new firm faces is to set in place a structure that allows the firm to capture and store the entrepreneur's tacit knowledge as the venture grows (Brush et al., 2001), thus making tacit knowledge explicit. Failure to do so may hamper growth and performance. Alexander et al. (1991) argues that not all facts and procedures containing tacit knowledge can become explicit, whereas others can be elevated to a level of consciousness at some particular point or for some specific task. Although tacit knowledge is hard to formalize and communicate to others, it can be achieved by participating in an activity for a longer period of time (Widding, 2003). In the section below an introduction to the ASO phenomenon is presented.

## 2.2 The phenomenon of academic spin-offs

An academic, or research based spin-off has the distinct feature of being initiated inside the university or research institution (Rasmussen, 2011), and is a mechanism to transfer technology and commercialize inventions originating from these institutions (Shane, 2004). This has become an international phenomenon and has stimulated the discussion among scholars and policy makers as to whether and how spin-offs generate wealth (Mustar et al., 2006, Clarysse et al., 2005, Wright et al., 2007a).

In contrast to established firms, spin-off firms tend to commercialize radical and early stage technologies which represents major advances in a particular field of research (Shane, 2004). It often has a strong intellectual property (IP) protection and is typically built on the tacit knowledge of the founders. In terms of industry, biotechnology is where most research based spin-offs occur, followed by computer software (Shane, 2004). While this is especially the case for the US context, similar patterns are seen across Europe. Due to the nature and type of technology and the issue of stemming from a non-commercial environment, academic innovations typically have longer development times (Shane, 2004). Furthermore, it is also seen that ASOs tend to remain rather small (Harrison and Leitch, 2010). This could be due to the multiple challenges faced by research based spin-offs. Understanding how these challenges affect the spin-off creation and development process and how they can be overcome is thus fundamental to be able to generate wealth (Wright et al., 2007a). This has led to researchers increasingly recognising the fact that spin-offs are complex and heterogeneous and depend on the context in which they occur (Mustar et al., 2006).

ASOs have historically been a US phenomenon and a great share of the literature stem from a small number of highly successful research institutions in the US (Wright et al., 2007a, O'Shea et al., 2005, Rothaermel et al., 2007). This context is unlike most research environments in Europe and therefore the spin-off process is likely to be different. Because of various factors, such as university and governmental policies, availability of financing as well as social norms, the US is in general better than Europe at transforming research into innovations (Wright et al., 2007a).

### 2.2.1 Defining an academic spin-off

University, or academic, spin-offs are defined in a number of different ways. The employment of an imprecise and vague definition may have disadvantageous effects on academic entrepreneurship research, as scholars are likely to use the same term even though they describe different situations and phenomena (Pirnay et al., 2003). Even the word "spin-off", used to describe a university spin-off is a matter of discussion, where terms such as spin-off, spinouts and start-ups are frequently used (Carayannis et al., 1998).

Even though definitions differ greatly, there are still a number of common elements, such as the object being defined (research based, university, academic), the founders, and how knowledge is transferred. Djokovic and Souitaris (2008) states that the "definition of a USO should specify the 'outcome' of the spin-out process, the essential 'parties' involved in it, and the 'core elements' that are transferred (spun-out) during that process." The definition of an ASO should include the same elements to leave no room for ambiguity. Table 1 presents some of the most used definitions and their characteristics.

It is clear from the definitions above that the outcome of the spin-off process is firm formation. However, based on Djokovic and Souitaris (2008) there are still some dimensions used in these definitions that need clarification; Technology transfer, institutions and founders. These dimensions will be treated before the definition used in this article is presented.

TABLE 1 - OVERVIEW OF SOME OF THE MOST USED DEFINITIONS OF ASOS

Defined by	Definition of	Definition
Smilor et al. (1990)	University spin-out	(i) The founder was a faculty member, staff member, or student who left the university to start a company or started the company while still affiliated with the university; and/or (ii) a technology or technology-based idea developed within the university was used to start the company.
Rogers et al. (2001)	Spin-off	A spin-off is a new company that is formed (i) by individuals who were former employees of a parent organization, and (ii) with a core technology that is transferred from a parent organization (Hashimoto et al., 1997)
Nicolaou and Birley (2003)	University spinouts	(i) The transfer of a core technology from an academic institution into a new company. (ii) The founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the academic institution.
Clarysse and Heirman (2000)	Research based spin-offs	New companies set up by a host institute (university, technical school, public/private R&D department) to transfer and commercialize inventions resulting from the R&D efforts of the departments.
Pirnay et al. (2003)	University spin-off	New firms created to exploit commercially some knowledge, technology or research results developed within a university.

The term *technology transfer* is defined by Eto et al. (1995): “Technology is information that is put to use in order to accomplish some task. Transfer is the movement of technology via some channel from one individual or organization to another”. Gibson and Rogers (1994) combines the two by saying that technology transfer is the application of knowledge, meaning taking ideas and products from the research laboratory across organizational boundaries into commercial applications. This definition of technology transfer does not explicitly touch upon the topic of IP rights. Thus, definitions using concepts such as technology transfer or technology based ideas may consist of patents or licensing as well as informal transferring of technology. In fact, Wright et al. (2007a) defines university spin-offs to be new ventures that are dependent upon either licensing or the delegation of an institution’s IP. Accordingly, the focus is on the IP that is being transferred into the spin-off, excluding tacit knowledge and technology that cannot be patented. However, IP is not always owned by the university and many companies are not built upon “formal, codified knowledge embodied in patents” (Wright et al., 2007a). Focusing on IP would only include a subgroup of university or research based spin-offs.

Smilor et al. (1990) states that a university spin-off is based on a technology or

technology-based idea developed within the university. As they avoid to specify what a “technology or technology-based idea” consists of, it may include patents, licensing and knowledge of a more tacit nature (informal).

According to Rogers et al. (1999) and Nicolaou and Birley (2003) a spin-off is founded around a “core technology”. The “core technology” being transferred is not specified, and may consist of either formal (such as IP and licenses) or more informal knowledge (tacit).

The definitions used by Clarysse and Heirman (2000) and Pirnay et al. (2003) have less focus on technology. Clarysse and Heirman (2000) defines research based spin-offs as an entity that commercialized transferred inventions, whereas Pirnay et al. (2003) are slightly more specific in their definition by describing university spin-offs as “New firms created to exploit commercially some knowledge, technology or research results”. An invention can be either technology, IP or a non-technical idea. By using the words knowledge, technology and research result, it opens up for the possibility to define a new company based on a university canteen-recipe as a spin-off. The spin-offs in both these definitions can accordingly have a very broad focus with an offering that is not necessarily related to technology.

*Unit and institution:* There are notable differences in the definitions with regards to the institution where the spin-off spins out from. Smilor et al. (1990) and Pirnay et al. (2003) specify that their defined university spin-off comes from the university. The institution in Nicolaou and Birley (2003)'s definition of university spinouts is an "academic institution", thus including research facilities such as university-based research centers as well as private research centers. Rogers et al. (2001) institution is simply a "parent organization", which can be just about anything, including for instance an established firm. Finally, Clarysse and Heirman (2000) defines research based spin-offs to spin out from an institute (university, technical school, public/private R&D department). This definition explicitly includes both private and public research institutions.

*Founders:* Mainly three aspects of the founders' roles appear in definitions: whether or not the inventor founds the spin-off, the founder's affiliation to the spin-off institution, and finally, what type of occupation they have (for instance staff, academics, researchers and students).

Radosevich (1995) makes a distinction between the *inventor-entrepreneur* and a *surrogate entrepreneur*. The former implies that the inventor founds the spin-off, while the latter is the case when an entrepreneur, not originally affiliated with the technology, founds the spin-off (with the technology developed in the parent organisation). Only Rogers et al. (2001) states that the spin-off must be formed by former employees of the parent organization. Their definition does not specify whether the founder(s) must be the inventor-academic, yet the definition implies this. Neither Clarysse and Heirman (2000) nor Pirnay et al. (2003) specify who the founders of the spin-off must be, and are thus open for both inventor-entrepreneurs and surrogate entrepreneurs. Smilor et al. (1990) and Nicolaou and Birley (2003) both open up for the possibility of founders that are not affiliated with the "parent organization" (i.e surrogate entrepreneurs).

Another element of the founders' role is their affiliation to the spin-off institution. In essence, this relates to whether or not the founders have to quit their current work to start the spin-off. The definitions that are studied have three possible outcomes; The first type of definition explicitly states that the founders have to leave the parent organization. Definitions of Rogers et al. (2001) and Smilor et al. (1990) are in this category. The second option is that the founder can choose to continue his or her work at the institution in question, at the same time as

founding the spin-off. Only Nicolaou and Birley (2003) explicitly states that this is an option. The final possibility is a definition that does not specify whether the founder can still work at the institute or not. As neither Clarysse and Heirman (2000) nor Pirnay et al. (2003) mention who founds the spin-off, they both fall under this category.

The last element of the definitions focuses on the nature of the founders' role at the institution. Neither Rogers et al. (2001), Clarysse and Heirman (2000) nor Pirnay et al. (2003) specify this. Nicolaou and Birley (2003) states that the founder has to be the "inventor academic(s)". This includes faculty, researchers and graduates, but excludes staff. The definition by Smilor et al. (1990) is quite different, and states that the founder can be a faculty member, staff member, or student. This definition is quite general, and makes it possible to classify a staff member leaving the university to start a catering business to be classified as a university spin-off (as long as there is some technology related to the business).

*Definition of an ASO:* As seen above, definitions differ significantly. With regards to the technology being transferred, some of the definitions specify that some kind of technology, technology-based idea or core technology is transferred, whereas others are more open as to what can be transferred. We choose to leave this more open and thus side with the latter group, which opens up for the possibility of early stage research results being commercialised.

With regards to the unit and institution used the definitions diverge. The unit is naturally related to the institution. We choose to define this as a *host institution*. While this definition includes other institutions than universities, it is important to notice that the context may be quite different. A private research institution might be more restrictive than a university when it comes to transferring knowledge to a spin-off company. It is likely that they wish to reduce the risk associated with the spin-off process, as their objective is to produce applied research. The university's objective is to serve public benefit, and may transfer knowledge to a spin-off earlier in the process.

Furthermore, we will define an *academic spin-off*. Defining the institution to be a *host institution* naturally excludes the possibility of using the term "university spin-off". Using the word *academic* emphasizes the focus on the academic nature of the host institution, and is chosen for this reason.

The role of the founders in the spin-off

diverges in the different definitions, where some demand that the founders quit their current affiliation with the institution, whereas others either do not specify it or explicitly opens up for the possibility of a surrogate entrepreneur to found the spin-off. In our definition we explicitly open up the possibility for the whole range, as surrogate entrepreneurship is also receiving considerable attention in entrepreneurship literature (Franklin et al., 2001).

Our definition of an ASO is as follows, using a combination of Nicolaou and Birley (2003), Pirnay et al. (2003) and Clarysse and Heirman (2000); *An academic spin-off (ASO) is defined as “ (i) The transfer of some knowledge, technology or research result from a host institute (university, technical school, public/private R&D department) into a new company. (ii) The founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the host institution.”*

### **2.2.2 The performance of academic spin-offs**

As this article is built on literature addressing the relation between human capital and performance, we believe it necessary to present the concept of performance of ASOs. A review of the literature shows that the aspect of success and performance is well addressed. However, as Rasmussen (2012) and Hayter (2011) points out there is limited consensus on the unit of analysis and which measures to use when seeking to find a definition. Scholars tend to choose measures that are easily accessible or measurable, or whichever measure that fits the purpose of their study.

The majority of definitions consist of one dimensional measures related to the performance of the venture. The benefit of using such data is that they are relatively accessible and can be measured objectively and quantitatively. Authors frequently use criteria like sales growth,

profitability and growth in terms of job creation (Clarysse et al., 2011, Colombo and Grilli, 2010). Others measure success as having an initial public offering (Walter et al., 2011, Shane, 2004), having attracted early stage financing or Venture Capital (VC) (Shane and Toby, 2002, Wright et al., 2007a), in number of patents and scientific papers (Zucker et al., 2002), speed to market (Clarysse and Heirman, 2000) or simply just remaining in business (Shane and Toby, 2002).

Rather than focusing on pure performance, a stream of literature, highlighted by Hayter (2011), looks at success as something defined from the viewpoint of the academic entrepreneur or shareholders, resulting in a number of subjective and interrelated definitions including technology diffusion, personal development, personal financial gain, social well being and peer motivations (Gurdon and Samsom, 2010, Hayter, 2011, Franklin et al., 2001). This will include those spin-offs that may still be viewed as successful by those involved, despite having a weak financial performance. In the case of ASOs there is empirical evidence of conflicting interests between key stakeholders such as the university, the venture management and the entrepreneurs. This causes a shared focus between spin-off activity and research activity, and thus a weaker financial performance (Rasmussen, 2011, Mustar et al., 2006).

Most of the above measures are used as proxies that predicts success, as spin-offs may take several years to develop into sustainable ventures (Lawton Smith and Ho, 2006). Attracting venture financing, for example, implies that investors assess the spin-off as a potential future success and is thus an intermediary measure of success (Rasmussen, 2012).

As a note to the reader, we do not discriminate between the different definitions and will include articles with all definitions in our literature review and discussion.

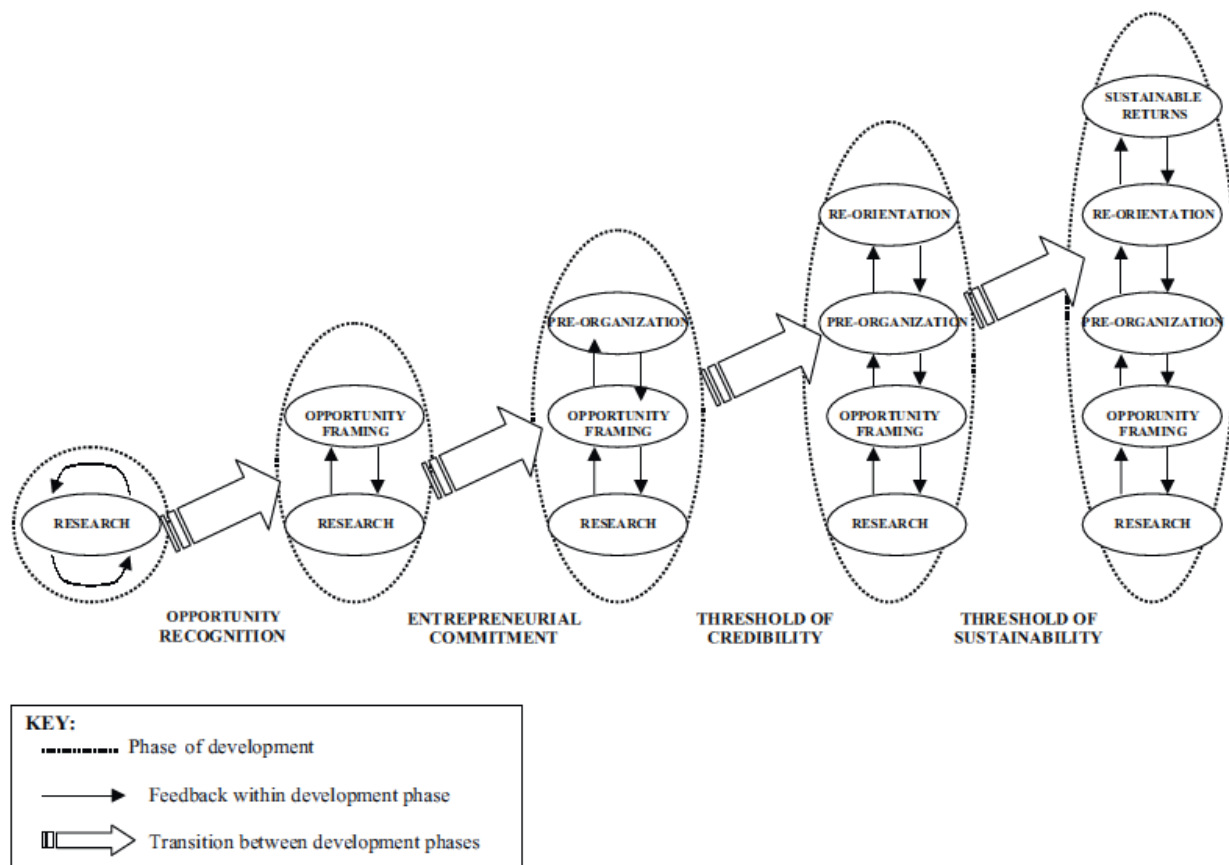


FIGURE 1 - FROM VOHORA ET AL. (2004) - "THE CRITICAL JUNCTURES IN THE DEVELOPMENT OF UNIVERSITY SPIN-OUT COMPANIES".

### 2.2.3 A process view of academic spin-off development

In order to understand the reasons why some ASOs outperform others it is necessary to understand how they develop and the difficulties they face. Thus, performance is a process-dependent output of ASO development.

Several researches have sought to explain how ASOs evolve using different life-cycle models (Wright et al., 2012, Vohora et al., 2004, van Geenhuizen and Soetanto, 2009, Rasmussen et al., 2011, Hindle and Yencken, 2004, Donato et al., 2011, Clarysse and Moray, 2004, Ambos and Birkinshaw, 2010). Life-cycle models are suited for a process view centered on human capital as they focus on how the ASO progresses from initial to later stages. However, such theories fail to explain how the venture moves from one phase to the next (Rasmussen, 2011).

The work of Vohora et al. (2004) has been used by many authors (Lockett et al., 2005, Lawton Smith and Ho, 2006, Mustar et al., 2006, van Geenhuizen and Soetanto, 2009). It is one of the few models that looks at ASOs in particular and

describes the process they go through. The model explains how an ASO progresses through five phases in an iterative and non-linear way, each phase being separated by a critical juncture. The junctures are characterised by several challenges the ASO has to surpass in order to move forward. These challenges are overcome by developing resources and dynamic capabilities (Vohora et al., 2004). These phases and junctures will be presented briefly (based on (Wright et al., 2007a) and (Vohora et al., 2004)). Figure 1 displays how ASOs transition through the phases and critical junctures.

In the *research phase* the IP is created, which again provides the opportunity for commercialization. To succeed to the *opportunity framing phase* the ASO must pass the *opportunity recognition juncture* where the main challenge is to offer the necessary solution to satisfy an unfulfilled market need (Bhave, 1994). The ASO moves from having recognized an opportunity and takes the formative steps needed to create a new venture. These steps mainly focus on the academic and the TTO. Furthermore, the *entrepreneurial commitment juncture* arises due to the need of committing a venture champion to a certain course of events. Failure to pass this juncture arises when the need for such

commitment is there, yet the venture fails to find someone with the necessary entrepreneurial capabilities. The juncture is followed by the *pre-organization phase*, in which management can develop and start to implement the strategic plans. Early decisions are crucial for the ASO's development, which emphasizes the usefulness of accessing human capital, prior entrepreneurial experience as well as networks of expertise (Wright et al., 2007a). Next, the *venture credibility juncture* must be overcome. Acquiring the necessary resources to be able to execute the business plan and form the entrepreneurial team is challenging. Credibility is necessary in order to convince customers and investors. In the *reorientation phase* the entrepreneurs try to generate returns, but face challenges in reconfiguring resources after having identified, acquired and integrated them. For those ventures that reach this phase, a learning effect was identified, as the academic entrepreneurs identify how to develop resources, knowledge and information and subsequently assemble new capabilities. The last juncture to pass through is the *venture sustainability juncture* in which there is a need to continuously reconfigure resources, capabilities and social capital according to new information, resources and knowledge. Deficiencies from earlier phases may at this point be too difficult to resolve, resulting in the inability to progress past the critical juncture. The ASOs that pass this juncture reach the final phase of *sustainable returns*. The ASO achieves sustainable returns and the entrepreneurial team focuses on acquiring and re-configuring resources as the development of capabilities is necessary to reach and stay successfully this phase.

Critique may be raised against Vohora et al.'s model. Vohora et al. (2004) claim the model is nonlinear while it is only the revisiting of earlier phases that gives the model nonlinearity. Furthermore, there is no explanation of the time aspect and how long the ASOs stays in each phase or juncture. Additionally, it views ASOs as a homogeneous group as it assumes that the academic inventors take part in the spin-off activity. Finally, as Vohora et al. (2004) based the model on cases of only seven ASOs, it can be argued that this is a very limited number to generalize from, as Vohora et al. (2004) are the first to point out. Despite the critique against the model it is still a valuable framework for looking at the process of ASO development as it explains how the ASO will face different resource needs at different points in its development. Vohora et al.'s model will be used to link human capital needs through the process of ASO development.

### 3. METHOD

A structured literature review was performed with the aim of identifying how different human capital factors affect ASO performance. This allows us to understand previous work relating to the topic, the different definitions used by scholars, literature gaps and issues being debated.

Reputable literature reviews of the ASO phenomenon from Rothaermel et al. (2007), Mustar et al. (2006) and Rasmussen (2012) formed the basis for an initial understanding of the field of ASOs. The reviews also served as a brief orientation to previous work. In order to accommodate for apparent gaps in the ASO literature, the search method was set up to include the larger and more explored field of NTBFs. ASO can be regarded as a subgroup of NTBFs, as they are both technology based, however ASOs are bound by the points discussed in chapter 2.2.4.

The literature review consisted of four stages. In the first stage a structured search in the ISI database was performed. In the second and third stage the articles were evaluated and reduced according to a set of criteria. *Reversed snowballing* was used on the remaining articles, to create a more robust literature search. Finally the remaining articles were rated and some irrelevant articles were discarded. Each of the stages are explained in detail below. Figure 2 displays the number of articles left after each stage.

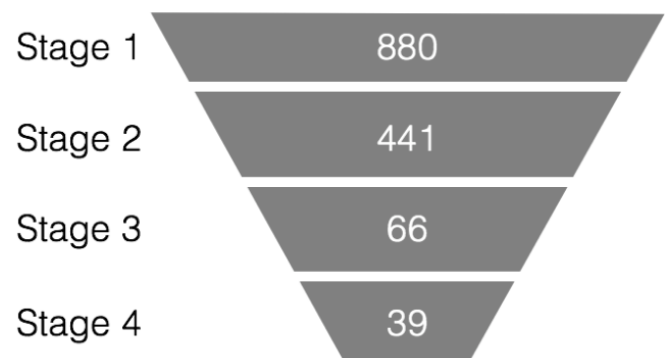


FIGURE 2 - OVERVIEW OF STAGES AND ARTICLES

The first stage consisted of a structured search using the extensive ISI Web of Knowledge database. This database includes leading journals from a broad range of publishers relevant for our research question. Three types of search terms were included in the search. First, search terms relating to the nature of the firm such as variations of NTBFs and ASOs were employed. Secondly, different search terms for "spin-off" were used. Finally, variations of "success" and "failure" were included. Variations for the first two search term

types were retrieved from Rasmussen (2012). The search words were used to search both title and abstract. The search word and search syntax can be found in appendix 1.

We chose to screen the literature based publishing journals. This is an effective way to exclude irrelevant areas of research that may include similar search terms. The selection of journals was based on the research conducted by Rasmussen (2012). In this way reputable journals relevant for research literature on ASOs and NTBFs were included in the search. Table 2 displays the selected publication sources. This automatic screening resulted in 880 articles.

TABLE 2 - CHOSEN PUBLICATIONS

Publication name	
Research Policy	Academy of management journal
Journal of Business Venturing	Management Science
Journal of Technology transfer	Strategic Management journal
Technovation	R & D Management
Small Business Economics	Industrial and Corporate change
Administrative science quarterly	Entrepreneurship theory and practice
Academy of management review	Organization science

The second stage consisted of screening articles by title. Articles that pertained to other scientific fields that were outside the scope of this paper were filtered out. Such articles were typically articles that did not look at NTBFs or ASOs and/or some performance variable. For example, titles including words such as family innovation, family firms, corporations and so on

TABLE 3 - RELEVANCE OF THE ARTICLES

Importance of the article for the research question	Criteria for relevance:	Number of articles:
<b>High</b>	The article illuminates a large or central part of the research question.	19
<b>Medium</b>	The article gives insight into parts or adjacent topics relevant for this article.	20
<b>Low</b>	The article has little relevant information for this paper.	27

were removed. This reduced the number of articles down to 441.

The third stage consisted of a detailed review of abstracts. The following three criteria formed the basis of elimination:

1. **Wrong unit of analysis;** Articles analysing anything different from the firm itself and its performance and growth were removed. Articles that were removed treated subjects such as university policies, industry and corporate policies.
2. **Focus on aspects outside the scope of this article;** Articles related to how human capital affects a NTBF or ASO and/or how a company can manage its resources in order to survive and/or grow were kept. For instance, articles focusing on internationalization and emerging economies were omitted.
3. **Not adhering to our definitions;** Articles clearly not focusing on NTBFs, ASOs, ASO and success/failure were removed. For example, articles focusing on larger corporations were excluded.

After the third screening stage 56 articles were left to review and rate. Combinations of the first two criteria were the main drivers for the drastic reduction.

In the fourth stage the process of reversed snowballing was performed (Streeton et al., 2004). This method uncovered articles that were relevant for the research question and not included in the articles left from the third stage. The reference list of every article was checked in order to make sure that relevant cited articles were included in the structured search. Relevant articles not included in the search were subsequently added. Finally, ten articles were added to the initial 56, resulting in a sample of 66 articles.

Of the ten articles added in the reverse snowballing, six of the articles were published in publications deemed relevant, however they did not include the chosen search words. The common theme for these articles was human



capital's effect on new ventures, thus not focusing on performance or success/failure but effect. The last four articles did include relevant search words but were published in publications that were automatically filtered before stage one. The first six revealed a limitation in the search that will be discussed in section 7 limitations and further research. The discovery of the last four articles is a typical advantage of the reversed snowballing method.

Every article read was rated on the basis of how relevant/important it was for this article based the criteria explained in table 3. As displayed in table 3, 27 articles were of little relevance. These were eliminated, and we ended up with 39 articles that were used.

#### 4. RESULTS

By analysing the 39 articles we are able to provide the reader with an overview of interesting descriptive statistics. The section below will graphically present the share of articles with ASOs as the unit of analysis, provide an overview of the journals where the articles were published, present which countries the data is collected from and provide some considerations related to the nationality of authors. Lastly, we will present the abundance of key topics relevant to the research question.

*Unit of analysis:* The majority of the articles focus on NTBFs as opposed to ASOs. Figure 3 displays the distribution of articles focusing on either NTBFs or ASOs. As pointed out by Rothaermel et al. (2007) and Rasmussen (2012) and, as illustrated by figure 3, there is a lack of literature focusing purely on ASOs. As a matter of fact, only 27% of the 39 articles focused on ASOs.

*Publishing sources:* The main publishing sources are displayed in figure 4. Four journals

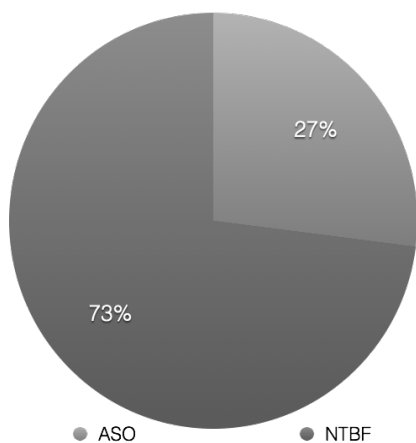


FIGURE 3 - DISTRIBUTION OF ARTICLES TREATING NTBFs AND ASOs

have been identified as the main publishing sources for the field relating to NTBF/ASO and success/failure. Furthermore, these four journals published 70% of the articles.

*Origin of data:* Figure 5 shows which countries the data used in the studies originate from. Most of the studies (28) collect data from a single country, whereas five of the studies collect data from several. The rest of the articles (six) were literature reviews. As expected, studying data from the US is by far the most common. This is linked to the fact that spin-off activity in academic environments is more developed in the US compared to Europe (Wright et al., 2007a).

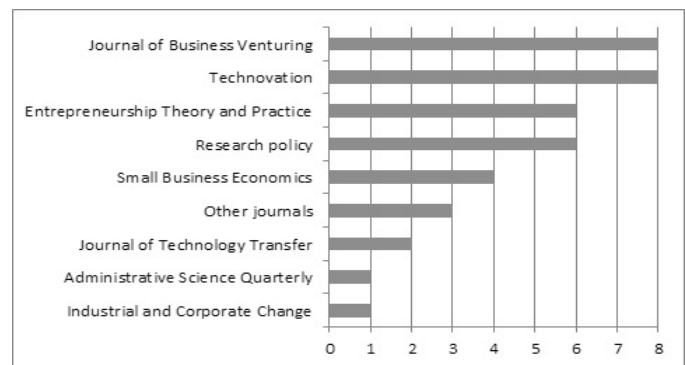


FIGURE 4 - OVERVIEW OVER JOURNALS AND PUBLICATION FREQUENCY

*Origin of authors:* Mike Wright has authored or co-authored 6 articles (15%), which is twice as many as the second largest contributors (Massimo Colombo, Luca Grilli and Donald Siegel). Furthermore, 4 authors (Deniz Ucbasaran, Matthew Marvel, Simon Mosey and Enrico Santarelli) have authored or co-authored two articles each. The rest of the authors, which amount to 77, have only written one article each, indicating that scholars contribute with only one article before they move on to a different field of study. However, this can also indicate that some authors do not hold research as their main occupation. Furthermore, it can be remarked that among the eight authors that have published more than one article, only two are American, while three from come the UK and three from Italy. This indicates that a field of study which has historically been a US phenomenon appears to be changing. Moreover, it may indicate that research environments within the field of human capital are in the process of getting established in the UK and Italy. However, as indicated by figure 5, most of the data used in the articles still originate from the US.

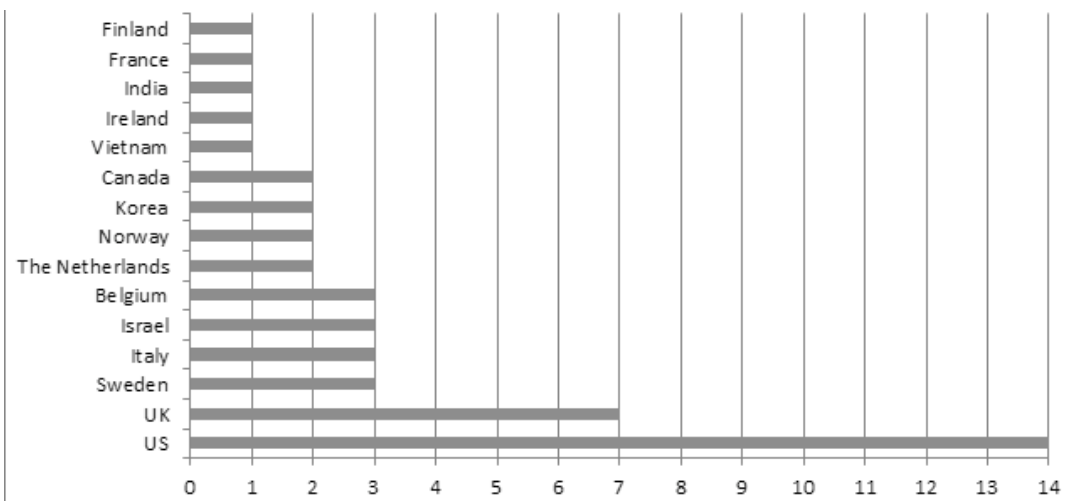


FIGURE 5 - COUNTRIES DATA ORIGINATE FROM

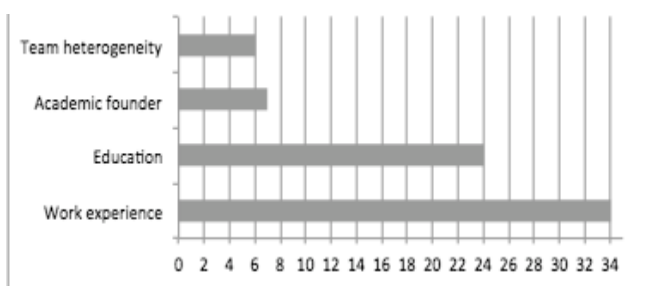
*Key findings:* A review of the articles and their key findings is found in appendix 2. As a result of the review we identified four different operationalizations of human capital that were recurrent in the articles. These four independent variables may affect ASO performance. A description of these operationalizations is found in table 4, and the distribution is displayed in figure 6.

In general many authors investigated work experience (87%) and education (62%) and their effect on the performance of ASOs. The presence of an academic founder was a topic in 18% of the articles, and team heterogeneity was only a topic in 15%.

Furthermore, VC has been used in several studies as an operationalization of performance. In fact, 23% of the articles investigated relations between VC, human capital and performance. Additionally, 30% of the articles had a process orientation to their studies and focused on the early stages of ASO development. Even though we focus on human capital variables, we will touch upon the topics of VC and a process view in the discussion.

To summarize, we see that few articles investigate the relation between ASOs and performance. As anticipated, most scholars study NTBFs. Secondly, we see indications that the field of study of human capital is changing away from being a US phenomenon. Finally, we found that some operationalizations of human capital

FIGURE 6 - OCCURRENCE OF RECURRENT OPERATIONALIZATIONS OF HUMAN CAPITAL



that are recurrent in the literature that was reviewed.

This article will explore work experience and education in connection with the other topics as presented in figure 6, thus developing a comprehensive view on human capital elements that affect ASO performance.

TABLE 4 - OPERATIONALIZATIONS OF HUMAN CAPITAL

Education	If the founder, entrepreneur or entrepreneurial team's education was evaluated.
Work experience	If the founder, entrepreneur or entrepreneurial team's work experience was evaluated.
Academic founder	If it is explicitly stated that the academic founder was assessed.
Team composition	If team heterogeneity was regarded

## 5. DISCUSSION

Researchers generally believe that higher levels of human capital is positively linked to ASO performance (Shane, 2004, Davidsson and Honig, 2003, Colombo and Grilli, 2005, Becker, 1964, Mosey and Wright, 2007). Higher levels of human capital (in the form of education and experience) is linked to being more productive than comparable employees. In the case of ASOs, where the need for problem solving and the ability to adapt to changing environments is essential, such individuals prove to be especially

useful (Bartel and Lichtenberg, 1987, Siegel, 1999, Siegel et al., 1997).

As previously mentioned, most authors look at education and work experience and argue that the various elements differ in how significant they are in predicting the performance of ASOs (Cooper et al., 1994, Unger et al., 2011, Wright et al., 2007b). Some also propose that various elements, in particular experience, are more important in various stages of spin-off development. Vohora et al. (2004)'s phase based model will be used to link these human capital elements to ASO development in the discussion. The focus will be on the *opportunity recognition* and *credibility junctures*. The second and fourth junctures, relating to *commitment* and *sustainability*, are thus left out. The former will not be emphasised as it relates more to the mindset of the "venture champion" rather than the type of experience this champion possesses. The latter is omitted as findings indicate that human capital indicators are insufficient as predictors of performance in later phases (Davidsson and Honig, 2003). Other factors present in the sustainability juncture, such as the choice of growth strategy, will impact human capital needs, indicating that human capital effects will become difficult to measure (Davidsson and Honig, 2003). Accordingly, the importance of human capital elements will be hard to generalise for the sustainability juncture.

A discussion of the reviewed literature on human capital and performance follows. The discussion will follow the same themes as indicated in section 4. First, we will look at how different types of work experiences impact ASO performance, and, where possible, how they differ in importance through junctures of spin-off development. Secondly, considerations on education's effect on performance will be treated. Arguably, education and work experience are closely related. However, the main knowledge type acquired from these differ; while explicit knowledge is the key component learned from education, tacit knowledge is gained through experience (Davidsson and Honig, 2003). Furthermore, type of education has largely been neglected in previous studies (Colombo and Grilli, 2005), and a review of this topic may lead to novel insights. For these reasons we have chosen to treat education separately. Thirdly, team composition and cognitive complementarity will be treated by looking at how different types of work experience and education could be combined. Finally, it will be examined if the academic founders' participation in the ASO will influence ASO performance. This comprehensive

treatment of human capital will help us answer our research question: *How do different types of human capital affect the performance of ASOs?*

## 5.1 Work experience and performance of spin-offs

The following section assesses work experience and its effect on performance. In line with other scholars, we treat the types that are believed to be relevant for the ASO setting; Managerial, commercial, technical and entrepreneurial experience (Ganotakis, 2012, Gimmon, 2010, Ucbasaran et al., 2008, Wright et al., 2007b). Although some of the categories may overlap, they arguably cover most skills that may help an entrepreneur in developing a performing spin-off. The four types are covered below.

### 5.1.1 Managerial work experience

In terms of occupational experience, scholars often assume that skills derived from managerial experience, meaning experience on how to manage and run companies including how to make complex strategic decisions and managing people, has positive effect on the performance of ASOs (Ucbasaran et al., 2008, Aspelund et al., 2005, Ganotakis, 2012, Santarelli and Hien Thu, 2013). As pointed out by Shane (2004), most academic founders do not have managerial experience and those who succeed are the ones that realize and recognise the fact that they need people in the business function of the company. Considering the fast moving environments with short product life-cycles that many high-tech firms operate in, management is a greater challenge than in many other environments (Ucbasaran et al., 2008). Hence, having people with experience in leading and coordinating the business efforts of a firm is expected to be useful. Additionally, managerial experience may foster the ability to see means-end relationships more clearly than those without this experience (Gaglio and Katz, 2001). Lastly, entrepreneurs with higher levels of managerial experience may be more responsive in terms of converting an idea to an opportunity (Ardichvili et al., 2003). In line with the above, successful entrepreneurs interviewed by Gurdon and Samsom (2010) specifically mentioned the importance of a team with management skills as researchers tend to play down the importance of business activities.

Colombo and Grilli (2010), Gurdon and Samsom (2010) and Gimmon (2010) also found a large and direct effect of number of years in managerial roles and ASOs' growth, implying that excellent managerial skills is a matter of

practice and experience rather than an academic talent. Moreover, these authors connect managerial experience with increased likelihood of receiving VC funding. On the one hand, VCs look for firms with high quality management teams and are drawn towards entrepreneurs with managerial experience, as they are more likely to successfully run a company. As a result of the investment, the venture is more likely to become a sustainable success (Colombo and Grilli, 2010). On the other hand, managerial experience implies the ability to run the ASO, administer its resources as well as doing what is necessary to secure external funding. Consequently, in cases where the entrepreneurial team lacks managerial experience, VCs usually replace the CEO with an experienced manager. This means that managerial experience leads to ASO growth both directly (as a result of skills) and indirectly (mediated by VC investment which in turn leads to growth).

From a process perspective, gaining external financing is one of the proxies for having reached venture credibility (Vohora et al., 2004), meaning the presence of managerial experience is helpful in passing this juncture.

In contrast to the above arguments, Davidsson and Honig (2003) reported that managerial experience failed to demonstrate a significant effect on opportunity discovery and exploitation. They argue that managerial experience may foster procedures and routines that do not stimulate effective resource allocation at an early stage. Based on these findings, one could argue that managerial experience is more vital in the later stages of a spin-off development process and at the time when the venture prepares for growth (Wright et al., 2007b, Ucbasaran et al., 2008).

Overall, the literature favours the presence of managerial experience in an entrepreneurial team. It is especially important in terms of gaining venture credibility and external financing as well as in later stages of growth. Some authors have argued that managerial experience is of lesser importance in the earlier stages related to opportunity recognition. The following hypothesis is put forward:

*1a. Managerial work experience among founders has a positive effect on academic spin-off performance. It has a positive effect on overcoming the venture credibility juncture.*

### **5.2.2 Technical work experience**

Technical experience relates to the experience in engineering, research and development or manufacturing (Ganotakis, 2012). The effects of

this type of human capital are found to be especially important in firms based on technology (Unger et al., 2011, Kirzner, 1997, Utterback, 1996, Shrader and Siegel, 2007). Authors highlight that among the different types of human capital, tacit knowledge from technical experience is believed to be one of the most critical types for ASOs (Shrader and Siegel, 2007, Knockaert et al., 2011). High technology based firms are known to be operating in dynamic, rapidly changing markets, meaning flexibility and the ability to create new products that are suited customer needs is of great importance (Ittner and Larcker, 1997, Unger et al., 2011). Accordingly, technical experience is suggested to be a fundamental part of ASO development, as an ASO's product offering is typically built upon the tacit knowledge of inventors/researchers and the transfer of such knowledge (Lowe, 2006, Carlile and Reberich, 2003). Hence, many argue that technological experience will help sustain competitive advantage as well as reduce the risks and costs related to development (Ucbasaran et al., 2008, Park, 2005).

Even though technical experience is expected to be positive to a firm's success, many authors highlight that technical experience must be complemented with other non-technical experience, such as managerial or commercial experience (Kakati, 2003, Oakey, 2003, Ganotakis, 2012, Gurdon and Samsom, 2010, Aspelund et al., 2005). An overemphasis on the technological side may lead to the lack of attention to commercial aspects of the ASO (Kakati, 2003). Shrader and Siegel (2007) argues that technical experienced individuals may overestimate one's skills and the potential of the technology, leading to negative development of the spin-off. Kakati (2003) follows by suggesting that once the product has overcome the prototyping phase and enjoys some protection, focus should be shifted away from technology efforts and balanced with commercial and business activities.

The above arguments suggest that technical experience is of lesser importance in later phases. However, it is especially important in the earlier phases of spin-off development as it reduces the risk and cost of product development (Ucbasaran et al., 2008). Additionally, as spin-offs often commercialize very early stage, embryonic and radical technologies (Shane, 2004, Thursby et al., 2009), where the application is not evident, technical experienced entrepreneurs will be able to understand the technology's potential and limitations. In relation to the process model of Vohora's et al. (2004) we suggest that technical

experience is of importance in the opportunity recognition juncture as it involves matching knowledge of the technology with a commercial application. Based on the above section, the following hypotheses are put forward;

*1c: Technical work experience among founders has a positive effect on academic spin-off performance. It has a positive effect on overcoming the opportunity recognition juncture.*

*1d: Technical work experience in combination with managerial or commercial work experience among founders has a stronger positive effect on academic spin-off performance compared to having technical work experience alone.*

### **5.2.3 Commercial work experience**

*Commercial experience* relates to previous employment with marketing and sales related tasks, as well as contact with customers, suppliers and manufacturers. The term “commercial” is often used interchangeably with industry experience, which may or may not give rise to commercial experience.

Commercial experience (including commercial industry experience) is of value for several reasons; Firstly, it enhances entrepreneurs’ ability to recognise opportunities in unserved markets and the commercial value of a technology. Secondly, it can help identify markets where the product or technology will be radically different to competitors, thus increasing competitive advantage. Lastly, it enhances an entrepreneur's ability to interact with customers, distributors and industry partners (Aspelund et al., 2005, Shane, 2000, Park, 2005, Marvel and Lumpkin, 2007, Shrader and Siegel, 2007, Marvel, 2013). The latter is partly due to an extended network from previous employments. Moreover, Heirman and Clarysse (2004) argues that commercial experience is positive to growth as it brings confidence and knowledge of managing risks in a particular market. Additionally, it signalizes credibility to investors, thus increasing chances of getting VC (Heirman and Clarysse, 2004).

As seen, commercial experience is generally reported to have positive effects on the performance of ASOs, though in line with what is written in the previous section, commercial experience will not perform ideally on its own, but should be complemented with technical experience (Wright et al., 2007b, Ganotakis, 2012, Colombo and Grilli, 2005). This enhances the entrepreneurs ability to understand and communicate how the product or technology can be tailored to fit customer needs. This will in turn

aid the founding team in recognising the best market opportunities for the technology (Knockaert et al., 2011, Ganotakis, 2012). Arguably, ASOs in the opportunity recognition juncture will greatly benefit from having commercial experience on the team.

*1e: Commercial work experience among founders has a positive effect on academic spin-off performance. It has a positive effect on overcoming the opportunity recognition juncture.*

*1f: Commercial work experience in combination with technical work experience among founders has a stronger positive effect on academic spin-off performance compared to having commercial experience alone.*

### **5.2.4 Entrepreneurial work experience**

Entrepreneurial experience is referred to as start-up experience and business ownership experience, and is generally believed to be positively linked to the performance of ASOs (Davidsson and Honig, 2003, Ucbasaran et al., 2008, Mosey and Wright, 2007, Colombo and Grilli, 2005). Two aspects are highlighted; The value of access to external human capital gained through networks and the benefit of direct learning from episodic skills about the entrepreneurial process (tacit knowledge). Prior start-up management is also a strong human capital signal to investors and thereby increases the chances of obtaining VC (Colombo and Grilli, 2005, Hsu, 2007). Shane (2004) argues that credibility (and funding) is gained more swiftly among people with entrepreneurial experience because they have developed an extensive network from previous entrepreneurial activity. Interestingly, there are also some findings suggesting that entrepreneurial activities have a negative relationship to generated profit. This is attributed to the likelihood of second time entrepreneurs being more cautious to the riskiness of ASOs. Second time entrepreneurs are likely to become overconfident and adopt strategies and routines that have worked in the past rather than making new ones.

Entrepreneurial experience has as such produced divergent results when it comes to performance outcomes, but overall, the view of entrepreneurial experience being positive to performance dominate. The following hypothesis is proposed:

*1g: Entrepreneurial work experience among founders has a positive effect on academic spin-off performance. It has a positive effect on overcoming the venture credibility juncture*

## 5.3 Education and performance

Two themes treating education and its effect on ASO performance is found to be recurrent in the literature review. Firstly, a recent stream of literature (Colombo and Grilli, 2005, Gimmon, 2010) focuses on how the type of education of entrepreneurs may affect ASO performance. Secondly, several authors have investigated how the level of education may have an impact on performance. Hence, the type and level of education will be treated in this section.

### 5.3.1 Type of education

Skills useful for entrepreneurs may be gained in education through the accumulation of explicit knowledge (Davidsson and Honig, 2003), and it is arguably interesting to investigate the effect of education on ASO performance. In fact, formal education is one component of human capital that has proved to give nonlinear and inconsistent effects of performance, growth and the exploitation of opportunities (Avermaete et al., 2004, Stuart and Abetti, 1990, Haber and Reichel, 2007, Davidsson and Honig, 2003, Bosma et al., 2004, Mayer-Haug et al., 2013).

Several studies (Davidsson and Honig, 2003, Mayer-Haug et al., 2013, Ucbasaran et al., 2008) have focused on general education by investigating how the level of education of the entrepreneurs affect firm survival or growth. However, the type of education has largely been neglected (Colombo and Grilli, 2005). In recent years some studies have focused on types of education that are found to be more relevant for an ASO setting, most often business, managerial, economic and technical/scientific education (for example (Colombo and Grilli, 2005, Gimmon, 2010)). Research regarding the effect of these education types on performance has produced somewhat divergent results.

Colombo and Grilli (2009) found a significant and positive effect of economic and managerial university education and to a lesser extent technical and scientific education on ASO growth and survival. The former is supported by both Oakey (2003) and Ganotakis (2012). Furthermore, Colombo and Grilli (2010) found that managerial and economic education has a positive effect on the likelihood of receiving VC funding, thus also affecting performance indirectly (see 5.1.1). With regards to technical education, Ganotakis (2012) found it had a significant and negative effect on performance. However, the findings also indicated that when a technical education was combined with commercial experience in an entrepreneurial team

the negative effects from technical education alone were reversed.

As seen the relation between education and performance produce divergent results. Business-related education types appear to have a positive effect on ASO performance, both directly and indirectly, whereas results have been more contradictory with regards to technical education. As seen in 5.2.2, technical work experience is expected to have a positive effect on ASO performance. Furthermore, the tacit knowledge of the researchers and transfer of this was seen as a fundamental part of ASO development (Lowe, 2006, Carlile and Rebentisch, 2003). Accordingly, technical education alone (without technical work experience) may have a negative impact on ASO performance because the person in question lacks tacit knowledge (gained through work experience) relevant for further development of the invention, and because such education may have to be very specific for the ASO in question in order for it to be a predictor of performance. The following hypotheses are put forward:

*2a: Managerial education among founders has a positive effect on academic spin-off performance.*

*2b: Technical education alone among founders (meaning founders with education and no work experience) has a negative effect on academic spin-off performance.*

Where *managerial education* is used as a collective term for business, managerial and economic education.

### 5.3.2 Level of education

Recent studies give support to a reversed U-shaped relationship between education and ASO performance (Oakey, 2003, Ganotakis, 2012, Unger et al., 2011). These studies suggest that individuals with very high levels of general education may not be able to turn their human capital into performance as they might adopt self-righteous attitudes, overestimate their abilities and perceive their present skills to be sufficient to pursue a successful spin-off. This may prevent them from seeking additional information that could have led to either new opportunities, better decisions or valuable contacts (Ucbasaran et al., 2008). In addition to adverse personality characteristics of highly educated, findings indicated that such people are more likely to want to stay in control of their ASOs, potentially threatening long term survival. Additionally, it may be that highly academic people are more oriented towards research (Roberts and Malonet, 1996).

Ganotakis (2012) and Unger et al. (2011) explain the reversed U-shaped relationship differently by proposing that very high education (assumably above masters) may be an indicator of higher age, a family, a desire to do research and a higher perceived opportunity cost of venturing, thus affecting performance indirectly. Furthermore, Gimmon (2010) found that high academic status among founders was not positively related to ASO survival.

Summed up, studies give strong indications that entrepreneurs with a PhD degree affects the performance of ASO in a negative manner, and we thus put forward the following hypothesis:

*2c: General education is expected to have a reversed U-shaped relationship to academic spin-off performance where low (below a bachelors degree) and high (above a master degree) levels of general education have a negative effect on academic spin-off performance.*

Where *general education* refers to all types of education.

## **5.4 Team heterogeneity and cognitive distance**

Several researchers emphasize the importance of complementary skills within entrepreneurial teams (Knockaert et al., 2011, Ganotakis, 2012, Kakati, 2003, Oakey, 2003, Gurdon and Samsom, 2010, Aspelund et al., 2005). Specifically, the presence of cognitive heterogeneity/cognitive distance (where cognitive distance relates to difference between individuals' reference frames, skills and experience) will trigger team members to challenge each others' views and opinions which ultimately leads to better strategy decisions (Wright et al., 2007b). Furthermore, it allows team members to extend and bridge their shared knowledge (Nooteboom et al., 2007). Too large cognitive distance, however, is expected to adversely affect performance; suggesting that cognitive and performance exhibit an inverted u-shaped relationship (Nooteboom et al., 2007).

As already indicated by the hypotheses, the coexistence of commercial (or managerial) experience and technical experience proves to be especially important in ASOs (Ganotakis, 2012, Knockaert et al., 2011, Colombo and Grilli, 2005, Kakati, 2003). In terms of technical education, the coexistence of commercial experience may reverse the negative effects from technical education alone. Compared to other coexistences, the combination of technical and commercial

experience is what scholars tend to highlight the most.

Entrepreneurs in ASOs often possess rich amounts of technical experience, but usually lack commercial experience, meaning such knowledge has to be acquired from outside of the founding team. This leads to the occurrence of a "knowledge gap" which is rooted in the cognitive distance between technical and commercial roles in the founding team (Knockaert et al., 2011, Wright et al., 2007b). Consequently, the introduction of any commercial person in the ASO may not be sufficient to fill the knowledge gap: On the one hand, the commercial person may not be able to communicate and understand the technology, leading to the inability of finding suitable market applications and serving customer demands. On the other hand, technical people with no commercial knowledge are less likely to understand how the market impacts the product development. Similar to Knockaert et al. (2011), we propose that there should be some overlap in cognitive maps so that effective knowledge sharing and coherent understanding of the technology, marketing strategies and the product development can take place. In particular this means that in an ideal ASO founding team, the technical responsible person has some commercial experience and the commercial responsible person has some technical experience, or technical education (as presented by (Ganotakis, 2012)). Based on the above, the following hypothesis is put forward;

*3a: In the presence of complementary skills among founders, overlaps in cognitive maps will enhance the performance of the academic spin-off.*

## **5.5 Presence of academic founder**

Most inventions are at an early stage when a spin-off is established (Shane, 2004). Furthermore, they tend to be of tacit nature, and the tacit knowledge that underlies these inventions makes it paramount that the academic founder is involved in the spin-off development (Shane, 2004).

Since all knowledge is either tacit or rooted in tacit knowledge (Polanyi, 1967) the argument presented by Shane (2004) should be valid for other types of technology transfer and not exclusively for inventions. Knockaert et al. (2010) found that the transfer of tacit knowledge is more inclined to be successful if the scientists who worked with the invention is part of the entrepreneurial team, regardless if the product or



technology is mainly based on explicit knowledge. In fact, spin-offs with the academic founder present are found to be less likely to fail (Nerkar and Shane, 2003), further indicating that having an academic founder affects success positively.

As seen previously, an overemphasis on the technical side may lead to the development of products that fail to serve markets appropriately (Kakati, 2003). Several authors Lockett et al. (2003), Daniels and Hofer (1993), Vohora et al. (2004) and Rasmussen et al. (2011) suggest that academic founders lack commercial experience or knowledge needed to understand the commercial environment surrounding the ASO. Thus, academic founders may have difficulties in finding an attractive market where the technology can satisfy a real consumer need (Vohora et al., 2004). Particularly, potential commercial applications may be easier to see for academic founders with industrial experience (Rasmussen et al., 2011). In fact, Knockaert et al. (2010) found that a top management team with both tacit knowledge about the technology as well as commercial knowledge/mindset will increase the spin-offs performance as the speed to market increases. However, a limitation was that the cognitive distance between the academic founder and the person with commercial knowledge or mindset must not be too large.

As seen above it seems likely that having the academic inventor(s) as founder(s) (called academic founders) of an ASO will increase the performance of the ASO. However, a distinction should be made with regards to the nature of the technology being commercialized and whether tacit or explicit components of knowledge are emphasized. The following hypothesis is proposed:

*4a: Active academic founders present in the entrepreneurial team at inception of an academic spin-off will have a positive effect on academic spin-off performance. The effect will be stronger if the main knowledge component of the technology, invention or research result is of tacit nature as opposed to explicit.*

Where *active academic founder* refers to a person:

(i) Who was part of the research team behind the technology, invention or research result being commercialised (ii) Who is actively involved in the daily operations of the ASO.

## 6. CONCLUSION

This article investigates how different types of human capital, operationalized through education and work experience, affect the performance of academic spin-offs. We treat spin-off development as a process and take a process view into account when addressing human capital needs. Our contribution has been to provide a state of the art review of existing literature and to synthesize this into hypotheses that can be tested in empirical studies. By doing so, we have answered our research question: *How do different types of human capital affect the performance of ASOs?* Specifically we have focused on linking human capital needs to various stages in the ASO development and argued that different kinds of human capital are needed at each juncture. For example, technical experience seems to be necessary in the earliest stages of spin-off development, whereas managerial experience is essential in later phases of spin-off development. Overall, we found that experience affects performance positively, even more so if the founding team is equipped with complementary skills. Education however, has produced inconsistent and generally weak effects on performance, with the exception of managerial education.

The research question should be of interest to scholars, practitioners and policy makers as research shows that spin-offs rarely develop into high-performing ventures (Wright et al., 2007b). Thus there is a need to understand the mechanisms behind ASO development and how effective support mechanisms can be designed. Based on our findings we present a number of implications for practitioners and policy makers.

Considering the TTOs role as commercialisation agents, they should be aware of the fact that ASOs go through several phases with different challenges. To overcome these challenges the human capital needs will differ, depending on the phase the ASO is in. More specifically, TTOs should acknowledge the value of coexistence of commercial and technical experience and aid academic entrepreneurs in finding people that can serve as the commercial counterpart in the team.

Providers of financial advice and funding should be made aware that technical skills are not sufficient to ensure sustainable spin-offs. In line with the above, such skills should be complemented with commercial or managerial skills. As ASOs originate from a non-commercial environment, some of these skills are likely to be absent at spin-off initiation, but are arguably very



important to be able to find a suitable market for the business idea.

Lastly, we make a suggestion related to technical and science-based PhD-programs, research based and technical education. As successful spin-off activity requires complementary non-technical skills, research institutions and technical schools should consider to provide training in such skills. Furthermore, we advise such institutions to adopt an increased focus on how one may commercialize research and pursue opportunities as this is believed to both enhance spin-off activity and increase the share of successful spin-offs.

## 7. LIMITATIONS AND FURTHER RESEARCH

Several elements may impact our findings. Limitations and possibilities of further research will be presented.

*Hypotheses testing:* The hypothesis derived from the literature review should be tested quantitatively. As our literature review draws on research from both ASOs and NTBFs as well as research from different types of spin-off contexts, it is likely that not all hypotheses will be supported or be valid for all types of spin-offs. This in line with Wright et al. (2007a), who points out that the context of the ASO influences how they develop and perform. Testing the hypotheses on real life cases will contribute to theory building on the ASO phenomenon.

*Learning:* Measuring the outcome (skills and knowledge) of a human capital investment (education and experience), in other words learning, is a challenge as it may, or may not, lead to knowledge and skills (Unger et al., 2011). In this paper we have assumed that experience and education results in knowledge or skills, as supported by literature (Unger et al., 2011). Measurement of the relation between a human capital investment and actual knowledge and skills should be looked further into, as it is probable that even people with comparable experience and education process this in different ways, resulting in diverging knowledge and skills (Quinones et al., 1995).

*Influence of personality traits:* Another issue related to human capital that might influence (the outcome of) human capital is grounded in studies related to psychology. The personality traits of the involved actors may affect our findings. As Ganotakis (2012) points out, high technical education may lead to or correlate with some personality traits that have adverse effects

on the performance of the spin-off. Furthermore, some skills may be a result of personality traits rather than a result of education or experience. Entrepreneurial skills is suggested to partly be such a trait. The relation between skills and experience as well as the relation between personality traits and skills should be further researched.

*Team composition and heterogeneity:* Another concern relates to the composition of the entrepreneurial team. As shown by Wright et al. (2007b), cognitive heterogeneity may be vital for team members to challenge each other, ultimately ending up with a superior strategy for the ASO. Wright et al. (2007b) argue that when expanding the entrepreneurial team, current members are often inclined to appoint new members that are cognitively alike and have similar views on doing business. Arguably, there is a chance that the new members' skills will not see their full potential and that skills in the team are overlapping. Furthermore, Knockaert et al. (2011) argues that the cognitive distance between founding members should not be too large as it may inhibit the effective transfer of knowledge. How personality traits, cognitive distance, team composition and team dynamics can mediate the knowledge and skills of these people is an area for further research.

*Literature context:* This literature review has focused on ASOs, yet several of the articles reviewed have focused on other objects such as research based spin-offs and NTBFs. This is something that may affect our findings as we generalize this to apply to ASOs. However, as ASOs are a subset of NTBFs, it may be that the effects of this are negligible. Furthermore, since we have supplemented with specific literature for ASOs and academic founders we argue that this effect is minimized.

*Industry influence:* ASOs can span a variety of industries. It is possible that industry differences may affect the human capital needs of an ASO as well as their effect on performance. For example, the resources required by firms in biotechnology may be quite distinct from those needed by software firms. One would also expect the timescale and phases over which these resources may be needed are very different (Mustar et al., 2006). However, Roure and Keeley (1990) found that industry differences do not affect ASOs' performance. Others again have looked at differences between high-tech and low-tech industries, and found that there is no difference of human capital effects between the two (Unger et al., 2011). A further investigation

of how industry affects human capital needs is warranted.

*Method:* As with any method, our method has both strengths and weaknesses. A trade-off is made between the scope and the time spent reviewing literature. Drawbacks of the methods used in this paper are highlighted below;

1. The scope of discarded articles may have been wider than indicated in the titles and abstracts. This may have affected our search since in the first two stages we only filtered based on title and title and abstract.
2. The search does not capture all the relevant literature as we only searched in a limited number of journals and with a defined set of keywords that may not be optimal. The search would be improved by doing a separate search based on the effects of human capital on new ASOs. These terms were not included in our search. However, most of these articles are likely to be registered through the other search words and through reversed snowballing.
3. Our search does not capture recently published works that are outside the scope of the structured search (but still possibly relevant) as reversed snowballing only tracks older articles.

## REFERENCES

- ALEXANDER, P. A., SCHALLERT, D. L. & HARE, V. C. 1991. Coming to Terms - How Researchers in Learning and Literacy Talk About Knowledge. *Review of Educational Research*, 61, 315-343.
- ALVAREZ, S. A. & BUSENITZ, L. W. 2001. The entrepreneurship of resource-based theory. *Journal of Management*, 27, 755-775.
- AMBOS, T. C. & BIRKINSHAW, J. 2010. How do new ventures evolve? An inductive study of archetype changes in science-based ventures. *Organization Science*, 21, 1125-1140.
- AMIT, R. & BELCOURT, M. 1999. Human resources management processes: a value-creating source of competitive advantage. *European Management Journal*, 17, 174-181.
- ARDICHVILI, A., CARDOZO, R. & RAY, S. 2003. A theory of entrepreneurial opportunity identification and development. *Journal of Business Venturing*, 18, 105-123.
- ASPELUND, A., BERG-UTBY, T. & SKJEVDAL, R. 2005. Initial resources' influence on new venture survival: a longitudinal study of new technology-based firms. *Technovation*, 25, 1337-1347.
- AVERMAETE, T., VIAENE, J., MORGAN, E. J., PITTS, E., CRAWFORD, N. & MAHON, D. 2004. Determinants of product and process innovation in small food manufacturing firms. *Trends in Food Science & Technology*, 15, 474-483.
- BAMFORD, C. E., DEAN, T. J. & MCDOUGALL, P. P. 2000. An examination of the impact of initial founding conditions and decisions upon the performance of new bank start-ups. *Journal of Business Venturing*, 15, 253-277.
- BARNEY, J. 1991. Firm Resources and Sustained Competitive Advantage. *Journal of Management*, 17, 99-120.
- BARTEL, A. P. & LICHTENBERG, F. R. 1987. The Comparative Advantage of Educated Workers in Implementing New Technology. *Review of Economics and Statistics*, 69, 1-11.
- BECKER, G. S. 1964. *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, by Gary S. Becker, London.
- BHAVE, M. P. 1994. A process model of entrepreneurial venture creation. *Journal of Business Venturing*, 9, 223-242.
- BORCH, O. J., HUSE, M. & SENNESETH, K. 1999. Resource configuration, competitive strategies, and corporate entrepreneurship: An empirical examination of small firms. *Entrepreneurship Theory and Practice*, 24, 49-70.
- BOSMA, N., VAN PRAAG, M., THURIK, R. & DE WIT, G. 2004. The value of human and social capital investments for the business performance of startups. *Small Business Economics*, 23, 227-236.
- BRUSH, C. G., GREENE, P. G. & HART, M. M. 2001. From initial idea to unique advantage: The entrepreneurial challenge of constructing a resource base. *Academy of Management Executive*, 15, 64-78.
- BRUSH, C. G., GREENE, P. G., HART, M. M. & EDELMAN, L. F. 1997. Resource configurations over the life cycle of ventures. *Frontiers of Entrepreneurship Research 1997*, 315-329.

- CARAYANNIS, E. G., ROGERS, E. M., KURIHARA, K. & ALLBRITTON, M. M. 1998. High-technology spin-offs from government R&D laboratories and research universities. *Technovation*, 18, 1-11.
- CARLILE, P. R. & REBENTISCH, E. S. 2003. Into the black box: The knowledge transformation cycle. *Management Science*, 49, 1180-1195.
- CLARYSSE, B. & HEIRMAN, A. 2000. AN INSTITUTIONAL AND RESOURCE BASED EXPLANATION OF GROWTH PATTERNS OF RESEARCH BASED SPIN-OFFS IN EUROPE. *Frontiers of Entrepreneurship Research*.
- CLARYSSE, B. & MORAY, N. 2004. A process study of entrepreneurial team formation: the case of a research-based spin-off. *Journal of Business Venturing*, 19, 55-79.
- CLARYSSE, B., WRIGHT, M., LOCKETT, A., VAN DE VELDE, E. & VOHORA, A. 2005. Spinning out new ventures: a typology of incubation strategies from European research institutions. *Journal of Business Venturing*, 20, 183-216.
- CLARYSSE, B., WRIGHT, M. & VAN DE VELDE, E. 2011. Entrepreneurial Origin, Technological Knowledge, and the Growth of Spin-Off Companies. *Journal of Management Studies*, 48, 1420-1442.
- COLOMBO, M. G. & GRILLI, L. 2005. Founders' human capital and the growth of new technology-based firms: A competence-based view. *Research Policy*, 34, 795-816.
- COLOMBO, M. G. & GRILLI, L. 2009. A capital partnership: how human and venture capital affect the growth of high - tech start - ups. *Strategic Change*, 18, 231-239.
- COLOMBO, M. G. & GRILLI, L. 2010. On growth drivers of high-tech start-ups: Exploring the role of founders' human capital and venture capital. *Journal of Business Venturing*, 25, 610-626.
- COOPER, A. C. & BRUNO, A. V. 1977. Success among High-Technology Firms. *Business Horizons*, 20, 16-22.
- COOPER, A. C., GIMENOGASCON, F. J. & WOO, C. Y. 1994. INITIAL HUMAN AND FINANCIAL CAPITAL AS PREDICTORS OF NEW VENTURE PERFORMANCE. *Journal of Business Venturing*, 9, 371-395.
- DANIELS, G. K. & HOFER, C. W. 1993. Characteristics of Successful and Unsuccessful Entrepreneurial Faculty and Their Innovative Research Teams. *Frontiers of Entrepreneurship Research 1993*, 598-609.
- DAVIDSSON, P. & HONIG, B. 2003. The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing*, 18, 301-331.
- DJOKOVIC, D. & SOUITARIS, V. 2008. Spinouts from academic institutions: a literature review with suggestions for further research. *The Journal of Technology Transfer*, 33, 225-247.
- DONATO, I., ALESSANDRO, I., ALESSANDRA, M. & SIMONE, O. 2011. Fostering entrepreneurship in academic spin-offs. *IJESB*, 12, 513-533.
- DRUILHE, C. & GARNSEY, E. 2004. Do Academic Spin-Outs Differ and Does it Matter? *The Journal of Technology Transfer*, 29, 269-285.
- EISENHARDT, K. M. & MARTIN, J. A. 2000. Dynamic capabilities: What are they? *Strategic Management Journal*, 21, 1105-1121.
- ETO, M., WIERENGO, D. & ROGERS, E. M. Technology transfer from government R&D laboratories in the United States and Japan. *System Sciences*, 1995. Proceedings of the Twenty-Eighth Hawaii International Conference on, 3-6 Jan 1995 1995. 671-680 vol.4.
- FRANKLIN, S., WRIGHT, M. & LOCKETT, A. 2001. Academic and Surrogate Entrepreneurs in University Spin-out Companies. *The Journal of Technology Transfer*, 26, 127-141.
- GAGLIO, C. M. & KATZ, J. A. 2001. The psychological basis of opportunity identification: Entrepreneurial alertness. *Small Business Economics*, 16, 95-111.
- GANOTAKIS, P. 2012. Founders' human capital and the performance of UK new technology based firms. *Small Business Economics*, 39, 495-515.
- GIBSON, D. V. & ROGERS, E. M. 1994. R&D collaboration on trial.
- GIMMON, E. 2010. *Founder's human capital, external investment, and the survival of new high-technology ventures*.
- GRANT, R. M. 1991. The Resource-Based Theory of Competitive Advantage - Implications for Strategy Formulation.

- California Management Review*, 33, 114-135.
- GURDON, M. A. & SAMSOM, K. J. 2010. A longitudinal study of success and failure among scientist-started ventures. *Technovation*, 30, 207-214.
- HABER, S. & REICHEL, A. 2007. The cumulative nature of the entrepreneurial process: The contribution of human capital, planning and environment resources to small venture performance. *Journal of Business Venturing*, 22, 119-145.
- HARRISON, R. T. & LEITCH, C. 2010. Voodoo Institution or Entrepreneurial University? Spin-off Companies, the Entrepreneurial System and Regional Development in the UK. *Regional Studies*, 44, 1241-1262.
- HASHIMOTO, M., ROGERS, E. M., HALL, B. J., STEFFENSEN, M. & SPEAKMAN, K. 1997. Technology transfer in university-based research centres at the University of New Mexico. *Thirtieth Hawaii International Conference on System Sciences, Vol 3*, 116-123.
- HAYTER, C. S. 2011. In search of the profit-maximizing actor: motivations and definitions of success from nascent academic entrepreneurs. *Journal of Technology Transfer*, 36, 340-352.
- HAYTER, C. S. 2013. Harnessing University Entrepreneurship for Economic Growth: Factors of Success Among University Spin-offs. *Economic Development Quarterly*, 27, 18-28.
- HEIRMAN, A. & CLARYSSE, B. 2004. How and Why do Research-Based Start-Ups Differ at Founding? A Resource-Based Configurational Perspective. *The Journal of Technology Transfer*, 29, 247-268.
- HINDLE, K. & YENCKEN, J. 2004. Public research commercialisation, entrepreneurship and new technology based firms: an integrated model. *Technovation*, 24, 793-803.
- HSU, D. H. 2007. Experienced entrepreneurial founders, organizational capital, and venture capital funding. *Research Policy*, 36, 722-741.
- ITTNER, C. D. & LARCKER, D. F. 1997. Product development cycle time and organizational performance. *Journal of Marketing Research*, 34, 13-23.
- KAKATI, M. 2003. Success criteria in high-tech new ventures. *Technovation*, 23, 447-457.
- KIRZNER, I. M. 1997. Entrepreneurial discovery and the competitive market process: An Austrian approach. *Journal of Economic Literature*, 35, 60-85.
- KNOCKAERT, M., CLARYSSE, B. & WRIGHT, M. 2010. The extent and nature of heterogeneity of venture capital selection behaviour in new technology-based firms. *R & D Management*, 40, 357-371.
- KNOCKAERT, M., UCBASARAN, D., WRIGHT, M. & CLARYSSE, B. 2011. The Relationship Between Knowledge Transfer, Top Management Team Composition, and Performance: The Case of Science-Based Entrepreneurial Firms. *Entrepreneurship Theory and Practice*, 35, 777-803.
- LAWTON SMITH, H. & HO, K. 2006. Measuring the performance of Oxford University, Oxford Brookes University and the government laboratories' spin-off companies. *Research Policy*, 35, 1554-1568.
- LOCKETT, A., SIEGEL, D., WRIGHT, M. & ENSLEY, M. D. 2005. The creation of spin-off firms at public research institutions: Managerial and policy implications. *Research Policy*, 34, 981-993.
- LOCKETT, A., WRIGHT, M. & FRANKLIN, S. 2003. Technology transfer and universities' spin-out strategies. *Small Business Economics*, 20, 185-200.
- LOWE, R. A. 2006. Who develops a university invention? The impact of tacit knowledge and licensing policies. *The Journal of Technology Transfer*, 31, 415-429.
- MAKADOK, R. & BARNEY, J. B. 2001. Strategic factor market intelligence: An application of information economics to strategy formulation and competitor intelligence. *Management Science*, 47, 1621-1638.
- MARVEL, M. R. 2013. Human Capital and Search-Based Discovery: A Study of High-Tech Entrepreneurship. *Entrepreneurship Theory and Practice*, 37, 403-419.
- MARVEL, M. R. & LUMPKIN, G. T. 2007. Technology entrepreneurs' human capital and its effects on innovation

- radicalness. *Entrepreneurship Theory and Practice*, 31, 807-828.
- MAYER-HAUG, K., READ, S., BRINCKMANN, J., DEW, N. & GRICHNIK, D. 2013. Entrepreneurial talent and venture performance: A meta-analytic investigation of SMEs. *Research Policy*, 42, 1251-1273.
- MOSEY, S. & WRIGHT, M. 2007. From human capital to social capital: A longitudinal study of technology - based academic entrepreneurs. *Entrepreneurship Theory and Practice*, 31, 909-935.
- MUSTAR, P., RENAULT, M., COLOMBO, M. G., PIVA, E., FONTES, M., LOCKETT, A., WRIGHT, M., CLARYSSE, B. & MORAY, N. 2006. Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy. *Research Policy*, 35, 289-308.
- NERKAR, A. & SHANE, S. 2003. When do start-ups that exploit patented academic knowledge survive? *International Journal of Industrial Organization*, 21, 1391-1410.
- NICOLAOU, N. & BIRLEY, S. 2003. Academic networks in a trichotomous categorisation of university spinouts. *Journal of Business Venturing*, 18, 333-359.
- NOOTEBOOM, B., VAN HAVERBEKE, W., DUYSTERS, G., GILSING, V. & VAN DEN OORD, A. 2007. Optimal cognitive distance and absorptive capacity. *Research Policy*, 36, 1016-1034.
- O'SHEA, R. P., ALLEN, T. J., CHEVALIER, A. & ROCHE, F. 2005. Entrepreneurial orientation, technology transfer and spinoff performance of US universities. *Research Policy*, 34, 994-1009.
- OAKLEY, R. P. 2003. Technical entrepreneurship in high technology small firms: some observations on the implications for management. *Technovation*, 23, 679-688.
- PARK, J. S. 2005. Opportunity recognition and product innovation in entrepreneurial hi-tech start-ups: a new perspective and supporting case study. *Technovation*, 25, 739-752.
- PETERAF, M. A. 1993. The Cornerstones of Competitive Advantage - a Resource-Based View. *Strategic Management Journal*, 14, 179-191.
- PIRNAY, F., SURLEMONT, B., NLEMVO, F., XOOE, XOOE & RIC 2003. Toward a Typology of University Spin-offs. *Small Business Economics*, 21, 355-369.
- POLANYI, M. 1967. The tacit dimension.
- QUINONES, M. A., FORD, J. K. & TEACHOUT, M. S. 1995. The relationship between work experience and job performance: A conceptual and meta-analytic review. *Personnel Psychology*, 48, 887-910.
- RADOSEVICH, R. 1995. A model for entrepreneurial spin-offs from public technology sources. *International Journal of Technology Management*, 10, 879-893.
- RASMUSSEN, E. 2011. *Understanding academic entrepreneurship: Exploring the emergence of university spin-off ventures using process theories*.
- RASMUSSEN, E., MOSEY, S. & WRIGHT, M. 2011. The Evolution of Entrepreneurial Competencies: A Longitudinal Study of University Spin-Off Venture Emergence. *Journal of Management Studies*, 48, 1314-1345.
- RASMUSSEN, E. B. 2012. *The Impact of Science-Based Entrepreneurial Firms - a Literature Review and Policy Synthesis. Unpublished.* -, -.
- ROBERTS, E. B. & MALONET, D. E. 1996. Policies and structures for spinning off new companies from research and development organizations#. *R&D Management*, 26, 17-48.
- ROGERS, E., STEFFENSEN, M. & DORF, D. 1999. Handbook of technology management. *Handbook of technology management*.
- ROGERS, E. M., TAKEGAMI, S. & YIN, J. 2001. Lessons learned about technology transfer. *Technovation*, 21, 253-261.
- ROTHAERMEL, F. T., AGUNG, S. D. & JIANG, L. 2007. University entrepreneurship: a taxonomy of the literature. *Industrial and Corporate Change*, 16, 691-791.
- ROURE, J. B. & KEELEY, R. H. 1990. PREDICTORS OF SUCCESS IN NEW TECHNOLOGY BASED VENTURES. *Journal of Business Venturing*, 5, 201-220.
- SANTARELLI, E. & HIEN THU, T. 2013. The interplay of human and social capital in shaping entrepreneurial performance: the case of Vietnam. *Small Business Economics*, 40, 435-458.
- SHANE, S. 2000. Prior knowledge and the discovery of entrepreneurial opportunities. *Organization Science*, 11, 448-469.

- SHANE, S. 2004. Academic Entrepreneurship: University Spinoffs And Wealth Creation. *Book*.
- SHANE, S. & TOBY, S. 2002. Organizational Endowments and the Performance of University Start-Ups. *Management Science*, 48, 154-170.
- SHRADER, R. & SIEGEL, D. S. 2007. Assessing the relationship between human capital and firm performance: Evidence from technology-based new ventures. *Entrepreneurship Theory and Practice*, 31, 893-908.
- SIEGEL, D. S. 1999. Skill-biased technological change: Evidence from a firm-level survey. *Books from Upjohn Press*.
- SIEGEL, D. S., WALDMAN, D. A. & YOUNGDAHL, W. E. 1997. The adoption of advanced manufacturing technologies: Human resource management implications. *Engineering Management, IEEE Transactions on*, 44, 288-298.
- SMILOR, R. W., GIBSON, D. V. & DIETRICH, G. B. 1990. University spin-out companies: Technology start-ups from UT-Austin. *Journal of Business Venturing*, 5, 63-76.
- STREETON, R., COOKE, M. & CAMPBELL, J. 2004. Researching the researchers: Using a snowballing technique: In this paper, Rosemarie Streeton, Mary Cooke and Jackie Campbell focus on an aspect of the needs and obligations of the UK Research Governance Framework (DoH 2001). In particular, they discuss the snowballing recruitment technique and how this relates to the demands of research governance. The discussion is supported by examples from the literature and from the authors' own experiences in identifying research activity and skills across health and social care within a single health authority in the UK. *Nurse Researcher*, 12, 35-46.
- STUART, R. W. & ABETTI, P. A. 1990. Impact of Entrepreneurial and Management Experience on Early Performance. *Journal of Business Venturing*, 5, 151-162.
- TEECE, D. J., PISANO, G. & SHUEN, A. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal*, 18, 509-533.
- THURSBY, J., FULLER, A. W. & THURSBY, M. 2009. US faculty patenting: Inside and outside the university. *Research Policy*, 38, 14-25.
- UCBASARAN, D., WESTHEAD, P. & WRIGHT, M. 2008. Opportunity identification and pursuit: Does an entrepreneur's human capital matter? *Small Business Economics*, 30, 153-173.
- UNGER, J. M., RAUCH, A., FRESE, M. & ROSENBUSCH, N. 2011. Human capital and entrepreneurial success: A meta-analytical review. *Journal of Business Venturing*, 26, 341-358.
- UTTERBACK, J. M. 1996. Mastering the dynamics of innovation: How companies can seize opportunities in the face of technological change. *Long Range Planning*, 29, 908-909.
- VAN GEENHUIZEN, M. & SOETANTO, D. P. 2009. Academic spin-offs at different ages: A case study in search of key obstacles to growth. *Technovation*, 29, 671-681.
- VOHORA, A., WRIGHT, M. & LOCKETT, A. 2004. Critical junctures in the development of university high-tech spinout companies. *Research Policy*, 33, 147-175.
- WALTER, A., PARBOTEEAH, K. P., RIESENHUBER, F. & HOEGL, M. 2011. Championship Behaviors and Innovations Success: An Empirical Investigation of University Spin-Offs\*. *Journal of Product Innovation Management*, 28, 586-598.
- WIDDING, L. 2003. *Bygging av kunnskapsreservoarer i teknologibaserte nyetableringer*, Bodø graduate school.
- WIDDING, L. Ø. 2005. Building entrepreneurial knowledge reservoirs. *Journal of Small Business and Enterprise Development*, 12, 595-612.
- WRIGHT, M., CLARYSSE, B. & MOSEY, S. 2012. Strategic entrepreneurship, resource orchestration and growing spin-offs from universities. *Technology Analysis & Strategic Management*, 24, 911-927.
- WRIGHT, M., CLARYSSE, B., MUSTAR, P. & LOCKETT, A. 2007a. Academic entrepreneurship in Europe.
- WRIGHT, M., HMIELESKI, K. M., SIEGEL, D. S. & ENSLEY, M. D. 2007b. The role of human capital in technological entrepreneurship. *Entrepreneurship Theory and Practice*, 31, 791-806.

WRIGHT, M., LOCKETT, A., CLARYSSE, B. & BINKS, M. 2006. University spin-out companies and venture capital. *Research Policy*, 35, 481-501.

ZHUANG, Y. L. & LEDERER, A. L. 2006. A resource-based view of electronic

commerce. *Information & Management*, 43, 251-261.

ZUCKER, L. G., DARBY, M. R. & ARMSTRONG, J. S. 2002. Commercializing knowledge: University science, knowledge capture, and firm performance in biotechnology. *Management Science*, 48, 138-153.

# Appendix

## Appendix 1 - search terms and syntax

Table below shows the search words that were used to search both title and abstract in order to uncover as much as possible of the relevant literature.

Nature of firm	Firms	Success/failure
NTBF	Venture*	success
New technology based	Spin-off*	Successful
Technology based	Spin-out*	non-success
Technology-based	Spinoff*	non-successful
research based*	Spinout	non success
research based*	New firm	non successful
science-based*	Entrepreneurial	Unsuccessful
science based*	Entrepreneurship	Fail*
Academic*	Start up	perform*
University*		Non-perform*
		accomplished
		Succeed
		surviv*

Search syntax:

Topic=((NTBF\* OR New technology based OR Technology based OR Technology-based OR research based\* OR research based\* OR science-based\* OR science based\* OR Academic\* OR University\*) AND (Venture\* OR Spin-off\* OR Spin-out\* OR Spinoff\* OR Spinout\* OR New firm OR Entrepreneur\* OR Start-up\* OR startup\*) AND (Successful\* OR non-success\* OR non-successful\* OR non success\* OR non success\* OR Fail\* OR Non-perform\* OR perform\* OR accomplish\* OR Suce\* OR surviv\*)) AND Publication Name=(Research Policy OR Journal of Business Venturing OR Journal of Technology transfer OR technovation OR Management Science OR strategic Management journal OR R & D Management OR Industrial and Corporate change OR small Business Economics OR Entrepreneurship theory and practice OR administrative science quarterly OR american economic review OR academy of management review OR organization science OR academy of management journal)



## **Appendix 2 - Literature review**

Article	Author	Research Question	Approach/method	Key findings	Human capital operationalizations
Initial resources' influence on new venture survival: a longitudinal study of new technology-based firms	Aspelund, A. Berg-Utby, T. Skjvedal, R.	To what extent the resources controlled by the entrepreneurs at the firm's inception affect the new organisation's ability to survive the first years.	Looked at 80 startups from Norway and Sweden. Studied businessplans and CVs	Found that the initial resources base affects the firms ability to survive the first few years. Also found that founding team's heterogeneity and that the technology radicalness both positively affect the firms survival chances.	Early stage, work experience
Determinants of product and process innovation in small food manufacturing firms	Avermaete, T. Viaene, J. Morgan, E. J. Pitts, E. Crawford, N. Mahon, D.	Examines the determinants of product and process innovation in small food manufacturing firms	Survey of 177 firms	Identified four groups of firms: followers, traditionals, leaders and non-innovators. The difference lies in their focus on innovation, where the former three have R&D activities. They found no support for the managers background and experience being related to innovation. Furthermore, they found that the workforce skills differed with the type of firm. They also found that the higher R&D activity was related to more intensive collaboration with research institutions and customers.	Education, work experience
The value of human and social capital investments for the business performance of startups	Bosma, N. van Praag, M. Thurik, R. de Wit, G.	To what extent does investment in human and social capital, besides the effect of 'talent', enhance entrepreneurial performance?	Empirical analysis of a rich Dutch longitudinal data set of firm founders	Found that specific investments of firm founders in human or social capital enhance their performance. However, without further explorations the authors argue that they cannot be sure whether this positive effect is solely due to the investment itself or partly due to the fact that more talented firm founders invest more in their human and social capital.	Education, work experience
The founders self-assessed competence and venture performance	Chandler, G. N. Jansen, E.	How does the founders self assessed competence affect the venture performance?	Questionnaire to entrepreneurs	Founders in successful startups rate themselves highly in the following personal characteristics: Ability to recognise a business opportunity, above average skills in a managerial role, organisational and interpersonal skills (These skills were enhanced by higher level business education and general manager experience), as well as having high technical expertise. The most successful founders look at themselves as competent in both a managerial, technical and entrepreneurial role. Thus, they can be considered as a "generalist" and understand all the aspects of their own startup.	Education, work experience
Success in Israeli high-tech start-ups; Critical factors and process	Chorev, S. Anderson, A. R.	What are the critical factors and process for a venture's success?	Interviews with VC's, founders and managers	Based on their findings Chorev and Anderson conceptualised a model for how a venture becomes a success. Key factors were identified: Core team's commitment, expertise, marketing, customer relationship, and R&D. They also identified some external factors: The economy, politics, and general business environment.	Education, work experience, VC
A capital partnership: how human and venture capital affect the growth of high-tech start-ups	Colombo, M G Grilli, Luca	How does human and venture capital affect the growth of high-tech start-ups?	Survey, large sample of Italian high-tech start-ups (439)	Found that an entrepreneurs' human capital and venture capital are two fundamental ingredients for the success of high-tech start-ups. However there were some limitations: The two seem to be substitutes rather than complements. Found that two growth models are typical for Italian NTBFs. One is characterised by financial constraints, and the key driver of firm growth is the skills of the entrepreneur. The other is characterised by receiving VC funding. The latter leads to greater growth, regardless of the skills of the entrepreneur.	Education, work experience, VC
Founders' human capital and the growth of new technology-based firms: A competence-based view	Colombo, Massimo G. Grilli, Luca	Analyze empirically the relation between the growth of new technology-based firms and the human capital of founders, with the aim of teasing out the "wealth" and "capability" effects of human capital.	506 Italian firms that operate in high tech industries. Use of a questionnaire.	Type of education and previous work experience in founders is found to have a strong influence on growth. The founder's years in managerial and business education affects growth positively. Founder's number of years in technical education is also found to affect firm growth positively, although to a lesser extent. Other types of education are found not to have a positive effect on growth. Previous work experience has to be industry specific for it to be related to growth in a positive way. Technical rather than commercial work experience determines growth. Also having a founding team where individuals have prior entrepreneurial experiences affects growth positively. Some combinations of complementary capabilities of founders was found to give synergistic gains.	Education, work experience, team heterogeneity

Article	Author	Research Question	Approach/method	Key findings	Human capital operationalizations
On growth drivers of high-tech start-ups: Exploring the role of founders' human capital and venture capital	Colombo, Massimo G. Grilli, Luca	Examine the joint effect of founders' human capital and VC investment.	439 Italian NTBFs. Use of a questionnaire	Firms that are founded by individuals with select human capital characteristics (university level education in management and economics and prior work experience in technical functions relevant for the new firm) can leverage these capabilities to gain a competitive advantage. Found that human capital has a direct positive impact on firm growth, and an indirect positive effect as VC investments are accessed.	Education, work experience, VC
Initial human and financial capital as predictors of new venture performance	Cooper, A. C. Gimenogason, F. J. Woo, C. Y.	Can you predict a new ventures performance based on their initial human and financial capital?	1053 new ventures, Questionnaire	Investigated the relation between the following elements with firm survival and growth: general background, management know how, specific industry know how and financial capital. Found that factors related to the general background were related to marginal survival and growth. Management know how was shown to have limited effects on survival and growth. Industry specific know how was influential on both survival and growth. Also financial capital had an impact on survival and growth. Created and confirmed a model that with some degree of confidence can predict a new ventures performance.	Education, work experience
The role of social and human capital among nascent entrepreneurs	Davidsson, P. Honig, B.	How does human and social capital impact the discovery, exploitation and success of a startup?	Compared nascent entrepreneurs (n= 360) with general population, a control group. 18 months longitudinal study. Interviews	Formal education and previous startup experience is important for opportunity identification and exploitation activity but not for successful outcome such as first sales. Managerial experience not a predictor for exploitation and opportunity identification. Tacit knowledge seems to become more important in later processes. Weak indicators of human capital for successful exploitation. Social capital was higher in the nascent entrepreneurs than in the control group. In particular, being a member of a business network had statistically positive effect on showing a profit, or first sales.	Early stage, education, work experience
Founders' human capital and the performance of UK new technology based firms	Ganotakis, Panagiotis	Investigating the role of entrepreneurs' general and specific human capital on the performance of UK new technology based firms using a human capital resource based approach to the entrepreneurship theory.	Uses data derived from surveys collected from 412 firms operating in both high tech manufacturing and service sectors. UK setting	Specific human capital's impact on performance is greater than that of general human capital. Business education was found to have a positive effect on performance. Technical education or experience had a negative or insignificant effect on performance. Found that entrepreneurial teams had better performing NTBFs compared to single entrepreneurs. The coexistence of technical education with commercial experience or was found to improve NTBF performance. Furthermore, the interaction of managerial technical experience with managerial commercial experience had a positive effect on performance.	Education Work experience Team heterogeneity
Predicting new venture survival: An analysis of "Anatomy of a Start-up." Cases from Inc. magazine	Gartner, W. B. Starr, J. A. Bhat, S.	Hypothesized that a series of activities and or knowledge and abilities would be in the startups that survived, and not in the ones that perished.	Questionnaire sent to 27 startups featured in INC magazines "anatomy of a startup" articles.	Found that entrepreneurs that possessed more knowledge and/or ability at the beginning or at the end of the case, were not part of the surviving firms. Previous industry experience was a predictor for failure. However the "change in knowledge" was proved to be a reliable measure for success. They point to this as the entrepreneur having the "flexibility" to adapt to new and unknown situations. Also predictors for survival were entrepreneurs who: Devoted more effort into the startup and analyzing potential new entrants and spent less time than average on determining the identity of their business, and focused on customized products or services (i.e targeted a niche market).	Work experience

Article	Author	Research Question	Approach/method	Key findings	Human capital operationalizations
Survival of the fittest? Entrepreneurial human capital and the persistence of underperforming firms	Gimeno, Javier Folta, Timothy B Cooper, Arnold C Woo, Carolyn Y	Why does some firms survive while other firms with equal economic performance do not?	Survey, sample of 1,547 entrepreneurs of new businesses in the U.S	Organizations differ in their thresholds of performance, and they argue that organizational survival is dependent on these thresholds, and not strictly a function of economic performance. The findings suggest that those firms with low thresholds may choose to continue/survive although they are experiencing low performance. Some dimensions of human capital (such as the entrepreneur's age, intrinsic motivation and his/her family's experience with entrepreneurship) are found not to influence performance, but they do influence the persistence, thus survival.	Work experience Education
Founder's human capital, external investment, and the survival of new high-technology ventures	Gimmon, E Levie, J	To what extent does the human capital of founders of new high-technology ventures attract external investors and facilitate survival?	First a literature review was carried out, resulting in 6 hypothesis. These were then tested using a survey of a sample of 193 founders of high-technology export start-ups in Israel .	Found three direct relations between human capital and venture survival: Business management expertise as well as general technological expertise significantly affected venture survival. The academic status of the founder did not affect survival in a positive way. Found three relations between human capital and attracting external investment: The academic status of the founder did have a significant and positive effect on the odds of achieving external investment. Business management expertise did also have a positive effect on external investment, whereas general technological expertise did not increase the chances of obtaining external investment in a significant way.	Work experience Education
A longitudinal study of success and failure among scientist-started ventures	Gurdon, M. A. K. J. Samsom	Provides an explanation for success and failure in terms of competencies and capabilities of the entrepreneurs	Longitudinal interviews. Followed firms from 1989 to 2001. Multiple case study. Scientist started ventures in North America and Canada. Biomedical firms.	Makes a point that the quality of human capital contributes to firm survival and growth, and that human capital is dependent on personality variables as well as technical know-how. Found the following reasons for success: Quality of the science, business capabilities of the management functions, personnel as well as venture team capabilities. The reasons for failure: overdependence on a narrow base of support - no business experience, lack of evidence of team building, failure of nerve and failure to address market properly.	Experience Academic founder
In search of the profit-maximizing actor: motivations and definitions of success from nascent academic entrepreneurs	Hayter, Christopher S.	Examines the motivations of entrepreneurs and their post establishment definitions of success. Why did you establish your company? Q2: What were your main motivations to do so? Q3: Now that your business is established, how do you define success?	In depth interviews with 74 nascent academic entrepreneurs	Success is defined in a number of ways, including technology diffusion, financial gain, and peer motivations. Money is not the main motivation of academic entrepreneurs, rather it is a compensation for the time not spent at their academic jobs. Other motivations are career enrichment, independency, job creation and public service. Firms are often established to pursue other sources of development funding, and few academic entrepreneurs are interested in growth.	Academic founder
The relationship between an entrepreneur's background and performance in a new venture	Jo, H. and J. Lee	How entrepreneurial characteristics such as background, education, experience related to performance of a venture during the early stages.	Data collected from 48 start-up firms in Korea. Early stages are examined. Not only high tech firms.	Found that education correlates with profitability but not with growth. A master in social studies improves profitability, whereas natural sciences are positively related to growth. Furthermore, found that managerial experience affects performance negatively on most occasions. Did not have any significant findings with regards to entrepreneurial experience's effect on performance. Furthermore, a professional background (work experience) related to the product has a positive effect on growth.	Education Work experience
Success criteria in high-tech new ventures	Kakati, M.	What criteria influence the performance of high tech ventures?	27 VCs who had both experienced failure and success were asked to rate both successful and failing high tech ventures on 38 criteria	Found that resource based criteria and the venture's competitive strategy scored high in importance for successful ventures. For failed ventures they were rated lower. Furthermore, failed ventures lacked a leadership quality and the ability to evaluate and react to risk. Found that market and financial criteria were not that crucial. Successful ventures are characterised by having exceptional entrepreneurial quality, leadership ability and handled risk well.	Work experience Education

Article	Author	Research Question	Approach/method	Key findings	Human capital operationalizations
The relationship between knowledge transfer, top management team composition, and performance: The case of science-based entrepreneurial firms (2010)	Knockaert, M. Ucbasaran, D. Wright, M. Clarysse, B.	How can knowledge be transferred and employed in SBEFs in order to enhance SBEF performance?	Inductive case study. Multi-case, embedded research as design. The 9 cases originated from one research institute in Belgium. Data was primarily provided from the founder and/or CEO, supplemented from other sources.	Found that the proportion of inventors present in the founding team as well as the combination of both technical and commercial mindsets in the team was related to tacit knowledge transfer which was needed to finish the first product more quickly. However, the cognitive distance of those possessing the technical and commercial knowledge cannot be too large. Those that experienced the quickest speed to first product had team members with commercial knowledge that also had previous technical experience or education, as well as joint work experience with technical team members.	Academic founder Work experience Education Team heterogeneity
Knowledge, learning and small firm growth: A systematic review of the evidence	Macpherson, A. R. Holt	Examines how human and social capital, organizational systems, and knowledge networks combine to facilitate or restrict growth.	Reviews papers written on growth and knowledge in small firms. Structured review. Not just NTBFs. 113 papers in total	Did a review of how empirical research on knowledge and growth is reported in small firms. Used five dimensions during the review and identified research gaps for each dimension: landscape of field, human and social capital, organizational systems and structures, networks and holistic themes. Makes the case that there few typical cases among small firms. Points out that it should be useful to learn more about the learning processes in such firms.	Work experience
Technology entrepreneurs' human capital and its effects on innovation radicalness	Marvel, M. R. Lumpkin, G. T.	Investigate how aspects of individual human capital are linked to the recognition of opportunities bearing radical innovation outcomes.	A literature review resulted in 7 hypothesis. 13 american incubators took part in a study, resulting in individual meetings with founders. The final sample consisted of 145 technology entrepreneurs from the Midwest.	Found that there are two reasons for why entrepreneurs have a radical innovation advantage. First, they have rich knowledge related to technology. Secondly, they are able to be creative without being restrained by their knowledge of current markets and customers. Innovation outcomes are dependent on both general and specific human capital. Formal education and prior knowledge of technology both have a positive influence on innovation radicalness, whilst prior knowledge of how to serve markets affects innovation radicalness negatively.	Work Experience Education
Human Capital and Search-Based Discovery: A Study of High-Tech Entrepreneurship	Marvel, Matthew R.	This study examines the knowledge and experience of new technology entrepreneurs who had been searching for an opportunity compared to those who identified opportunities without searching. What types of knowledge and experience enable those who have the desire to start a venture to find an appropriate opportunity?	Reviews literature and derives hypotheses related to search based discovery. Interviews 166 founders from technology based ventures 5 years or younger.	General and human capital are useful to explain the mode in which opportunities are realized. Professional experience was negatively related to search based discovery. Prior knowledge on how to serve markets and customers was positively associated with search based discovery. Indicates that market knowledge allows you to find better opportunities to meet customer needs. Opportunity that came about without a search were identified or developed by entrepreneurs with more experience or education. Entrepreneurs that have more professional work experience are not as likely to search for opportunities. Startup experience raises likelihood that an entrepreneur will search and find opportunities in the future. Rather, they come across them in an accidental way.	Work experience Education
Entrepreneurial talent and venture performance: A meta-analytic investigation of SMEs	Mayer-Haug, Katrin Read, Stuart Brinckmann, Jan Dew, Nicholas Grichnik, Dietmar	How does entrepreneurial talent affect performance	A review of literature as well as a meta analysis of 50045 firms, SMEs. by synthesizing prior empirical studies.	Found a weak connection between education and performance. Tracked planning skills effect on performance, and found a connection between planning and performance. Planning skills is one of several measures of talent.	Work experience Education

Article	Author	Research Question	Approach/method	Key findings	Human capital operationalizations
From human capital to social capital: a longitudinal study of technology-based academic entrepreneurs	Mosey, S. Wright, M.	How do differences in the human capital derived from the entrepreneurial experience of academic entrepreneurs influence their ability to develop social capital?	Multiple case study. 24 subjects: both novice, habitual and nascent entrepreneurs. Longitudinal study	Found that prior industrial experience was not related to venture growth. A relation existed for business ownership experience. Made a difference for nascent entrepreneurs (opportunity recognition) and novice entrepreneurs (phasing the entrepreneurial commitment phase). In the former, some use their network to gain critical resources. To reach the credibility phase they need funding and industry specific knowledge. The latter uses contacts to acquire business resources. Habitual entrepreneurs emphasised the value to providers of industry knowledge, business development knowledge and technical knowledge. These also continued to see value in their research colleagues.	Work experience Academic founder
A stage model of academic spin-off creation	Ndonzuau, F. N. Pirnay, F. Surlemont, B.	The paper focuses on the creation of academic spin-offs, and aims at identifying, understanding and distinguishes the major issues that are raised by the creation of academic spin-offs, both from the point of view of academic and public authorities.	First they identified 15 international spin-off support programmes that fulfilled the criteria they had set. Then they interviewed officials at these 15 universities, including founders of spin-off companies, managers of universities liaison offices and incubators from local development agencies.	They develop a model explaining what happens in the "black box" between research results being made until economic value has been created. This model consists of four steps which each end up with a new status that the research results have to undergo in order to end up creating economic value. First they generate business ideas. Secondly they finalise new venture projects before spin-off firms are launched. These are further strengthened in order to start the creation of economic value. To pass from one stage to the next the venture has to pass through a "critical juncture" characterised by challenges related to the specific juncture. The model can be used to make suitable institutional mechanisms to support academic entrepreneurship.	
Entrepreneurial orientation, technology transfer and spinoff performance of US universities	O'Shea, R. P. Allen, T. J. Chevalier, A. Roche, F.	In order to understand why some universities are more successful than others to generate technology-based spinoff companies they set fourth 8 hypothesis to see what role the resource-capability link plains in explaining variations in univeristy spinoff activity.	Looks to litterature to end up with 8 hypothesis. These were then tested using database and survey sources on 141 U.S. e review univerisities.	4 key findings: (1) each university has a different resource base that it can use in different combinations, these different combinations explain differences in spinoff activity from different universities. (2) Star scientists and engineers as faculty affect spinoff activity in a positive way. (3) The size and type of financial resources that is earmarked to the universities influence the academic entrepreneurship. (4) the size of the resources that are invested in Technology Transfer Office personell increase spinoff activity	
Technical entrepreneurship in high technology small firms: some observations on the implications for management	Oakey, RP	Aim at offering a number of conceptual insights on the role of the technical entrepreneur in the high technology firm formation and growth process	Literature review.	Finds a tendency for technical entrepreneurs to take an independent approach to high technology small firm management. This approach is misled. Unwillingness to hire people people with business management skills is likely to affect the survival of the firm negatively.	Education
Opportunity recognition and product innovation in entrepreneurial hi-tech start-ups: a new perspective and supporting case study	Park, John S	Seeks to synthesize the available literature into a more complete and integrative model of opportunity recognition in high-tech start-ups. Proposes a process model involving three main components: the founding entrepreneur, the knowledge and experience of the firm and technology.	First a literature review was carried out, resulting in a model. This was then tested using a case study.	With a literature search the author identified a mutually beneficial relationship surrounding the elements of opportunity recognition and development. Demonstrated the need to synthetically model these interactions. Created a new model that provides a theoretical platform from which to explore the nature and dynamics of the opportunity recognition and development process in high-tech start-up firms.	Work experience

Article	Author	Research Question	Approach/method	Key findings	Human capital operationalizations
Predictors of success in new technology based ventures	Roure, J. B. Keeley, R. H.	The study looks at how technology-based companies respond to time pressure and uncertainty, which are major determinants of success or failure.	Literature review to end up with 11 variables to test. These are tested empirically using the business plans of 36 new, technology-based companies, provided by two prominent venture capital firms.	Roure discovered that 7 of the 11 qualities were shown to predict success (completeness of team, prior joint experience, expected time for product development, buyer concentration, projected market share, product superiority, competitive conditions). However; founder equity share, experience in similar position, high growth experience shows no influence.	Work experience
Entrepreneurship and the process of firms' entry, survival and growth	Santarelli, E. M. Vivarelli	Aims to discuss recent literature on firm formation and survival, as well as the growth of new-born firms in order to help identify the role of entrepreneurship in economic growth.	Literature review.	Discoverd that entry of new firms is heterogeneous, and founders can be innovative entrepreneurs as well as over-optimistic gamblers. Due to this gambling founders can make "entry" mistakes, and policies should be highly selective. Favouing motivated entrepreneurs with promising predictors of business performance. Furthermore Santarelli found that the "ex-ante" features of the founder can in fact lead to business performance that is above average.	Work experience
The interplay of human and social capital in shaping entrepreneurial performance: the case of Vietnam	<i>Santarelli, Enrico Hien Thu, Tran</i>	To look at the interaction between human and social capital to see the effect it has on entrepreneurial performance.	A litterature review led to X hypothesis to test. These were tested using surveys to 1398 vietnameese companies, the oldest survey dating back to 1991.	Human capital (categorized into education, experience and learning) has a significant impact on successful entrepreneurship. Particularly industry experience, learning and education has a positive influence, whereas entrepreneurial experience is negatively correlated to fim profitability. As for learning effects, product innovation and process innovations are strongly related to success, whereas the introduction of new products is not notably related to success. Within social capital benefits are greater from weak ties than from strong ties. Furthermore the interaction of human and social capital has a positive effect on performance.	Work experience Education
Assessing the relationship between human capital and firm performance: Evidence from technology-based new ventures	Shrader, Rod Siegel, Donald S.	1. Are entrepreneurial team characteristics related to the competitive strategies of technology-based new ventures? 2. Is the fit between venture team characteristics and strategy related the financial performance of technology-based new ventures?	A literature review led to 3 hypothesis. These were tested on 198 publicly traded new ventures, found from investigating and screening a list of firms issuing IPOs from 1988 to 1993. The data used was collected from prospectus' from when the ventures issued public stock.	Found that team experience is significantly related to the competitive strategies followed by the firms. Marketing experience is positively related to marketing-based differentiation, technical experience is positively related to innovation-based differentiation, and international experience is related to internationalization. On the other hand the direct effects of team experience on the performance of the new venture were weak, and it was found that previous industry experience was negatively related to performance.	Work experience Team heterogeneity
Universities and the success of entrepreneurial ventures: evidence from the small business innovation research program	Siegel, DS Wessner, C	Hypothesis: the academic founder is an entrepreneurial leader that affects the success of the firm.	Analysis of data from a program that requires key federal agencies to allocate part of their research budget to small firms that try to commercialize new technologies. 920 samples from this database was used. Based on this they outline an econometric framework and test several hypothesis related to the role of the universities and academics in improving the success of the firm.	Start-ups with strong ties to the university perform better. The entrepreneurial experience of the founder, age of the project and the size of the award (funding from the program used in this study) are related to sales (actual and expected) in a positive way. Additional development funding, previous awards and the firm size are related to success in an insignificant way. There is a positive and significant relationship between the number of academic founders and jobs created. In particular university involvement has an effect on sales-based measures of project success. Larger awards and older projects are found to be more successful. Indicators of interaction between the start-ups and universities show that there is a positive effect on successful commercialization.	Academic founder Work experience

Article	Author	Research Question	Approach/method	Key findings	Human capital operationalizations
Spin-offs from research centers at a research university	Steffensen, M. Rogers, E. M. Speakman, K.	1. What conflicts occur between a spin-off and its parent organization in competing for scarce resources? 2. What mechanisms facilitate or inhibit the spin-off process from a university-based research center? 3. How does a planned spin-off differ from a spontaneously-occurring spin-off? 4. In what ways does a university-based research center facilitate technology transfer?	Study of 6 spin-offs from the New Mexico area. Data was gathered from written, open sources, personal interviews with the entrepreneurs and other key individuals from the formation and development of the company as well as company literature.	The key findings relate to the four research questions. (1) The success of the company depends on the support from parent organization in the start-up process. (2) The universities played in general a key, positive role in establishing the spin-offs. (3) A planned spin-off is more likely to be an extension of the university's research center in question, whereas the spontaneously occurring spin-off is instigated by the entrepreneur and has a relatively autonomous relationship with the parent organization. (4) As research centers are multidisciplinary and span boundaries, they open up for information and other resources to flow across the university's boundary, in this way facilitating technology transfer.	
Opportunity Identification and Pursuit: Does an Entrepreneur's Human Capital Matter?	Ucbasaran, D. Westhead, P. Wright, M.	The relation between an entrepreneur's human capital profile and opportunity identification	Questionnaire sent to 588 owners of private firms	Found several variables that were associated with both a higher probability of identifying more opportunities and pursuing more opportunities. These were business ownership experience, managerial and entrepreneurial capabilities. The authors also found that the skills needed for opportunity recognition were also needed in later stages of the entrepreneurial process.	Education Work experience
Human capital and entrepreneurial success: A meta-analytical review	Unger, Jens M. Rauch, Andreas Frese, Michael Rosenbusch, Nina	Is the relationship between human capital and success different dependent on which specific concept of success is used (profitability, growth, size)?	Empirical studies matching the research questions were used. A meta-analysis was done based on a set of criteria, reducing the set from 24 733 samples to 70.	There is an overall positive relationship between human capital and success. This was divided into three groups representing moderators: (1) A distinction between human capital investments (education and experience) and outcomes of human capital investments (knowledge and skills) was done, and the effect on success was higher for the latter. (2) Business context showed that the effect was higher for young rather than old businesses. (3) The choice of success moderator showed differences, notably size oriented success shows a higher relationship with human capital than growth and profitability.	Work experience Education Team heterogeneity
Critical junctures in the development of university high-tech spinout companies	Vohora, A. Wright, M. Lockett, A.	1. What phases do USOs go through in their development? 2. What are the key challenges these ventures face in their development?	Field study of nine USOs from seven different UK universities. Inductive approach with interviews and the use of background materials.	USOs go through 5 stages (research, opportunity framing, pre-organization, re-orientation and sustainable returns) in their development in an iterative and non-linear way. There are challenges related to each stage which leads to four "critical junctures" (opportunity recognition, entrepreneurial commitment, threshold of credibility and threshold of sustainability) with regards to resources and capabilities that the USO must overcome in order to reach the next stage.	Work experience Education Academic founder
The role of human capital in technological entrepreneurship	Wright, M. Hmieleski, K.M. Siegel, D.S. Ensley, M.D.	A review of the literature on academic entrepreneurs and human capital and what research should be given greater attention?	A literature review of articles in the field of human capital and technological entrepreneurship. Implies suggestions for further research on firm, individual and team level	Further research for firm level: exploitation of the heterogeneity of firms, and what type of human capital they require. Also the choice of path has implications for human capital requirements and should be looked at. How is human capital assessed by firms? Team level: How the team evolves through the different stages of development and in relation to that what types of human capital is needed and how to identify and utilize surrogate entrepreneurs in ASOs. Individual level: The link between social and human capital. How to close the gap between holders of these types of capital.	Work experience Education Team heterogeneity



Article	Author	Research Question	Approach/method	Key findings	Human capital operationalizations
The evolution of entrepreneurial competencies: a longitudinal study of university spin-off venture emergence	Rasmussen, E. Mosey, S. Wright, M.	Which entrepreneurial competencies are needed for nascent spin off ventures within a university context to reach the credibiity threshold. Who provides these competencies. How are these competencies developed?	longitudinal case study. Four spin-case sompanies from Norway and the UK	The paper identified 3 competencies; leveraging, championing that are important so that the ventures can gain credibility. Accessing the industrial expereince needed to develop the competency of opportunity refinement seems to be a distinctive challenge since it is less likely to be present intially. It is also difficult to obtain credibility, since the leveraging competency required may be lacking in the entrepreneurial team. The championing competency lacks as the team lacks industrial and entrepreneurial experience.	Work experience Academic founders

# How does human capital affect the performance of academic spin-offs: An empirical study

Mari Haga Rimestad  
Tlf: +47 45474874  
Email: [mari.h.rimestad@gmail.com](mailto:mari.h.rimestad@gmail.com)

Ole Jørgen Seeland  
Tlf: +47 93027481  
Email: [olesee@gmail.com](mailto:olesee@gmail.com)

Frøydis Folvik Bjerholt  
Tlf: +47 90673050  
Email: [froydisbjerkholt@gmail.com](mailto:froydisbjerkholt@gmail.com)

## Abbreviations:

ASO = Academic spin-off

TTO = Technology transfer office

VC = Venture capital

NTBF = New technology based firm

KBV = Knowledge based view

RBT = Resource based theory

IP = Intellectual property

R&D = Research and development

TMT = Top management team

DV = Dependent variable

CV = Control variable

IV = Independent variable

CEO = Chief executive officer

ACEO = Average chief executive officer

OR = Odds ratio

## ABSTRACT

*Commercializing of technology from academic institutions through the establishment of academic spin-offs is gaining increased attention from scholars and policy makers. This article focuses on the human capital of the top management team in academic spin-offs, in particular that of the chief executive officer. Through synthesizing existing literature on human capital and academic spin-off performance a set of hypotheses was put forth, building on the previous work of Bjerkholt et al. (2014). These investigate the relation between different types of work experience and education present in the top management team, and their effect on ASO performance. We also explore whether the presence of an academic founder (inventor) affect performance positively. By performing a comprehensive quantitative study on 100 Norwegian academic spin-offs we were able to test the support for these hypotheses. We found that managerial experience affects performance positively. Even more significant and positive was the effect of managerial education. Surprisingly, we found that the presence of PhD degrees had a positive and moderately significant effect on performance. With regards to academic founders, we found that academic founders possessing commercial knowledge have a positive effect on performance. Our results are of interest to entrepreneurs, investors, technology transfer offices and policy makers as they indicate that some types of human capital are more important than others in spin-off development.*

## 1. INTRODUCTION

The commercialization of technology and the generation of wealth from universities and other research institutions is of growing interest among scholars and policymakers (Mustar et al., 2006, Wright et al., 2007a, Rothaermel et al., 2007). Following the US Bayh-Dole act in 1980, many European countries, counting Norway, have adopted similar policies and several other initiatives to stimulate the growth of academic spin-offs (ASOs) (Wright et al., 2007a, Rasmussen et al., 2013). ASOs have thus become a popular mechanism to transfer and commercialize knowledge from research institutions.

Even though some ASOs are highly successful (Shane, 2004) it is found that most spin-offs remain small and many do not generate substantial wealth (Nerkar and Shane, 2003, Wright et al., 2007a, Wright et al., 2012, Harrison and Leitch, 2010). This is also the case for Norwegian science based firms (Rasmussen, 2012). Consequently, this there is a need to understand how these firms develop, and especially, why some ASOs perform better than others. Such knowledge may be constructive input in designing effective support mechanisms which in turn can assist spin-offs in performing better.

The performance of young ASOs is strongly related to the human capital of founders, where human capital refers to skills and knowledge derived from education and experience (Becker, 1964). In the earliest stages of a technology venture, when essential resources have not yet been acquired and

developed, the resources of the venture are strongly correlated with the human capital of the founders (Cooper and Bruno, 1977). Furthermore, the early decisions and actions that take place in an ASO have lasting effects on its development path (Bamford et al., 2000). As the decisions and choices made relies on the human capital of the founders, the human capital present in the early stages of an ASO is likely to ultimately affect long-term performance. This is supported by several scholars (Unger et al., 2011, Aspelund et al., 2005, Clarysse and Moray, 2004, Bamford et al., 2000, Brush, 2001) and can be explained by several factors; Firstly, because ASOs commercialize high technology inventions and operate in knowledge-intensive and complex environments, there is a need to integrate different kinds of human capital to create a competitive advantage (Unger et al., 2011, Kirzner, 1997, Utterback, 1996). Secondly, human capital can reduce the “liability of newness”, which is related to the lack of resources and their limited ability to access these resources. This is partly attributed to insufficient networks to investors, customers and other stakeholders (Stinchcombe, 1965). Arguably, networks gained through previous work experience and education give access to valuable resources, thereby reducing the liability of newness.

In light of the above, we chose to focus on human capital in earlier stages, as this is suggested to be a key issue in predicting long term-performance of ASOs. As an extension to Bjerkholt et al.’s (2014) article on

human capital of entrepreneurial teams and performance of ASOs, we conduct an empirical study on how the human capital of ASOs' "top management teams" (TMTs) and especially how the function of the chief executive officer (CEO) affects performance. Since organizational outcomes of a firm are dependent on the characteristics of the TMT and the top leader (Hambrick and Mason, 1984), the performance of an ASO is arguably dependent on the human capital of these individuals. We furthermore investigate the importance of having an academic founder present in the early phases of development. This is considered to be especially critical for ASOs as the firm is typically built upon the tacit knowledge of the inventor (Shane, 2004, Zucker et al., 1999). Hence, the value of the academic founder cannot simply be explained in terms of which human capital he or she has and must therefore be treated separately. Our research questions read:

*"How do different types of human capital of the top management team affect the performance of ASOs?" and "How does the presence of an academic founder affect the performance of an ASO?"*

The study contributes to the expanding field of literature which investigates how different types of human capital affects performance of an ASO in an empirical setting. Set in a Norwegian context, we use a sample that is likely to differ from that of frequently used US samples (Rothaermel et al., 2007, O'Shea et al., 2005). Although ASOs face many of the same challenges, country-specific contextual factors such as public policies, support programmes and funding conditions differ. This may ultimately influence the development and performance of the ASO, meaning there lies value in studying spin-offs from non-US contexts. Furthermore, the political system of Norway is designed in a way which allows for a comprehensive overview of the outcomes of spin-off creation, perhaps more so than in other countries.

Following this, the study is based on longitudinal data from 100 Norwegian ASOs registered in the "FORNY-program". The FORNY database is unique as it provides consistent and detailed data of the vast majority of ASOs established in Norway since 1995 (Borlaug, 2009). Furthermore, it includes data from both successful and failed firms, making it an excellent and extensive source of

data for quantitative as well as qualitative studies on ASOs. Quantitative empirical testing of conceptual models has frequently been called for, as this has traditionally been lacking in the ASO research context (Djokovic and Souitaris, 2008). This study has a quantitative approach where we consider changes in the human capital throughout the initial development of the ASO. This allows us to overcome some of the limitations associated with static studies.

The research question should be of interest to policy makers, scholars, entrepreneurs and investors, as it seeks to explain and clarify some of the mechanisms and characteristics leading to successful spin-offs in a European context.

This article is structured as follows; First, based on the findings of Bjerkholt et al.(2014), a set of hypotheses which relate human capital to the TMT and the performance of the spin-off is presented. Next, a detailed description of the quantitative data collection is given, followed by an outline of some methodical limitations. Our data is analysed using a series of regression methods and is presented in the following chapter. Section 5 discusses the results and outcome of the hypothesis testing. The conclusion considers the practical implications for different stakeholders. The article concludes with limitations and further research.

## **2. THEORY AND HYPOTHESES**

Based on the Resourced-based Theory (RBT) and Knowledge-based View (KBV), Bjerkholt et al. (2014) provided a state of the art review of existing literature on how founders' human capital affects ASO performance. Their study resulted in a set of hypotheses where work experience and education were used as proxies for human capital. Furthermore they looked at how the presence of the academic founder affects performance. This section will briefly present the definition of an ASO and the same definition will be used in this article.

There is a lack of consensus among researchers as to how to define a university, or academic, spin-off. The employment of imprecise and vague definitions may have disadvantageous effects on academic entrepreneurship research as scholars are

likely to use the same terms even though they describe different situations and phenomena (Pirnay et al., 2003). This article will use Bjerkholt et al.(2014)'s definition, adapted from Nicolaou and Birley (2003), Pirnay et al. (2003) and Clarysse and Heirman (2000):

*An academic spin-off (ASO) is defined as “(i) The transfer of a some knowledge, technology or research result from a host institute (university, technical school, public/private R&D department) into a new company. (ii) The founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the host institution.”*

This definition is useful as it opens up for the commercialization of early stage research results. Moreover, it does not confine “founder” to only the academic founder, hence, it includes the use of surrogate entrepreneurs. Lastly, as the commercialization of research takes place in all research institutions, which arguably experience similar challenges as universities, the definition does not exclusively consider universities.

## **2.2 Human capital and performance**

The purpose of this article is to examine how different types of human capital, namely experience and education, of the TMT and in particular the CEO affects performance of the spin-off. We will also investigate how the initial presence of the academic founder affects performance. As Bjerkholt et al. (2014)'s review was related to the human capital of the *founding team* we will make a justification for the use of their findings in relation to the aforementioned research question. We would argue that the terms “founding team” and the “top management team” of early stage spin-offs are closely related both in theory and practice. The TMT is described as the group of people who are responsible for strategic decision making (Wiersema and Bantel, 1992, Hambrick and Mason, 1984). Ensley and Hmieleski (2005) requires that TMT-members need to meet two of the three criteria; they have to be founders, significant equity stakeholders or involved in the strategic decision making of the firm.

Scholars have many ways of describing the criteria for being part of the

entrepreneurial, or founding team; They own equity, take managerial roles and are responsible for making strategic decisions (Ganotakis, 2012, Colombo and Grilli, 2005, Cooney and Bygrave, 1997, Ucbasaran et al., 2003). Some describe the entrepreneurial team members as core people having played an active role in the founding and growing of the startup (Wright et al., 2007a, Ensley et al., 1998). Although definitions of founding/entrepreneurial teams are not consistent, we would argue that in young ASOs, the entrepreneurial team and the TMT are very closely related, and in some cases identical. An ASO may consist of a large group of researchers, each having various degrees of commitment and responsibility. However, the core entrepreneurial team arguably consists of key people active in the founding of the startup, which are in power to take strategic decisions related to the development of the spin-off. These are in other words, the TMT. Following the above arguments, the theoretical foundation of this article is therefore based on the literature derived from founding/entrepreneurial teams.

The following sections outline the findings on human capital from Bjerkholt et al (2014). We note that human capital is related to the stock of skills and knowledge derived from education and experience (Becker, 1964). Because skills and knowledge are difficult to measure, most researchers use human capital investments, such as education and work experience, as proxies for human capital (Unger et al., 2011). Since there is a strong relationship between these human capital investments and their potential outcomes (skills and knowledge) (Unger et al., 2011, Unger et al., 2009), this is a reasonable, and also a necessary approach. Accordingly, it will also be applied in this article.

### **2.2.1 Work experience and performance**

Work experience is valuable as it allows an employee to accumulate tacit knowledge through episodic skills and learning-by-doing (Arrow, 1962, Jovanovic, 1982, Wright et al., 2007b). Work experience can enhance an individual's ability to accumulate new knowledge, adapt to new situations and may also increase productivity (Parker, 2006, Davidsson and Honig, 2003).

Many researchers assess work experience by grouping them into different types that are believed to be relevant for the ASO setting (Ganotakis, 2012, Gimmon, 2010, Ucbasaran et al., 2008, Wright et al., 2007b). Although some of the categories may overlap, they arguably cover skills that may help an entrepreneur in developing a performing spin-off. In line with the above authors we categorize experience the following way: Managerial, commercial, technical and entrepreneurial experience. We present our findings on how they affect the performance of an ASO below.

*Managerial work experience*, which refers to the experience of running a firm, leading its employees and to make complex strategic and organizational decisions, is by many researchers recognised as being positive to firm performance and growth (Ucbasaran et al., 2008, Aspelund et al., 2005, Ganotakis, 2012, Santarelli and Hien Thu, 2013). Managerial experience may enhance a person's ability to see means end relationships and assemble the resources necessary to convert an idea into a business opportunity (Gaglio and Katz, 2001, Ardichvili et al., 2003, Ucbasaran et al., 2008). Scholars also suggest that ASO performance is positively correlated with the number of years in managerial roles, implying that management and leadership is a matter of practice rather than an academic talent (Colombo and Grilli, 2009, Gurdon and Samsom, 2010, Gimmon, 2010). Furthermore, managerial experience is believed to increase the chance of receiving venture capital (VC) funding, as VCs tend to look for experienced individuals that are likely to run a company successfully (Colombo and Grilli, 2009, Tyebjee and Bruno, 1984). In contrast to the above, Gimeno et al. (1997) and Davidsson and Honig (2003) found that managerial experience failed to demonstrate a significant effect on performance, arguing that managerial experience fosters procedures that do not stimulate effective resource allocation in young firms. Since the focus of these studies were on the very earliest phases of spin-off development, one may argue that managerial experience in the TMT is of lesser importance in early phases of opportunity recognition. Furthermore, it is suggested to become more needed as the firm prepares for growth, in terms of increasing the number of

employees, turnover, sales and production activity. Hence, setting in place organisational structures and routines should become more important as the boundaries and scope of the firm expands.

Nevertheless, the majority of the literature seems to suggest that the positive influence of managerial work experience outweighs the negative, and the following hypothesis is put forward:

*1a. Managerial work experience in the top management team has a positive effect on academic spin-off performance.*

*Technical work experience*, namely prior experience in technical or scientific roles including R&D, engineering or manufacturing is believed to be especially important in firms that operate in rapidly changing markets. This is arguably the case for high technology firms (Knockaert et al., 2011, Unger et al., 2011, Shrader and Siegel, 2007, Ittner and Larcker, 1997). Many scholars do however argue that technical experience should be complemented with commercial or managerial experience to ensure firm performance (Kakati, 2003, Oakey, 2003, Ganotakis, 2012, Gurdon and Samsom, 2010, Aspelund et al., 2005), as an overemphasis on the technical side may lead to the lack of attention to commercial aspects (Kakati, 2003).

Nevertheless, as the majority of ASOs based on high technology inventions are built on the tacit knowledge of academic founders (Lowe, 2006, Carlile and Reberich, 2003), technical experience in the TMT is essential. We note that even though some knowledge is made explicit through patents, successful exploitation of patents and licenses is likely to require some tacit knowledge (Shane, 2004). There are several reasons for technical experience being important: (i) It will enhance the effectiveness of transfer of tacit knowledge from founders to the rest of the team as the cognitive gap becomes smaller (Zucker et al., 1999, Knockaert et al., 2011) (ii) It will enhance the TMT's ability to translate the technology into marketable product as well as create innovative products suited customer needs (Park, 2005, Ganotakis, 2012, Unger et al., 2011, Shrader and Siegel, 2007, Knockaert et al., 2011). This is because technically experienced individuals are likely to be familiar with the technology's potential and

limitations as well as how it can be customized once a market is identified (iii) It will allow for more effective product/prototype development; Technically experienced individuals are more likely to have skills related to product development or have an accessible network of people that know how to develop products. This may in turn make the development process cheaper and faster as well as reduce the risks involved (Ucbasaran et al., 2008).

Arguably, as technical experience is related to recognising the best product-market fit as well as prototype development, one may suggest that technical experience is of critical importance in the early stages of spin-off development. The following hypothesis is put forward:

*Ib: Technical work experience in the top management team has a positive effect on academic spin-off performance.*

*Commercial work experience* relates to previous employment with marketing and sales related tasks, as well as contact with customers, suppliers and manufacturers. Commercial experience is considered valuable due to several reasons: (i) It enhances the TMT's ability to recognise the commercial value of a technology as such experience implies the understanding of how customers and suppliers interact (Vohora et al., 2004, Park, 2005, Shane, 2000, Marvel, 2013). (ii) It may help identify unserved markets where the product will be radically different to other competitors as previous experience may have given a better overview of the supply side of the market as well as how one may design a differentiation strategy (Aspelund et al., 2005, Shrader and Siegel, 2007, Shane, 2000) (iii) It enhances the TMT's ability to interact with customers, distributors, suppliers and industry partners as they have the experience with such tasks. Furthermore, they are likely to have developed such networks (Marvel and Lumpkin, 2007, von Hippel, 1988). However, in line with what is mentioned earlier, commercial experience should be complemented with technical experience (Wright et al., 2007b, Ganotakis, 2012, Colombo and Grilli, 2005) as this will enhance the TMT's ability to understand and communicate how the product can be tailored to fit customer needs (Knockaert et al., 2011).

Based on the above, the following hypothesis is put forward:

*Ic: Commercial work experience in the top management team has a positive effect on academic spin-off performance.*

*Entrepreneurial work experience*, or the experience with starting a business, is generally believed to be positively linked to the performance of ASOs (Davidsson and Honig, 2003, Ucbasaran et al., 2008, Mosey and Wright, 2007). Entrepreneurial experience may prove beneficial as it; (i) Provides access to external human capital gained through entrepreneurial networks. This may increase the chances of getting seed and investment finance (Mosey et al., 2006). Furthermore, access to entrepreneurial networks increases the chances of meeting other experienced entrepreneurs that may serve as advisors or board members (Mosey and Wright, 2007) (ii) Gives an individual direct learning from episodic skills about the entrepreneurial process. Thus it allows for the accumulation of tacit knowledge. This may arguably be helpful the second-time around (Wright et al., 2007b, Spender, 1996).

Prior start-up management is also suggested to be a strong human capital signal to investors and thereby increases the chances of obtaining VC funding (Colombo and Grilli, 2005, Hsu, 2007). On the contrary, Santarelli and Hien Thu (2013) suggest that entrepreneurial experience may hamper performance because firstly, second-time entrepreneurs may be more cautious to risk and less willing to take chances. Secondly, second-time entrepreneurs may be more likely to become overconfident and adopt strategies and routines that have worked in the past rather than making new ones. Although the research on entrepreneurial experience has produced divergent results, the positive outcomes appear to dominate. The following hypothesis is put forward:

*Id: Entrepreneurial work experience in the top management team has a positive effect on academic spin-off performance.*

Reviewing the hypotheses we observe that according to literature, all types of experience seem to have a positive impact on the performance of an ASO. Even though this may



reflect reality, we would argue that some types show a more positive effect in certain phases of spin-off development than others and that this is worth investigating. Technical and commercial work experience, for example, seems to be essential in early phases as there is a need to identify the best commercial market and customize the technology to satisfy customer needs. In contrast, managerial work experience seems to be of greater importance in later phases. As the spin-off prepares for growth, the need for skills on how to run a company, allocate resources and design strategies arise. Nevertheless, testing whether all types of experience are equally positive is an interesting topic of research.

Furthermore, as human capital needs depend on contextual factors (Unger et al., 2011), we believe that our Norwegian ASO context may yield different results. As pointed out by Bjerkholt et al. (2014), only 27% of the studies they found relevant for this research area specifically addressed ASOs. Hence, there is value in investigating whether these results are valid in an ASO setting. Furthermore, several studies focus on survival or success cases only. Since we also include failed ASOs into consideration we assume to obtain other results.

### **2.2.2 Education and performance**

Skills useful for entrepreneurs may be gained from education through the accumulation of mainly explicit knowledge (Davidsson and Honig, 2003). Yet, formal education is one component of human capital that has proved to give nonlinear and inconsistent effects of performance, growth and the exploitation of opportunities (Avermaete et al., 2004, Stuart and Abetti, 1990, Haber and Reichel, 2007, Davidsson and Honig, 2003, Bosma et al., 2004, Mayer-Haug et al., 2013). Critics argue that positive effects of education is more a matter of signalling effects and status rather than the skills it gives a person (Dore, 1976). As such, judging a person's skills from education, which is partly what employment recruiters do, may be an unreliable and weak measure.

Furthermore, studies assessing different *types* of education have been largely neglected, and is arguably an interesting topic of research. Although education is tightly linked to work experience, (i.e, having technical experience means you probably have

technical education) studying the contribution education has on performance in isolation may provide new insights. It is especially valuable in cases where spin-offs are started by founders fresh out of school. By considering different types of education and their impact on performance, we expect to find that some types of education may have a greater impact on performance than others. While it is clear that technical education is needed, given the technical orientation of ASOs, it is unclear whether managerial education will enhance the performance of an ASO.

*Type of education:* Scholars tend to look at education believed to be most relevant for the ASO setting, namely managerial/economic and technical/scientific education (for example (Colombo and Grilli, 2005, Gimmon, 2010)). Findings from such studies are somewhat diverging. Colombo and Grilli (2009), Oakey (2003) and Ganotakis (2012) found a significant and positive effect of economic or managerial university education, whereas technical education has produced weaker although positive results, in predicting firm performance (Colombo and Grilli, 2009). Ganotakis (2012) actually found that technical education had a negative and significant effect on performance. They make a case for the issue of technical education *on its own* (meaning the individual has no other work experience or education) producing negative effects and that technical education needs to be complemented with other types of experience and/or education to become of value. It is possible that TMTs with a technical education can become too focused on product development and the technical side of the spin-off, abandoning the commercial aspects, which can affect ASO performance in a negative way. Furthermore, to prove positive, the technical education may have to be very specifically related to the ASO's activities. In general, managerial/economic education is found to have a stronger effect on performance compared to technical education. Managerial/economic education provides a person with business related skills that can prove advantageous even if education is not complemented with work experience. As research regarding the effect of technical education diverges, we propose that there is no effect, stated differently, the positive effects

balance the negative. The following hypotheses are thus proposed:

*2a: Managerial education in the top management team has a positive effect on academic spin-off performance.*

*2b: Technical education in the top management teams has no effect on academic spin-off performance.*

*Level of education:* Several studies look at the level of education among entrepreneurs and give support to an inverted U-shaped relationship between education and ASO performance (Oakey, 2003, Ganotakis, 2012, Unger et al., 2011). Although *some* education may prove beneficial, too much education, meaning education above masters level, may be detrimental to performance. These studies suggest that individuals with very high levels of general education (measured as either number of years in schooling or possession of PhD) might overestimate their abilities, thereby disregarding the importance of seeking additional information that could have led to either new opportunities, better decisions or valuable contacts (Ucbasaran et al., 2008). In addition to adverse personality characteristics of highly educated, findings indicate that such people are more likely to want to stay in control of their ASOs, potentially threatening long term survival. Lastly, some scholars propose that high education corresponds to higher age, a family, a desire to do research and a higher perceived opportunity cost of venturing (Ganotakis, 2012, Unger et al., 2011). Summed up, studies give considerable indications that TMTs with degrees above masters affects the performance of an ASO in a negative manner, and we thus put forward the following hypothesis:

*2c: PhDs within the top management team has a negative effect on academic spin-off performance.*

### **2.2.3 Presence of academic founder**

Most inventions are at an early stage when a spin-off is established (Shane, 2004). Furthermore, they tend to be based on the tacit knowledge of the academic founder (the key researcher(s) who worked on the project from the institution where the ASO originated from), suggesting that founder involvement is essential in the development of the spin-off

(Shane, 2004). Following this, Knockaert et al. (2010) found that the transfer of tacit knowledge is more inclined to be successful if the academic founder is part of the entrepreneurial team, regardless if the product or technology is mainly based on explicit knowledge. In fact, spin-offs with the academic founder present are found to be less likely to fail (Nerkar and Shane, 2003), further indicating that having an academic founder affects performance positively. Even though the technology is made explicit in patents, the successful exploitation of the technology is likely to involve some tacit knowledge from the inventor (Shane, 2004).

Overall literature seems to emphasize the importance of academic founder involvement, and the following hypothesis is put forward:

*3a: Academic founders present in the top management team at the academic spin-off's inception will have a positive effect on performance.*

## **3 METHOD**

The methodical approach used in this article is driven by the chosen analytical tool. The dependent variable (DV) has been operationalized to be binary as has most of the independent variables (IVs), and thus they fit into a binary logistic regression model. It would have been possible to analyse the data using t-testing. However, this type of analysis does not take covariation between the IVs into consideration. As seen in section 2, previous theory indicates that some of the IVs may covariate and a simple t-test would not allow us to investigate this interesting and important covariation.

A regression attempts to describe the dependence of the DV on the IVs; it implicitly assumes that there is a one-way causal effect from the IV to the DV.

To summarize: Regression is the chosen technique in this article as it enables us to answer the research questions in a more satisfactory manner compared to other approaches, such as for example a t-test.

This section is structured as follows: Firstly, to understand the context of the sample better, a thorough introduction of the FORNY-

programme will be provided. Secondly, we will describe the comprehensive data gathering procedure. Next, we introduce the variables that were used in the regression analysis and provide some descriptive statistics. Finally, we will discuss the limitations associated with the chosen method.

### 3.1 Sample context

The dataset which forms the basis for the findings in this paper is based on the Norwegian FORNY-programme. FORNY was established in 1995 and is a governmentally funded research support programme within the Research Council of Norway. The first programme was closed in 2012 and replaced by a new program, FORNY2020. It is the main support programme for commercialization of publicly funded research in Norway. The programme is one of many initiatives which has led to increased attention to commercialization activities. Furthermore, in 2003, universities were granted the intellectual property rights to research originating from the university, which earlier belonged to the researchers themselves. As a result of this, the largest research institutions in Norway established technology transfer offices (TTOs), acting as commercialisation agents for research and promoters for the formation of spin-off companies (Gulbrandsen and Rasmussen, 2012, Borlaug, 2009).

The general objective of the FORNY-programme is to increase wealth in Norway through the commercialization of research based business ideas. This includes increasing the number of ideas with sufficient value creation potential from researchers, stimulating realisation of potential business opportunities through new ventures or license agreements and lastly, increased and closer cooperation between commercialisation actors such as TTOs, research institutions, investors, entrepreneurs, industry and governmental authorities. Since 1995, the FORNY-programme has generated 471 startups (Rasmussen et al., 2013). The accumulated value creation, which is calculated by adding up the accumulated operating result, wage costs and depreciation for all spin-offs, is estimated to pass 15 billion NOK in 2017 (Rasmussen et al., 2013). Per 2012, more than one billion NOK has been invested through the FORNY-programme (Rasmussen, 2012).

Until 2012 the FORNY-programme worked exclusively through TTOs. TTOs are either, or in combination, connected to universities, public or private research institutions, private research firms, science parks and incubators. TTOs register all ideas from the research institutions' employees. Such a structuring has been an advantage when collecting data from the firms. However, since 2012 the programme has opened up for more funding being directed to the startups themselves. As this is a quite recent change, the effects remain to be seen.

The information available through the FORNY-programme is unique as it comprises a list of research based spin-offs as well as data that is not normally readily available in other countries. Several arguments are put forward to justify the database as a suitable dataset for studying research based spin-offs in Norway; (i) Its comprehensive scope. As it includes most TTOs in Norway, this means that the database is likely to include data from the vast majority of research based spin-offs after 2003 (Rasmussen et al., 2013). (ii) It spans all high-technology research sectors, ranging from biotechnology/pharma, marine technology, energy/environment and information/communication sectors (Rasmussen et al., 2013). (iii) The database comprises firms from all geographical locations in Norway. Due to this, research can control for many external factors, including economic, cultural and environmental variables. We also take social capital factors into consideration. As all firms are affiliated with a TTO, one can assume that much of the TTO's social capital is transferred to and exploited in the ASO.

### 3.2 Data collection

The data collection process was part of an extensive research project directed by Bodø Business School and the Norwegian University of Science and Technology (NTNU). The data gathering was performed in two steps. The first step relates to the data collection process on firm level, while the last step focuses on the individuals in each firm. These steps will be explained in separate sections.

TABLE 1 - DISTRIBUTION OF FORNY SPIN-OFFS

Year	Before 00	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
New companies	99	26	37	34	23	20	37	27	32	33	36	19	26	22	471
Coded in step 1	1	13	30	21	13	5	9	1	4	1	1	0	0	1	100
Included in final data set	1	9	26	17	10	5	9	1	4	1	1	0	0	0	84
%	1%	35%	70%	50%	43%	25%	24%	4%	13%	3%	3%	-	-	0%	18%

### 3.2.1 Firm level data collection process

In the first step a general template in Microsoft Office Excel was used to track the status of each FORNY spin-off. The format of the template was developed in an iterative process where an earlier version was tested and discarded. The main input to the template was information from the FORNY database, consisting of annual reports from the national business register<sup>1</sup> and news articles extracted from the norwegian news archive Retriever. The news article archive covers both print and online media, and contains all news articles up until february 2013. Additional searches in Retriever were performed to uncover articles written after february 2013. Annual reports consist of three parts, namely the financial statements, notes to the financial statements and the board statement. The latter must include information such as an overview of what the firm does, the financial development of the firm, its R&D activities and prerequisites for further operations<sup>2</sup>. Additionally, the corporate announcements archive in the national business register, available on the register's web pages, was used extensively, giving an overview of business enterprises activities such as business establishment, equity issues, board changes and changes in CEOs.

The final template consisted of three sections; (i) A general overview of the business consisting of information about the research background, nature of the technology being commercialized, first international sales, first occurrence of VC, whether the business has been discontinued or acquired, occurrence

of international subsidiaries, if software was a key product or service offering, whether products or services were based on biotechnology and/or pharmaceuticals were offered, and a summary of unexplained issues and areas for further investigation (ii) Changes in the company's legal entity consisting of establishment, acquisitions, mergers, divestments, subsidiaries, change in names, other restructuring and other events (iii) The history of the firm on a year to year basis including financial status, business activities, new significant contracts, sales or customer agreements and an overview of the 10 largest owners (including background information and type of ownership).

In total nine researchers and students tracked 100 FORNY spin-offs at the beginning of 2014. All completed templates were re-checked in detail, ensuring consistency in the interpretation of data.

Table 1 displays the year of establishment of the 100 spin-offs in the study. The majority of the spin-offs were established between 2000 - 2003, thus leaving 10 years of spin-off development to analyze. In fact, the average age of the ASOs in the sample is 9,5 years. The initial goal for the spring 2014 was to cover all FORNY companies from 2001-2003. This was not accomplished, and an average coverage of 68% was achieved, randomly sampled. Furthermore, companies were added to the data set randomly both from before 2001 and after 2003 to ensure resilience with regards to the time dimension. However, with the exception of one ASO established in late 1999, ASOs established before 2000 were not included in the data set. Annual reports were not delivered digitally before 2000 and were thus hard to come by. Furthermore, the structure of FORNY was changed in 2000, when it became an independent program within the Research Council (Borlaug, 2009). It was not until 2000 that it was specified that the main goal was to contribute to increased value creation *based on research results*. As the goal of the programme before 2000 was

<sup>1</sup> Brønnøysundregistrene : <http://brreg.no/>

<sup>2</sup> <http://lovdata.no/dokument/NL/lov/1998-07-17->

<sup>2</sup> [http://lovdata.no/dokument/NL/lov/1998-07-17-56/KAPITTEL\\_3#KAPITTEL\\_3](http://lovdata.no/dokument/NL/lov/1998-07-17-56/KAPITTEL_3#KAPITTEL_3)

less specific, several of the FORNY spin-offs would not fall in under the definition of an ASO as used in this article.

### 3.2.2 Individual level data collection process

The second data gathering step consisted of gathering data relevant for human capital and performance parameters and was based on the 100 templates in the previous step. In order to operationalize the TMT we analysed the CEO(s) throughout the development of the spin-off. We rationalize the use of CEO due to the following reasons; (i) The CEO plays a unique and strong role in strategic decisions which in turn are influential on the development path and performance of the organisation (Offstein and Gnyawali, 2005). Besides having the overhead decision role, the CEO is also responsible for hiring employees and exercise leadership, which is arguably related to the performance of the firm (ii) As young firms tend to be small in terms of number of employees, CEOs are even more influential in ASOs compared to large firms, as they are heavily involved in daily operations, the coordination and execution of activities (Bruton et al., 1997, Miller and Toulouse, 1986, Wasserman, 2003) (iii) As the CEO reports to and advises the board of directors, he or she must have a detailed overview of all operations in the firm and thus, the CEO has overlapping knowledge and skills to all other members of the TMT (iv) Collecting quantitative data on the TMT would be very resource demanding as all the spin-offs and TTOs would have to be contacted. This would have been outside the scope of our master thesis. Furthermore, information about CEOs is openly available in the national business registrar, where all companies are obliged to inform about changes in the CEO.

Due to the first three points above, the human capital of the CEO is evidently the most important and influential factor of the TMT. In some young firms, one may even experience that the CEO is the only “representative” of the TMT. The discussion above supports the operationalization of TMT through the use of CEO. However, there are some drawbacks related to this operationalization, which will be discussed in section 3.4.

In order to extract relevant data not covered by the general template used in step 1, we developed a second Excel template. The measures that were tracked in this template are explained in detail in 3.3.2, since they form the basis of our predictor variables. We also tracked ASO income and net result on a year to year basis. In order to collect necessary empirical data to analyze hypothesis 1 and 2 we registered the names of all the CEOs for each FORNY firm on a year to year basis. CEOs that held the position for less than half a year were not registered, as we assumed that it takes time to get acquainted with the ASO and for knowledge transfer to take place. Stated differently, it likely takes time before a new CEO can influence the direction of the ASO. Furthermore, this allowed us to register only one CEO per year, which was our chosen time unit. Since we tracked the ASOs on a yearly basis in the first template, it seemed natural to choose the same time unit when tracking changes in CEOs. In order to collect necessary empirical data to analyze hypothesis 3 we extracted the overview of firm shareholders from the general template for the first two years after firm establishment. All shareholders classified as *founders* were further investigated. To summarize; when tracking the CEO we have looked at the process of ASO development by taking into account that CEOs change, i.e we do not only look at the initial or current CEO, but track all changes. It is important to emphasise that it would have been possible to investigate how the initial CEO affected ASO performance, but we wish to investigate how changes over time impact performance. When investigating the academic founder we looked at the ASO at the time close to ASO establishment (two years) as we are interested in the *initial* knowledge transfer. We chose to look at two years of data to ensure that the founders were committed to the ASO.

Data on founders and CEOs was mainly collected using LinkedIn Recruiter, companies' web pages<sup>3</sup>, and news articles from Retriever. For each firm, we first investigated if the founders were *academic* founders, meaning that they had previously

---

<sup>3</sup> For ASOs that had failed, the internet archive web.archive.org was used to access deleted web pages

worked on the research project or research institution where the ASO originated from. Subsequently we tracked the background of all the CEOs and academic founders as outlined in 3.3.2, by specifying *yes*, *no* or *unknown* for each variable. Stated differently, we did not register human capital elements in number of years but rather looked at the presence of such elements. This poses some limitations, which will be discussed in section 3.4. During this step we also described the type of education or work experience that each CEO had as comments. To verify that all three authors were consistent in interpreting data we started by tracking the same ASO individually. The results were then compared and discussed. The remaining 99 ASOs were divided among the three authors and tracked individually.

Finally, we went through all the 100 templates together to ensure that ambiguities and discrepancies were eliminated. We actively used the aforementioned comments to ensure that we had treated different types of educations and work experiences in a consistent way. All the *unknown* elements were further investigated. During this process, 16 spin-offs were excluded from the data set. The two main reasons for this were: (i) Insufficient information about key people or the background of the spin-off was found (seven cases) and (ii) Did not fit our definition of an ASO, notably due to an unclear or complete lack of a scientific basis (nine cases). Furthermore, at this point we also evaluated the performance of each ASO as outlined in 3.3.1. The performance was marked using binary numbers, where 1 signified a *performer* and 0 signified a *failure*. If applicable, we registered the year of failure or the year of acquisition by merger (see 3.3.1). CEOs from the year of failure or acquisition by merger and CEOs from years after these events were deleted. This was done to ensure that we did not track human capital's effect on performance *after* the outcome of the ASO had been categorized. At this point most of the *unknown* factors had been eliminated. Next, we translated all the answers (yes, no and unknown) to binary numbers for the CEOs, where 1 was used for *yes* and 0 was used for *no* and *unknown*. *Unknown* typically occurred when we were not able to find all details about a persons background on LinkedIn or from other sources. If we found no indications of such experience from these other sources we

assumed they did not possess it. With regards to the academic founder, we registered how many academic founders that were present in each ASO, and how many of these that had commercial experience.

### 3.3 Variables

In this section we will first present the dependent variable (DV), secondly the independent variables (IVs), and thirdly, the control variables (CVs). For each type of variable we will explain how it was operationalized and the criteria that was used. Towards the end we provide descriptive statistics of the variables.

#### 3.3.1 Dependent variable

As performance is the dependent variable in our data analysis, a short presentation of how other scholar define the term follows.

The aspect of success and performance is well addressed. However, as Rasmussen (2012) and Hayter (2011) points out there is limited consensus on the unit of analysis, and which measures to use when seeking to find a definition. Many scholars rely on one-dimensional measures which are easily accessible, such as accounting based indicators, number of employees, sales numbers and occurrence of IPOs. The drawback of these measures is that they can give false perceptions of reality as performance is usually a function of several variables. Furthermore, in early stage technology companies, such indicators are inappropriate (Shane and Toby, 2002). We seek to overcome this limitation and base our characterization of a performing ASO on several variables. Furthermore, we look at performance indicators that predict future success as well as the opposite - indicators that predict a likely future fail. By taking indicators of different nature into account we seek to overcome errors related to (i) ASOs long and extremely capital intensive development times and the fact that they remain rather small before they start to grow (ii) The fact that performance and success is assessed differently depending on which stakeholder you ask, i.e, academic entrepreneurs may consider non-financial milestones such as technology diffusion as measures of higher performance. The criteria for classifying firms as performers or failures are further described below. It is important to emphasise that an

overall assessment was done for each ASO. We investigated the activity through the ASO's entire lifespan (from inception until the end of 2012<sup>4</sup>) in order to decide which of the two categories were the most suitable for the ASO in question.

The first aspect that was investigated was whether or not the ASO had been acquired. In fact, 18.1% of the ASOs in the sample were acquired. As most of the ASOs in the sample had existed for around or less than 10 years, many were still in an early phase, possibly too early for acquisition to be an option. Furthermore, two types of acquisitions were regarded. First, the ASO could be acquired and kept as an independent entity. The second type of acquisition refers to ASOs that were acquired and merged into the buying entity. For each acquisition we checked if it was distressed, meaning that the acquisition was a "last resort" for the ASO. If no comments related to the acquisition were present in the general template we checked the annual reports. If the statement from the board indicated that it was distressed, we classified the ASO as a failure. For those that were not distressed (5% of the total sample) the following steps were performed; Those that were merged into the buying entity were classified as "performers" in the year of the acquisition. Human capital parameters were not tracked the following years. This is due to the issue of human capital of the buying entity, which could possibly influence the ASO strongly and accordingly, influence our results. Furthermore, we did not have access to the annual reports of these companies. We continued to track the ASOs that were acquired and kept as independent entities as described below.

In the second and final step we assessed the activity levels in the ASOs. First, we looked into ASOs that had been discontinued and marked as failures. However, we still assessed their activity level to see if they ceased operations and were de facto failures before the ASO was legally discontinued. This means that if a firm showed no activity the last two years before legal

discontinuation, it was classified a failure two years before discontinuation. By investigating the year of actual failure we are able to adjust for this when we tracked the CEOs of the failed ASOs. If we were to track the human capital for a CEO in an ASO that is de facto failed, this would affect our results.

For the remaining ASOs, we first considered the income levels and net profit for all the years of operation. We looked at changes in the economic trend. ASOs that increased their activity and net profit over several years were classified as performers, counted from the final year of observation. However, if the yearly expenditure was less than 50 000 NOK for three consecutive years, we marked the ASO as a failure in the first year this occurred. This amount of money was chosen as it indicates that expenses only covers the services of accountants and similar, thus indicating that there is limited activity in the ASO. Furthermore, ASOs that had an expenditure of 50 000 - 250 000 NOK in three or more consecutive years were further investigated to establish whether they were in the process of ceasing operations, and if so, when it was decided. The upper limit was chosen as it roughly translates to a 50% part time employment of one person for one year. In these cases the statements of the board were considered. By looking at the statements from the year before the expenditure diminished as well as the statements from the years with low expenditure, we were able to classify the ASO as either (on its way to) performance or as a failure. We used statements of the board to determine which year the ASO failed, as future prospects would often be remarked.

This means that firms that (i) were discontinued or had gone bankrupt (14%) or (ii) showed minimum activity over the last three years (10%) or (iii) underwent a panicked acquisition (15%), were classified as failures. It should be noted that "*living dead*" ASOs, ASOs that exist as a legal entity but have ceased all activity, were classified as failures. To summarize, 39% of the ASOs in our sample were failures.

### 3.3.2 Independent variables

The IVs were used to track human capital parameters relevant to our research questions. In total there were 167 CEOs and 165 academic founders in the 84 ASOs in our sample, resulting in an average of two CEOs

---

<sup>4</sup> Even though the latest annual reports were from 2012, we track firm activity through the national business registry until 2014. I.e. if a firm discontinued in January 2014, this was considered.

and two academic founders per ASO. To ensure consistency in how the IVs were treated we developed a set of criteria for each IV. Furthermore, some general criteria was set. Employments with a duration of less than half a year were not registered, assuming that it takes time to acquire skills and knowledge. Moreover, industry-specific experience, thus experience which is directly relevant for the ASO in question, was not tracked separately as such specificity was hard to judge with the available data.

As previously mentioned, we tracked whether an individual possessed (1) or did not possess (0) the different types of experience. Moreover, this was done for all the CEOs. This information was used to calculate an average CEO for each ASO. For IVs relating to the CEO, the inputs to the model were constructed as averages. For each CEO, we had registered the number of years the position was held. To calculate the average for each IV we first multiplied the number of years each CEO had held the position as CEO, by the experience or education the CEO held (1 or 0). These were calculated for all the CEOs and added together. By dividing this sum on the number of years of operation of the ASO we were able to get an average CEO for each ASO. From now on the average CEO will be referred to as *ACEO*. Each ASO thus has an *ACEO* for all of the IVs.

There is one distinction between experience and education which this calculation does not take into consideration. Education is finite in time and its presence is easy to measure. Experience, on the other hand, is something that is gained over time, meaning a CEO with 10 years of experience should have acquired more human capital than a CEO with one year of experience. This is a limitation of the chosen method, and will be treated in section 3.4.

First, each type of experience will be presented as well as the criteria that was used to judge each case.

*Entrepreneurial work experience* measures if the CEO was previously employed in, or owned a startup. A startup was defined as a firm that had existed for less than 10 years at the time of the employment or ownership. Lawton Smith and Ho (2006) demonstrated that it generally takes at least 10 years before the rate of growth of spin-off companies start

to accelerate. The limit of 10 years was chosen as we did not want to include experience from spin-off companies in the growth stage, as it can be assumed that procedures have been set in place that reduce the influence or importance of the employees' human capital. Experience from companies such as personal consulting companies, real estate management companies and holding companies was not included even if they had existed for less than 10 years. This distinction was done for three reasons. Firstly, in personal consulting companies the "product" being sold is the consultant's knowledge, which we did not consider as relevant for this type of experience. Secondly, in real estate management companies the nature of the tasks are more managerial than "entrepreneurial", and they are typically driven by tax concerns. Thirdly, as private holding companies are concerned with ownership, the nature of the tasks are more managerial than entrepreneurial. On a different note, those that became CEO after having worked in a different position in the same ASO were registered to have entrepreneurial experience. However, learning from the position as CEO in the ASO was not registered. In other words, even though a CEO remained in the CEO position for several years, he or she were not rewarded with entrepreneurial experience in our coding system. This limitation will be discussed in section 3.4. 24% of the ASOs had CEOs with prior entrepreneurial work experience.

*Commercial work experience* measures previous employment with marketing and sales related tasks, as well as contact with customers, suppliers and manufacturers. Employments where it was stated explicitly that a person was responsible for such tasks were registered. Furthermore, work experience from TTOs, seed funding companies and other types of investment companies was also registered as commercial experience. Previous employments within project management were also registered as commercial experience as it was assumed that the project management tasks would include extensive contact with suppliers and customers. 45 % of the ASOs had CEOs with this type of human capital.

*Technical/scientific work experience* measures if the CEO previously has had an employment typically dealing with technical



or scientific tasks. If a CEO held a technical PhD degree, the CEO would automatically get technical/scientific work experience as it was assumed that technical work had to be performed in order to receive the PhD degree. Almost 70% of all ASOs had CEOs with technical work experience.

*Managerial work experience* measures whether the CEO previously had an employment with responsibility for managing other people or managing a firm. It had to be stated explicitly in the job description that the CEO had responsibility for other employees or was a leader of some kind. A lot of the time the CEO would have worked as a project manager or leader. Additionally, work experience from TTOs, seed funding companies and other types of investment companies was also classified as managerial work as such employments most often require that the person has to take an active and managerial role in start-up companies. The number of employees and level at which they were managed was not specified. In fact, in most cases such information was not readily available. 50% of the ASOs had CEOs with managerial work experience.

*Technical education* measures if the CEO holds a bachelor degree or higher from a technical area of study. 81% of the ASOs had CEOs with some sort of technical education.

*Managerial education* measures if the CEO holds a bachelor degree or more from managerial, business or economic studies. 23% of the ASOs had CEOs with this type of education.

*Phd* measures if the CEO holds a Phd degree, which was the case for 34% of the sample. This high occurrence of Phd degrees will be commented in 3.3.4.

*Academic founder* refers to founders of the ASO (classified as those who own shares within the first two years after establishment) that worked as key researchers on the project or institution where the ASO originated from. 86% of the ASOs in the sample had one or more academic founders.

*Academic founder with commercial work experience* measures if an academic founder, as described above, has commercial work experience. This was the case for 18% of the ASOs.

### 3.3.3 Control variables

Four factors are used as CVs. The justification for this follows.

*Venture Capital:* VC is used as a CV as we are interested in the independent effect of experience and education, and thus want to control for the effect on performance arising from resources obtained through VC financing. Access to VC is a key driver of ASO performance (Colombo and Grilli, 2009). In fact, receiving VC financing is found to be associated with superior growth when compared to companies that did not receive such financing (Gimmon, 2010). Based on the literature we expect that this variable is highly and positively correlated with ASO performance. As illustrated in table 3, a strong correlation between ASO performance and receiving VC funding was found. Furthermore, 48% of the ASOs in the sample received VC funding.

Receiving VC funding is also closely linked to human capital. Several scholars give support to the issue of VCs investing in people with certain types of human capital, such as managerial skills derived from either education or work experience (Colombo and Grilli, 2010, Gurdon and Samsom, 2010, Gimmon, 2010). As our study investigates human capital's effect on performance over time, it is necessary to control for the effect of receiving VC, as receiving VC has a high and positive impact on performance. Furthermore, the particular human capital coveted by VCs will most likely be artificially inflated in the model if not controlled for. Another reason to use VC as a CV is based on Colombo and Grilli (2009) findings which indicate that new technology based firms (NTBF) that receive VC funding experience higher growth independently of the founders' human capital. This was explained by the coaching function of VCs, improved financials as well as the signalling effects it gave to other stakeholders (Colombo and Grilli, 2009).

*Bio/pharma:* ASOs in the biotechnical and pharmaceutical industry differ from those in other industries as they typically have longer product development times and potential for significantly higher returns. Stringent requirements for clinical trials and verification causes longer and more resource demanding development periods compared to other industries (Mustar et al., 2006).

Accordingly, we expect this variable to be negatively correlated with ASO performance as our observation window of less than 10 years is too short to capture the potential for higher returns. This expected negative correlation appears to be correct, as can be seen in table 3. Moreover, 23% of the ASOs operate in the Bio/pharma industry. Thus it is important to control for their extended development time.

*Software:* Firms in the software industry have faster and less resource intensive development periods compared to those in other industries (Druilhe and Garnsey, 2004). Since they differ from other ASOs with regards to their resource needs, we expect ASOs based on software to behave differently. 35% of the ASOs operate in the software industry.

*CEO change per year:* Frequent CEO changes in a firm are often interpreted as a sign of distress (Daily and Dalton, 1995). On the other hand, when VCs invest they also tend to change the CEO (Gimmon, 2010). However, we expected that the latter will have a small effect as not all ASOs in the sample received VC funding, and this only accounts for a small portion of the CEO changes. Thus, we expect this variable to be negatively correlated with ASO performance. As illustrated in table 3, the correlation was negative. In line with the above argumentation, a positive correlation was found between CEO

changes per year and receiving VC funding.

### 3.3.4 Descriptive statistics

Table 2 displays some descriptive statistics of the variables used in this study. Relatively high or low percentages will be commented.

Interestingly, 86% of the ASOs have at least one academic founder present at inception, which may indicate that academic inventors are important in deciding if a technology or research result should be commercialized through the establishment of an ASO.

Furthermore, it can be noted that 81% of the ASOs have CEOs with technical education, and 70% of all ASOs have CEOs with technical work experience. A possible explanation is that there an abundance of inventor CEOs. Actually, 42% of FORNY spin-offs had inventors as the *current* CEO (Borlaug, 2009). It may be that the occurrence of inventor CEOs is higher in our sample. This may be attributed to the fact that we look at all CEOs as opposed to current the CEO. Another reason can be that academic founders hire CEOs with a similar mindset as them, put differently, it may be that they prefer CEOs with a similar background to theirs.

Moreover, 34% of the ASOs have CEOs holding a PhD degree. In line with the above, this high percentage may be attributed to having academics or researchers as CEOs, as they often have PhD degrees.

Lastly, the occurrence of one the CVs

TABLE 2 - DESCRIPTIVE STATISTICS

Variable name:	Variable value:	No. of cases	% of cases	Mean	S.D.
<b>Dependent variable:</b>					
	Non-performers = 0	33	39,30%	,607	,491
Performing	Performers = 1	51	60,70%		
<b>Independant variables:</b>					
	No academic founder present at inception = 0	12	14,30%	,857	,352
Academic founder present	Academic founder present at inception = 1	72	85,70%		
	No academic founder w/commercial wxp present at inception = 0	69	82,10%	,179	,385
Academic founder w/ commercial wxp	Academic founder w/commercial wxp present at inception = 1	15	17,90%		
	CEO has no technical edu = 0	16	19,10%	,810	,324
CEO technological edu	CEO has technical edu = 1	68	80,90%		
	CEO has no managerial edu = 0	64	76,40%	,236	,348
CEO managerial edu	CEO has managerial edu = 1	20	23,60%		
	CEO has no Phd = 0	55	65,90%	,341	,405
CEO has a Phd	CEO has Phd = 1	29	34,10%		
	CEO has no entrepreneurial wxp = 0	66	78,29%	,217	,326
CEO Entrepreneurial wxp	CEO has entrepreneurial wxp = 1	18	21,71%		
	CEO has no technical wxp = 0	26	30,50%	,683	,395
CEO technical wxp	CEO has technical wxp = 1	58	69,50%		
	CEO has no commercial wxp = 0	46	54,90%	,451	,431
CEO commercial wxp	CEO has commercial wxp = 1	38	45,10%		
	CEO has no managerial wxp = 0	42	50,20%	,498	,445
CEO managerial wxp	CEO has managerial wxp = 1	42	49,80%		
<b>Control variables:</b>					
	Not recived VC = 0	44	52,40%	,476	,502
VC	Recived VC = 1	40	47,60%		
	Total number of CEOs divided by firms age			,212	,136
	Not software company = 0	65	64,30%	,357	,482
Software	Software company = 1	19	35,70%		
	Not bio/pharma company = 0	54	77,40%	,226	,421
Bio / pharma	Bio/pharma company = 1	30	22,60%		

wxp = work experience  
edu = education

is high, namely VC. 48% of the ASOs received VC funding. This is almost the double of what Borlaug (2009) found to be the case based on UK evidence, which showed that 25% of ASOs received this type of funding. The percentage may be unnaturally high due to the nature of one of the funds which was registered as a VC fund, S korn Invest Midt-Norge. This was a seed fund which typically invested smaller amounts in several ASOs, thus the fund had a different profile from a typical VC fund. This could have been adjusted for by changing the variable which refers to first occurrence of VC in step 1, as explained in 3.2.1. However, we chose not to do this. We assume that this seed fund company used a set of criteria in order to decide if an ASO should receive money, thus indicating that the ASOs that receive this seed funding were more likely to perform better than those who did not receive funding. As such, it is in line with the reasoning used when explaining why we used VC as a CV.

### 3.4 Methodical limitations

As shown in the above sections, several simplifications and operationalizations have been made in order to be able to test the hypotheses quantitatively. Limitations related to our chosen method will now be presented.

*LinkedIn:* Although LinkedIn mostly proved to be an excellent source of information, there is still an important limitation with regards to the incompleteness of the information available on LinkedIn. The CEOs and academic founders' backgrounds were occasionally incomplete, which led to some assumptions on work experience and education based on available information. There is also an argument to be made whether or not LinkedIn can be assessed as a trustworthy source of information as people provide the content for their personal page themselves. Furthermore, they likely have a clear purpose to make it available on LinkedIn; to attract job offers and other interesting opportunities. In fact, several individuals omitted information about CEO experience from ASOs that failed (on LinkedIn), information we found in the national business register. A rather expected but important data gathering limitation is that a number of professors and researchers did not have a LinkedIn profile. In these cases we

assumed that they stayed in the same position since finishing their studies unless the results from a web search contradicted this. In order to limit the consequences of this limitation we supplemented and cross checked information through web searches.

*Annual reports:* Overall, the annual reports were a valuable source of information. However, several of the statements of the board were very short and did not include updated information about the status of the ASO. On some occasions they were simply copy pasted from the previous year. To some extent we were able to correct for this limitation by studying the financial statements and comparing them to previous years.

*Learning:* Learning was not taken into consideration. Some CEOs held the position since ASO establishment, yet the experience gained from the earlier years was not registered in later years. However, if they were CEOs twice in the same ASO, with an interim CEO, we registered the experience gained from the first period. Ideally we would have treated the two cases in the same way.

*Overlap in work experience:* Some types of previous employment were attributed several types of work experience. For example, work experience from TTOs, seed funding companies and other types of investment companies would lead to both managerial and commercial work experience, which may influence the results.

*Binary variables:* Our choice of using binary variables poses some limitations. Education is finite in time and it can be easily measured if a CEO has a bachelor, master or PhD degree. However, there may be differences in the quality of the education from different education institutions, which the use of binary numbers does not account for. International rankings of universities could have been used to adjust for this. Experience, on the other hand, is gained over time. I.e a CEO with experience as Head of Sales of a large corporation for a decade will receive the same experience as a CEO which has worked in phone sales for a year. It would be natural to assume that the former would have a "stronger" experience than the latter, due to both industry specificity and duration. Thus, we could have strengthened our method by taking industry specificity into account as well as using continuous, as opposed to binary, variables.

*Types of education:* We did not track general education. On some occasions a CEO would have an educational background not covered by the two categories that were tracked, which may impact the results. Furthermore, we did not specify whether at PhD was technical, managerial or other, however we observed that the majority were technical/scientific PhDs. Finally, business, education and managerial educations were all registered as “managerial education”. This grouping was chosen as there may be overlaps in the various types of education, and it would have required that we checked the curriculum of the education (if it was still offered) in order to ensure consistency in the grouping. Moreover, on a few occasions people on LinkedIn would just state the school (the Norwegian school of economics and BI Norwegian Business School were most commonly stated) and level of education, without specifying the degree, thus making it difficult to verify the curriculum. It may be that there are differences within this grouping.

*Path dependency:* While we weighted the CEOs’ experience and education with the number of years they held the position, we did not give more weight to the first CEOs. Arguably the decisions made by the first CEO(s) impacts the future of the ASO. Ideally we would have weighted the first CEO(s) to correct for the inferred path dependency. The required analysis techniques to operationalize the dynamics of the time dimension was outside the scope of this master thesis, and accordingly was not done.

*Timing:* By calculating an ACEO we take difference in human capital of the various CEOs into consideration, and thus acknowledge that differences inferred over time matter. However, we do not take into consideration the timing of these human capital differences. This is an interesting area for further research which will be described in section 7.

*Active academic founder:* Although the presence of academic founder at inception

was registered, we have no way of knowing if the academic founder took an active part in the TMT. Our analysis is based on the assumption that the academic founder is actively involved in the ASO. However, this was not possible to measure quantitatively with the available data.

*Definition of performance and failure:* The way performers and failures are defined may impact the results. ASOs that have considerable activity are defined as performing. However, they may still fail in a close future. Moreover, with only 10 years of data it is hard to see if any of the ASOs have become highly successful. For example, in our sample there is only one IPO. Furthermore, the fact that we did not have annual reports for 2013 poses a limitation as we lack the information to judge the most recent status and activity level of the ASO. However, the consequences of this limitation were reduced by checking if the ASO had been discontinued in the national business register later than 2012. The ASO’s web pages were also used to see if there were any indications of a change in activity level.

*VC as a CV:* The fact that we used VC as a CV is a limitation as receiving VC is related to human capital factors. Even though we chose to build the model in this way we could have built it differently by arguing that human capital is vital for receiving VC funding. Access to VC funding will affect performance, accordingly human capital that helped secure this funding indirectly affects performance.

## 4. ANALYSIS

In this section we outline the data analysis method. It was performed using binary logistic regression. Utilizing logistic regression makes it possible to create a statistical model which explains how each of the IVs affect our DV (ASO performance), thus enabling us to test whether the hypotheses derived in section 2.2 are supported.

TABLE 3 - CORRELATION MATRIX

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Performing	1													
2 Academic founder present	,020	1												
3 Academic founder w/commercial wxp	,120	,190	1											
4 CEO technical edu	-,011	,009	,000	1										
5 CEO managerial edu	,170	-,043	,245*	-,312**	1									
6 CEO has a Phd	,002	,110	-,019	,286**	-,307**	1								
7 CEO technical wxp	,064	,064	,176	,567**	,001	,442**	1							
8 CEO commercial wxp	,105	-,280**	,257*	-,218*	,467**	-,210	-,003	1						
9 CEO managerial wxp	,166	-,237*	,263*	-,174	,410**	-,174	,164	,736**	1					
10 CEO entrepreneurial wxp	,071	-,060	,112	-,057	,260*	-,005	,194	,614**	,536**	1				
11 CEO change per year	-,089	-,375**	-,033	-,048	,151	-,007	-,101	,178	,237*	,093	1			
12 VC	,474**	-,019	-,009	-,014	,118	-,035	,051	,166	,251*	,187	,219*	1		
13 Software	,040	,162	,171	,237*	,037	,035	,159	-,107	,043	-,173	-,115	-,014	1	
14 Bio / pharma	-,148	-,186	,045	-,160	,361**	-,013	-,001	,266*	,211	,305**	,169	-,003	-,403**	1

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

wxp = work experience

edu = education

Having created a model, it is also critical to test to what extent the model fits the data. Among the several tests available, we chose to use the *Nagelkerke R Square* test and the *Hosmer and Lemeshow* test. Nagelkerke R Square is a measure for how well the statistical model fits the data and is useful as the DV is binary. The Hosmer and Lemeshow-test is a similar test, however it assesses if the observed IVs match the expected IVs in subgroups of the model. By using these two tests and common statistical evaluation tools like *Chi-square* and *log-likelihood* we can thoroughly assess the validity of the model suggested by the regression.

To interpret the created model we are using odds ratio (OR) and p-value. OR is a measure of the association between an IV and the DV. The OR represents the odds that the DV will occur given a particular IV, compared to the odds of the outcome occurring in the absence of that IV. An OR above one means that the IV has a positive effect on the DV, while an OR below one means that the presence of this variable will have a negative effect on performance. The OR also has a significance measure tied to it. This indicator (p-value) explains the probability of the effect observed occurring by chance. The closer to zero, the more certain one can be that the IV has structural predictive power to the DV. The limit for significance typically used in social sciences is 0.2 (Field, 2009). Anything above this implies the high chance for random variation and therefore the lack of support of the hypothesis.

Before performing the regression the possible existence of multicollinearity problems has to be ruled out (Freund and Wilson, 1998). Variables in the final model

may appear statistically insignificant even though they are significant due to high correlation between two or more of the IVs (Field, 2009). First we will investigate how the variables correlate with each other. Lastly, the regression is presented.

#### 4.1 Correlation matrix analysis

The correlation matrix makes no a priori assumption as to whether or not one variable is dependent of others. The matrix only gives an estimate to the degree of association between the variables. As seen in the correlation matrix (table 3), VC funding has a significant, but moderate, correlation (<0.48) with performance, while the other CVs and IVs demonstrate weak correlations (<0.2) with the DV. While no single variable (excluding VC) seems to significantly affect performance independently, it is possible to reveal the effect of each variable when analysed in a regression system. However, for the regression to produce significant results it is vital that all correlations are below the 0.8 standard used by many in social sciences (Field, 2009). This indicates that the dataset has no multicollinearity problems that will affect the regression.

There are four correlations worth noting; (i) Technical education and technical work experience (0.567); this correlation is not surprising as it stands to reason that a person with technical education quite often will get a technical job and that a technical job requires a technical education. Situations where CEOs are fresh out of school or have gone straight into commercial/managerial jobs might explain dynamics working against the correlation (ii) Managerial work experience and commercial work experience (0.736);



Quite often managerial work will also have a commercial component to their duties (ie. talk to customers, and suppliers) especially in the case of smaller firms. (iii) Entrepreneurial work experience and commercial work experience (0.614); The same argument as above applies here. When you are an entrepreneur you often have to do multiple tasks in the company and arguably market related tasks are one of them. (iv) Entrepreneurial work experience and managerial work experience (0.536); This correlation is also explained as quite often entrepreneurs will have to do managerial work in their start-up. Even though all correlation-values are below the 0.8 limit, some of the highest valued variables may exhibit weak signs of multicollinearity. Due to this, they have been paid special attention to in the subsequent data analysis.

## 4.2 Regression analysis

To investigate further whether multicollinearity problems exist, the variance inflation factors (VIF) were calculated for all IVs. With a maximum in the dataset of 3.3, the VIF scores were significantly below the widely accepted threshold of 10 (Kutner et al., 2005). Considering VIF scores combined with the study of table 3 leads us to conclude that the dataset has no multicollinearity problems that will be problematic when interpreting the results.

The hypotheses look at two different contexts; H1 and H2 investigate how the ASOs develop over time due to the influence of the CEO while H3 looks at whether the academic founders' presence at the inception

TABLE 5 - CEO REGRESSION

	Step 1		Step 2		Step 3		Step 4	
	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio
CEO entrepreneurial wxp			,698	,646			,613	,545
CEO technical wxp			,724	,772			,515	,487
CEO commercial wxp			,954	1,058			,686	,650
CEO managerial wxp			,292	2,684			,217	3,802
CEO technical edu					,977	1,027	,578	1,929
CEO managerial edu					,037	8,753	,042	10,848**
CEO has a Phd					,285	2,276	,173	3,656*
VC	,000	14,457**	,000	13,785**	,000	14,585**	,000	14,597**
Software	,754	,827	,600	,707	,418	,575	,278	,454
Bio / pharma	,224	,428	,185	0,368*	,045	0,19**	,039	0,169**
CEO change per year	,063	0,016**	,041	0,007**	,034	0,007**	,020	0,003**
Constant	,425	1,576	,502	1,652	,887	1,140	,925	,912
Chi-square	,000	26,166	,000	28,106	,000	31,599	,000	33,360
-2 Log likelihood		86,396		84,456		80,963		79,202
Hosmer and Lemeshow Test	,749	5,076	,713	5,412	,437	7,964	,997	1,150
Nagelkerke R Square		,363		,385		,425		,444
Δ R-Square				,022		,040		,019
% of cases correctly predicted		72,600		73,800		77,400		81,000

\*\* Odds ratio is significant at the 0.1 level (2-tailed).

\* Odds ratio is significant at the 0.2 level (2-tailed).

wxp = work experience

edu = education

of the ASO has an effect on performance. When regression is used for analyzing data, the context of the IVs need to be the same (Kutner et al., 2005), leading us to perform two separate regressions for H1/H2 and H3. With regards to the CVs, "CEO changes per year" is left out in H3. This is logical as the regression looks at the ASO's inception, thus compensating for how rapidly an ASO changes CEOs during its lifetime is irrelevant. When performing the regression the IVs were sorted into groups. In order to observe the IV's influence on the model in detail, these groups were added to the regression in steps. The two regression procedures are described below.

### 4.2.1 CEO regression

Variables were divided into three groups as presented in table 4. The first group consists of CVs, the second group comprises IVs related to work experience and the last group consists of IVs relating to educational background.

TABLE 4 - GROUPS USED IN THE CEO REGRESSION

	CEO change per year
Group 1	Venture Capital Software Bio / Pharma
Group 2	Entrepreneurial Technical wxp Commercial wxp Managerial wxp
Group 3	Technical edu Managerial edu PhD

wxp = work experience  
edu = education

Table 5 presents the CEO regression. The table displays each of the partial regressions and shows how the p-values and ORs of the IVs change when other groups are added. Table 5 also shows how well the model fits the data as each group is added to the model. Step 4 includes all variables and is the final model used to answer the hypotheses. Group 2 and 3 were separately added to group 1 (CVs) in the regression in order to observe how each group interacted with the CVs. Each of these partial models got acceptable Nagelkerke R Square and Hosmer and Lemeshow scores (step 2 and 3). Moreover, when all groups were included in a larger and more complete model (step 4) we observed a significant increase in both Nagelkerke R Square and Hosmer and Lemeshow. The Chi-square and -2 Log likelihood coefficients suggest that both groups of IVs significantly contribute to the model.

Although the p-values and ORs fluctuated, their overall influence on the model (negative or positive effect on performance) stayed the same through each step, with two exceptions; (i) Commercial work experience went from an OR of 1.058, indicating no effect, in step 2 to a negative effect (OR=0.650) in step 4. This implies that when only work experiences are analysed by the regression commercial work experience has no impact. However, allowing for covariation with education components, commercial experience has a negative impact on performance (ii) Technical education went from not having an effect in step 3 (OR=1.027) to having a positive effect in step 4 (OR=1.929). This has a similar explanation as the above. When the regression looks on how education in isolation affects performance technical education seems to have no impact. However, when the regression considers both work experience and education and their effects on performance, the contribution from technical education becomes positive, thus indicating a covariation between these two groups. It is worth noting that neither commercial work experience, nor technical education has p-values that make them significant in the model, so although these

changes are interesting it is not at a level of significance where we can draw any concluding remarks.

When adding the two groups together two IVs and one CV got a decrease in p-value, i.e an increase in significance. The decrease in PhD (down 0.11) can be explained by a strong correlation with technical work experience that indicates a covariation with one or several work variables. Similarly, the decrease in managerial work experience (down 0.08) can be explained by a strong correlation with managerial education that indicates a covariation with one or several work variables. Bio/pharma has a steady reduction in p-value (down 0.185) and in the OR (down 0.259) when the two other groups are added. This indicates that this variable has some covariation with both groups.

Correlations between the groups (education and work experience) appears to have a positive effect on the model as each group adds to the fit and predictive power of the model. The regression in Table 5 classifies 81% correctly, which is significantly higher than the 60.1% baseline classification. Where baseline classification refers to the blind prediction of an ASO as “performing”, this being the most common outcome in the dependent variable. As 60.1% of our sample is classified as “performers”, the baseline classification is set to 60.1%.

#### 4.2.2 Academic founder regression

Variables were divided into two groups, as seen in table 6. The first group consists of CVs, while the second contains IVs related to the presence of an academic founder at ASO inception.

TABLE 6 - GROUPS USED IN THE ACADEMIC FOUNDER REGRESSION

	Venture Capital
	Software
Group 1	Bio / Pharma
	Academic founder present
	Academic founder w/
Group 2	commercial wxp
	wxp = work experience
	edu = education

TABLE 7 - ACADEMIC FOUNDER REGRESSION

	P-value	Odds ratio	P-value	Odds ratio
Academic founder present			,832	,847
Academic founder present w/commercial wxp			,192	2,551*
VC	,000	9,699**	,000	9,923**
Software	,885	,918	,663	0,766
Bio / Pharma	,153	0,378*	,129	0,336*
Constant	,590	,792	,816	,832
Chi-square	,000	22,387	,000	24,193
-2 Log likelihood		90,174		88,368
Hosmer and Lemeshow Test	0,215	5,799	0,128	11,247
Nagelkerke R Square		0,317		0,339
$\Delta$ R-Square				0,022
% of cases correctly predicted		72,6		75

\*\**. Odds ratio is significant at the 0.1 level (2-tailed).*

\**. Odds ratio is significant at the 0.2 level (2-tailed).*

*wxp = work experience*

*Sig. = Significance*

When the first group was added to the model the variables acted as expected. Bio/pharma affect the firms performance negatively, while obtaining VC funding is highly positive. Software appears not to have a significant effect. When adding the second group, the CVs still behaved as expected with only slight variations in their OR. Both VC and Bio/Pharma became more significant when group 2 was added. This indicates that these two control variables has some covariation with the founders components. Also worth noting is that when the second group was added one can observe a significant increase in both Hosmer and Lemeshow, Nagelkerke R Square, Chi-square and log-likelihood scores. This increase in scores suggest that the group of IVs contributed to the predictive power of the model. The regression in table 7 has a correct classification of 75%, which is significantly higher than the 60.1% baseline classification.

## 5. RESULTS AND DISCUSSION

Based on the binary logistic regression we performed, we are able to assess our hypotheses. We will present and subsequently discuss whether or not we have found support for the hypothesis. Results that are not significant will also be discussed, thus taking the direction indicated (given by the OR) into consideration. First, we investigate the work experience related hypotheses. Secondly, we

investigate the education related hypotheses. Thirdly, we assess the effect of the presence of the academic founder. Finally, we investigate the inter linkedness between these three variables by providing some overall considerations. Since the hypotheses have been tested on our operationalization of the TMT, the CEO, the discussion revolves around the CEO.

### 5.1 Work experience

*Hypothesis 1a: Managerial work experience in the top management team has a positive effect on academic spin-off performance.*

In line with literature, managerial work experience appears to have a substantial positive effect on ASO performance. Thus *hypothesis 1a is weakly supported* as the significance level is slightly above the 0.2 limit. Furthermore, it was found that half of the ACEOs had managerial experience, giving room for variance in the sample. As seen in table 3 this type of experience correlates with VC. However, as we employed an average CEO we cannot say if this is because managerial experience attracts investors, or if investors require a change in CEO in order to get a CEO with managerial experience. Nonetheless, receiving VC correlates with CEO changes (significant at the 0.05 level), indicating that receiving VC leads to a change in CEO. Moreover, literature indicates that VCs look for ASOs with management experience in the TMT (Colombo and Grilli,



2010), indicating that both scenarios as presented above occur.

*Hypothesis 1b: Technical work experience in the top management team has a positive effect on academic spin-off performance.*

Technical experience generates a p-value of 0.5, meaning the relationship between technical experience and performance is random and inconclusive, thus the *hypothesis is not supported*. Furthermore, the OR indicates a negative effect (0.5). This is slightly contradicting with literature as we expected to find a clear positive effect, especially since our sample consists of high-tech firms. Worth noting is the fact that most ACEOs in our sample (70%) have technical experience, meaning the variance in the variable is low, which may be the reason for the inconclusive results. Even though, the suggestion of ASOs needing technical experience may still apply, as the crucial type of technical experience may reside in other founders than the CEO.

Furthermore, the high level of technical experience among our ACEOs may be an illustration of the original entrepreneurial team appointing external CEOs that have similar backgrounds to themselves or that the founders themselves become CEOs. On the one hand, a CEO with similar background may be positive, as it reduces cognitive distance and enhances the transfer of tacit knowledge (Knockaert et al., 2011, Zucker et al., 1999). On the other hand it may lead to group thinking and bad strategic decisions, as different viewpoints are not introduced and discussed (Buyl et al., 2011). Our model cannot be used to find support for these assumptions as it does not codify subjective and personal opinions of the individuals involved. If further investigated, a case study approach with in-depth interviews is suggested to be more appropriate.

We also observe that 30% of the ACEOs lack technical experience, meaning no technical experience has ever been present in CEOs throughout the development of the ASO. This is worth a comment as this could be a reason for the insignificant and negative result. Assuming this is indeed the case, one could argue that the lack of technical experience of the CEO in very early stages of an ASO may lead to failure to find a suitable market for the technology. The CEO is

arguably influential in strategic decisions, meaning the failure to comprehend the technology and its value offerings may be detrimental to firm development. Even though technical experience is suggested to become of lesser importance in later phases, early decisions have lasting effects on the firms performance, implying that poor decision making in early phases may limit future prospects of growth (Bamford et al., 2000).

*Hypothesis 1c: Commercial work experience in the top management team has a positive effect on academic spin-off performance*

Results regarding the effect of commercial experience are inconclusive as the p-value is well above the limit of significance (0.7). *Hypothesis 1c is not supported*. This is somewhat contradicting to the majority of existing literature which outlines commercial experience as a positive influence on ASO performance (Aspelund et al., 2005, Shane, 2000, Park, 2005, Marvel and Lumpkin, 2007, Shrader and Siegel, 2007, Marvel, 2013), albeit more so when complemented with technical experience (Wright et al., 2007b, Ganotakis, 2012, Colombo and Grilli, 2005). Several factors may have lead to the failure to support the hypothesis; (i) If commercial experience was not complemented with technical experience, the commercial experience may not have had an impact. Arguably, having knowledge of technology increases the understanding of the scope of the business idea and raises the chances of recognising opportunities (ii) If the cognitive distance between technical roles and commercial roles was too large this may have hampered performance as this inhibits effective knowledge sharing (Nooteboom et al., 2007) (iii) If commercial experience was not present in initial phases, the team may have failed to recognise the best opportunities and markets (Bjerkholt et al. 2014 ) (iv) Even though general commercial experience is expected to have a positive effect, the lack of experience from the particular market where the spin-off operates may have produced insignificant result. Arguably commercial experience is expected to produce more significant results if the experience is industry-specific. This is an interesting topic for further research.

*Hypothesis 1d: Entrepreneurial work experience in the top management team has a positive effect on academic spin-off performance.*

The effect on entrepreneurial work experience is insignificant in our model as the p-value is 0.6. Hence, the hypothesis is not supported. Even though the result is inconclusive, the OR points in a negative direction. If the negative effect was to be significant, it is somewhat contradicting to previous literature, as we expected to see a positive effect on firm performance. A stream of literature does however point out that second time entrepreneurs may become overconfident and adopt strategies that have worked in the past (Santarelli and Hien Thu, 2013). As ASOs operate in dynamic and rapidly changing environments (Unger et al., 2011), second-time entrepreneurs should be just as eager to seek out new knowledge as challenges in a high tech venture are likely to be different from those of their previous firm. Hence, entrepreneurs should never rest on their laurels. Furthermore we also made observations that some CEOs with entrepreneurial experience were surrogate CEOs hired from TTOs and VC firms. We were given the impression that their role as a CEO was merely one of administrative and practical function and far from a full-time engagement as they would often work in the several startups at the same time. Arguably, this makes it difficult to take full advantage of their entrepreneurial experience resulting in divergence in our sample.

## **5.2 Education**

*Hypothesis 2a: Managerial education in the top management team has a positive effect on academic spin-off performance.*

In line with existing literature (Colombo and Grilli, 2009, Oakey, 2003, Ganotakis, 2012), managerial education is found to have a high impact on ASO performance. *Hypothesis 2a is supported* with a p-value of 0.04, thus with high significance. In fact, managerial education is the IV in the model with the strongest (measured by the OR) positive effect to predict ASO performance. It is surprising that managerial education has such a strong effect on performance compared to managerial work experience. A possibility is that the

combination of education and experience has an effect on performance. In other words, the combination of management education and managerial work experience may exert a greater impact on ASO performance compared to technical education (or no education) combined with managerial work experience. This would explain why management education appears to have a stronger impact on performance compared to managerial work experience.

Furthermore, the difference between managerial education and managerial experience may be due to the way the variables *managerial education* and *managerial experience* were measured. Managerial education includes business, managerial and economic educations. On the other hand, managerial experience measures previous experience in managing people (see 3.3.2). It is possible that it is advantageous to have knowledge about businesses and economy, and that this explains why managerial education has a higher impact on ASO performance compared to managerial experience.

Finally, as 86% of the ASOs have academic founders it is likely that the majority of ASOs have technical knowledge within the TMT. It is possible that positive synergy effects occur due to the coexistence of technical knowledge and managerial education. This is in line with literature emphasizing the importance of technical skills being balanced with managerial/business and commercial skills (Kakati, 2003, Oakey, 2003, Ganotakis, 2012, Gurdon and Samsom, 2010, Aspelund et al., 2005).

*Hypothesis 2b: Technical education in the top management team has no effect on academic spin-off performance*

The p-value of technical education's impact on the performance of an ASO is too low (0.6) for us to say something conclusive. Accordingly, *hypothesis H2b is not supported*. Nonetheless, we will discuss the results assuming they are significant. In fact, the variable appears to have a positive impact on ASO performance. This is in line with Colombo and Grilli (2009)'s findings, which indicate that technical education has a limited, but positive impact on performance. However, 80% of all ACEOs had technical education in our dataset, which makes it difficult to draw conclusions on its

importance. It may be that CEOs with technical backgrounds are more likely to understand the technology, its limitations and possible applications. Furthermore, it may be that technical education in the TMT is particularly important in ASOs as early phase technical inventions are commercialised (Shane, 2004).

*Hypothesis 2c: PhDs within the top management team has a negative effect on academic spin-off performance.*

*Hypothesis is not supported* as it was found that those holding a PhD degree were in fact more likely to positively affect ASO performance. Furthermore, this can be said with moderate significance (p-value of 0.173). The results thus appear to be in opposition with previous studies, which give support for an inverted U-shaped relationship between education and ASO performance (Oakey, 2003, Ganotakis, 2012, Unger et al., 2011, Gimmon, 2010), in which it is specified that higher education in the form of PhDs affect ASO performance negatively. While we do not test for an inverted U-shape, we are able to say that the endpoint (having higher education in the form of PhDs) of this relationship does not affect performance negatively, but rather positively. It may be that having high education at the PhD level gives credibility in the academic environment of an ASO, which again facilitates the access to resources in academic institutions as well as receiving governmental funding. In fact, Gimmon (2010) found that academic status in the form of holding a PhD increased the chances of receiving external investment. Since we have used average values for the CEOs we do not have the data to investigate if this is the case. However, we do know that receiving VC funding is positively and significantly correlated to performance.

Furthermore, it should be noted that practically all of the PhDs in the sample were of technical character. In this way we have rather tested if technical PhDs, as opposed to general PhDs, have a negative effect on ASO performance. If other types of PhDs had been present in CEOs, for example social science PhDs, we believe that the positive effect on ASO performance might diminish. However, this belief is based on the assumption that most of the PhDs are held by academic founders that at some point in time hold the position as

CEOs. Moreover, it assumes that the PhDs are closely related to the technology or research result being commercialized. It is important to emphasize that this is an assumption, so it needs to be investigated whether this link exist. However, as previously pointed out, Borlaug (2009) found that in 42% of the FORNY spin-offs, the founder was also the current CEO, thus indicating that our assumption might be true. This is an interesting area of further research.

### **5.3 Academic founder**

*Hypothesis 3a: Academic founders present in the top management team at the academic spin-off's inception will have a positive effect on performance.*

Due to a p-value of 0.8 we are not able to investigate whether the presence of academic founders is advantageous for ASO performance, thus *hypothesis 3a is not supported*. As the significance is so low we cannot say anything conclusive, although the OR indicates that the presence of academic founders have little or no impact on ASO performance. Worth noting is the fact that the majority of the tracked ASOs had the academic founder present, making the impact of this variable in the model inconclusive. We were not able to uncover to what degree academic founders were committed to the spin-off, assuming that this would give a more conclusive result. However, if the academic founder possesses commercial experience, the data points to a positive and moderate effect on ASOs performance. This supports the literature stating that academic founders with commercial experience are more likely to build performing spin-offs (Franklin et al., 2001). Founders with commercial experience are more likely to recognise commercial opportunities and the need to make products that are suited customer needs (Aspelund et al., 2005, Shane, 2000, Park, 2005, Marvel and Lumpkin, 2007, Shrader and Siegel, 2007, Marvel, 2013). Furthermore, when founders have experience in several areas, it is expected to reduce the cognitive distance in the TMT, acting as a bridge between the technical and commercial roles (Knockaert et al., 2011).

Interestingly, we failed to find a positive effect of commercial experience (the results are inconclusive) on ASO performance. As stated in the discussion of those results, it

may be that cognitive distance between commercial and technical roles were too large. Arguably, if an individual has both commercial and technical experience, drawbacks of cognitive distance are overcome. Furthermore, the presence of technical and commercial experience in the earliest phases is argued to enhance performance. Our result appears to support this argumentation since we found that academic founders with commercial experience (coexistence of technical and commercial knowledge in the same person) present at ASO establishment (indicating an early phase) affect ASO performance positively.

## 5.4 Other remarks

Overall, when comparing results of education with those of work experience, there is a moderate indication that education has a stronger effect on performance compared to experience. Out of three education variables (technical, managerial and PhD), PhD and managerial education were among the variables that showed the most significant and positive effects.

All experience variables, except managerial experience, produced insignificant results in the direction of a negative effect. It could be that the different types of experience prove valuable in certain phases of development and less in others. If this was true, this could be the reason why our results on experience are inconclusive as we did not identify at what point in time the various work experiences were introduced.

Even though we are not able to extract supporting data, it could also be that too much work experience in early phases actually has an adverse effect on performance as it implies a higher age, less willingness to take risk and also a psychological commitment to the current situation, preventing them to take innovative risks (Hambrick and Mason, 1984, Colombo and Delmastro, 2002). Additionally, experienced individuals are likely to be accustomed to higher spendings, both professionally and in their private life. The former may imply the accumulation of higher expenses in the spin-off, thus draining resources. The latter indicates a dependency on monthly income, which the spin-off may be unable to support in the long run. Hence, experience present in later phases could be

positively related to performance as the CEO will benefit from episodic learning from previous employments and a large network of contacts. Although the following is mere speculation and not supported in our dataset, newly graduated students have less obligations, are more willing to take risk and do not perceive the opportunity costs of not pursuing a paid job as high. Considering the Norwegian research context, this makes sense. Opportunity costs of quitting a well-paid job are high, the unemployment rate is significantly low<sup>5</sup> and accordingly very few become entrepreneurs out of necessity. Nevertheless, it is certainly an interesting topic of debate and further research.

## 6. CONCLUSION AND IMPLICATIONS

Explaining why some ASOs perform better than others is an increasingly interesting topic of study and is valuable as it helps to understand how one can create better performing spin-offs. The research questions of this study relates to how, and to what extent, human capital of the TMT and how presence of the academic founder affects performance. By looking at human capital indicators like experience and education of the TMT, operationalized through the CEO, we were able to investigate relationships between human capital and performance.

Whereas most other studies are static and study firms by taking a snapshot in time, we consider how *changes* over time in the TMT affects performance. By calculating an ACEO value for each type of human capital for each ASO we were able to see which types of human capital that affect ASO performance positively on *average*. With regards to experience, we found weak support for managerial experience's positive effect on ASO performance. Surprisingly, we found strong evidence that managerial education has the strongest positive effect on predicting ASO performance among all the variables that were tested. Furthermore, we found that the

---

5

[http://www.regjeringen.no/en/dep/asd/topics/labour-market-policy/arbeid\\_og\\_ledighet/arbeidsledighet-2.html?id=86893](http://www.regjeringen.no/en/dep/asd/topics/labour-market-policy/arbeid_og_ledighet/arbeidsledighet-2.html?id=86893)

presence of PhD degrees has a positive effect on performance.

As most ASOs are built upon the tacit knowledge of academic founders we also make a case for the study of the initial presence of the academic founder in the entrepreneurial team. While the results regarding the presence of an academic founder were inconclusive, we found that academic founders with commercial experience have a positive and significant effect on ASO performance.

Our contribution is also related to our chosen dataset. In contrast to a number of other studies, we have looked at the context of Norwegian ASOs, suggesting that Western-European spin-offs may exhibit other characteristics than those from US institutions, notably due to less developed high-tech environments and centers (Wright et al., 2007b). Additionally, being based on consistent and comprehensive information of 100 successful and failed Norwegian ASOs, it is arguably a unique and reliable dataset. By also taking failed ASOs into account, we prevented a survivor bias in our study.

Our findings offer a number of practical implications for all parties involved in spin-off creation and development. In the following section we will introduce practical implications for entrepreneurs, investors, TTOs and policy makers.

#### *Entrepreneurs*

Managerial education in the TMT has a strong effect on ASO performance. Additionally, managerial work experience has a positive effect on performance. We suggest that entrepreneurs gain managerial knowledge, possible through taking an MBA. Alternatively they could benefit from choosing individuals with managerial knowledge when expanding the team.

#### *External investors*

For the case of external investors, it is seen that they typically favor team members with managerial and entrepreneurial experience (Tyebjee and Bruno, 1984). However, the results of our study indicate that also managerial education and PhD degrees affect performance positively. High technical education, in the form of a Phd, should not be underestimated as this may provide the ASO with the academic credibility necessary to

obtain funds from governmental research grants and other resources from the research institution. Furthermore, the presence at ASO inception of academic founders with commercial experience appears to be a good predictor of high performance, and as such, should be emphasised by investors.

#### *TTOs*

As academic entrepreneurs with commercial knowledge have a positive effect on ASO performance, TTOs could contribute through focusing even more on the commercial aspects of spin-off development through coaching academic entrepreneurs. Hence, TTOs could contribute to raising academic founders' commercial awareness and help them develop a commercial mindset.

#### *Policy makers*

The strong relationship between managerial education and performance deserves some attention. Even though the relationship is likely to be affected by a combination of managerial education and some kind of work experience, we argue that people with managerial education regardless of experience may be a source of valuable input to an ASO. As research commercialization activity is primarily the work of technical universities and other research institutions, pure business schools are less likely to be involved in this kind of activity. We suggest business schools and technical research institutions form stronger bonds so that (i) business school graduates can become more involved in spin-off activity and complement the skills of technical entrepreneurs (ii) Practical and research related knowledge from business school environments can become of use to ASOs.

## **7. LIMITATIONS AND FURTHER RESEARCH**

While we have aimed at conducting a representative study, it is not without limitations. We encourage others to address these limitations. Accordingly, we will suggest some areas for further research.

*Longitudinal panel study:* Ideally, a longitudinal panel study should have been used to test the hypothesis in this article. This type of study may have helped in understanding *when* the different types of

human capital enhance ASO performance. These types of studies are based on observations that usually span several years. As this is outside of the scope of this master thesis we were unable to do so. However, we do suggest that others research when the different types of human capital are needed.

*Interaction effects:* Interaction effects from different combinations of the independent variables were not tracked, as described in 3.4. This could have further enriched the regression model, and enabled us to do an even more extensive discussion of the results. The choice of using an ACEO in the regression model made it very difficult to include interaction effects in the model, and this is the reason why these effects were left out of this study. Replicating our study while taking interaction effects into consideration is an interesting area of further research.

*Weighting the variables:* As indicated in 3.4, the use of binary variables poses some limitations. We encourage others to investigate how the use of continuous variables might affect the results of this study. We think that adjusting for the number of years of previous work experience of a CEO might influence the results, as experience is gained over time. Furthermore, a weighting of the variables with regards to the ranking of the educational institution where the education of the CEO originate from may impact the results (as explained in 3.4), and adjusted for.

*Larger sample:* Some of our results had elevated p-values and small variance in the samples, making the results inconclusive. However, assuming that the results had been conclusive, some of these results indicated that the hypotheses were wrong. Specifically, it appears that technical, commercial and entrepreneurial work experience may have a negative impact on ASO performance. While our sample of 100 firms is large enough to perform logistic regression, the validness of the results should be tested in larger samples. It would be interesting to see if the results of the analysis would have been different if we had performed them on the entire database of FORNY spin-offs. Additionally, it would be of interest to investigate the extent to which the context affects the results. Similar studies could be performed in other countries to verify the applicability of the results in an international context.

*Study the entire TMT:* Our findings are based on data focused on one individual namely the CEO, arguably the most influential person in the entire ASO. However recently other scholars have argued that most new ventures are started by teams, not individuals and that these teams take decisions together thus making the team and not the individual the most integral part of the performance of the ASO (Klotz et al., 2014). Thus, our operationalization of the TMT through the CEO poses a limitation that may affect our results. It is probable that some of the measures of human capital we tested for is present in other members of the TMT. Hence, replicating the study by looking at the whole TMT might influence the results, and we encourage others to do this.

*Effect of technical PhDs:* We had a surprising result with regards to the effect of PhD degrees in the TMT as we found that such presence has a positive impact on ASO performance. As this partly contradicts previous literature it should be further investigated. Furthermore, as most of the PhDs in our samples were of a technical character, it should be investigated whether the distinction between a technical and general (other than technical) PhD degree is the reason for this result.

*Education:* Surprisingly, we found indications that education may have a more positive impact on performance compared to work experience. As previously discussed, this may be due to some attributes associated with work experience (for example a higher age). This may indicate that inexperienced individuals that come straight out of the university are better suited to run an ASO in its earlier phases. We strongly encourage others to research this topic to test if this can be true.

## REFERENCES

- ARDICHVILI, A., CARDOZO, R. & RAY, S. 2003. A theory of entrepreneurial opportunity identification and development. *Journal of Business Venturing*, 18, 105-123.
- ARROW, K. J. 1962. The economic implications of learning by doing. *The review of economic studies*, 155-173.

- ASPELUND, A., BERG-UTBY, T. & SKJEVDAL, R. 2005. Initial resources' influence on new venture survival: a longitudinal study of new technology-based firms. *Technovation*, 25, 1337-1347.
- AVERMAETE, T., VIAENE, J., MORGAN, E. J., PITTS, E., CRAWFORD, N. & MAHON, D. 2004. Determinants of product and process innovation in small food manufacturing firms. *Trends in Food Science & Technology*, 15, 474-483.
- BAMFORD, C. E., DEAN, T. J. & MCDOUGALL, P. P. 2000. An examination of the impact of initial founding conditions and decisions upon the performance of new bank start-ups. *Journal of Business Venturing*, 15, 253-277.
- BECKER, G. S. 1964. *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, by Gary S. Becker, London.
- BORLAUG, S. B. 2009. *Between entrepreneurship and technology transfer: Evaluation of the FORNY programme*, NIFU STEP.
- BOSMA, N., VAN PRAAG, M., THURIK, R. & DE WIT, G. 2004. The value of human and social capital investments for the business performance of startups. *Small Business Economics*, 23, 227-236.
- BRUSH, C. 2001. How do "resource bundles" develop and change in new ventures? A dynamic model and longitudinal exploration. *Entrepreneurship theory and practice*.
- BRUTON, G., FRIED, V. & HISRICH, R. D. 1997. Venture capitalist and CEO dismissal. *Entrepreneurship Theory and Practice*, 21, 41-54.
- BUYL, T., BOONE, C., HENDRIKS, W. & MATTHYSSENS, P. 2011. Top management team functional diversity and firm performance: The moderating role of CEO characteristics. *Journal of management studies*, 48, 151-177.
- CARLILE, P. R. & REBENTISCH, E. S. 2003. Into the black box: The knowledge transformation cycle. *Management Science*, 49, 1180-1195.
- CLARYSSE, B. & HEIRMAN, A. 2000. AN INSTITUTIONAL AND RESOURCE BASED EXPLANATION OF GROWTH PATTERNS OF RESEARCH BASED SPIN-OFFS IN EUROPE. *Frontiers of Entrepreneurship Research*.
- CLARYSSE, B. & MORAY, N. 2004. A process study of entrepreneurial team formation: the case of a research-based spin-off. *Journal of Business Venturing*, 19, 55-79.
- COLOMBO, M. G. & DELMASTRO, M. 2002. How effective are technology incubators? Evidence from Italy. *Research Policy*, 31, 1103-1122.
- COLOMBO, M. G. & GRILLI, L. 2005. Founders' human capital and the growth of new technology-based firms: A competence-based view. *Research Policy*, 34, 795-816.
- COLOMBO, M. G. & GRILLI, L. 2009. A capital partnership: how human and venture capital affect the growth of high-tech start-ups. *Strategic Change*, 18, 231-239.
- COLOMBO, M. G. & GRILLI, L. 2010. On growth drivers of high-tech start-ups: Exploring the role of founders' human capital and venture capital. *Journal of Business Venturing*, 25, 610-626.
- COONEY, T. M. & BYGRAVE, W. D. The evolution of structure and strategy in fast-growth firms founded by entrepreneurial teams. Working Paper presented at the Babson Entrepreneurship Conference, 1997.
- COOPER, A. C. & BRUNO, A. V. 1977. Success among High-Technology Firms. *Business Horizons*, 20, 16-22.
- DAILY, C. M. & DALTON, D. R. 1995. Ceo and Director Turnover in Failing Firms - an Illusion of Change. *Strategic Management Journal*, 16, 393-400.
- DAVIDSSON, P. & HONIG, B. 2003. The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing*, 18, 301-331.
- DJOKOVIC, D. & SOUITARIS, V. 2008. Spinouts from academic institutions: a literature review with suggestions for further research. *The Journal of Technology Transfer*, 33, 225-247.
- DORE, R. 1976. The Diploma Disease. Education, Qualification and Development.

- DRUILHE, C. & GARNSEY, E. 2004. Do Academic Spin-Outs Differ and Does it Matter? *The Journal of Technology Transfer*, 29, 269-285.
- ENSLEY, M. D., CARLAND, J. W. & CARLAND, J. 1998. The effect of entrepreneurial team skill heterogeneity and functional diversity on new venture performance. *Journal of Business and Entrepreneurship*, 10, 1-14.
- ENSLEY, M. D. & HMIELESKI, K. M. 2005. A comparative study of new venture top management team composition, dynamics and performance between university-based and independent start-ups. *Research Policy*, 34, 1091-1105.
- FIELD, A. 2009. *Discovering statistics using SPSS*, Sage publications.
- FRANKLIN, S., WRIGHT, M. & LOCKETT, A. 2001. Academic and Surrogate Entrepreneurs in University Spin-out Companies. *The Journal of Technology Transfer*, 26, 127-141.
- FREUND, R. & WILSON, W. 1998. Regression Analysis: Statistical Modeling of a Response Variable. 1998. Academic Press.
- GAGLIO, C. M. & KATZ, J. A. 2001. The psychological basis of opportunity identification: Entrepreneurial alertness. *Small Business Economics*, 16, 95-111.
- GANOTAKIS, P. 2012. Founders' human capital and the performance of UK new technology based firms. *Small Business Economics*, 39, 495-515.
- GIMENO, J., FOLTA, T. B., COOPER, A. C. & WOO, C. Y. 1997. Survival of the fittest? Entrepreneurial human capital and the persistence of underperforming firms. *Administrative science quarterly*, 750-783.
- GIMMON, E. 2010. *Founder's human capital, external investment, and the survival of new high-technology ventures*.
- GULBRANDSEN, M. & RASMUSSEN, E. 2012. The use and development of indicators for the commercialisation of university research in a national support programme. *Technology Analysis & Strategic Management*, 24, 481-495.
- GURDON, M. A. & SAMSOM, K. J. 2010. A longitudinal study of success and failure among scientist-started ventures. *Technovation*, 30, 207-214.
- HABER, S. & REICHEL, A. 2007. The cumulative nature of the entrepreneurial process: The contribution of human capital, planning and environment resources to small venture performance. *Journal of Business Venturing*, 22, 119-145.
- HAMBRICK, D. C. & MASON, P. A. 1984. Upper echelons: The organization as a reflection of its top managers. *Academy of management review*, 9, 193-206.
- HARRISON, R. T. & LEITCH, C. 2010. Voodoo Institution or Entrepreneurial University? Spin-off Companies, the Entrepreneurial System and Regional Development in the UK. *Regional Studies*, 44, 1241-1262.
- HAYTER, C. S. 2011. In search of the profit-maximizing actor: motivations and definitions of success from nascent academic entrepreneurs. *Journal of Technology Transfer*, 36, 340-352.
- HSU, D. H. 2007. Experienced entrepreneurial founders, organizational capital, and venture capital funding. *Research Policy*, 36, 722-741.
- ITTNER, C. D. & LARCKER, D. F. 1997. Product development cycle time and organizational performance. *Journal of Marketing Research*, 34, 13-23.
- JOVANOVIĆ, B. 1982. Selection and the Evolution of Industry. *Econometrica: Journal of the Econometric Society*, 649-670.
- KAKATI, M. 2003. Success criteria in high-tech new ventures. *Technovation*, 23, 447-457.
- KIRZNER, I. M. 1997. Entrepreneurial discovery and the competitive market process: An Austrian approach. *Journal of Economic Literature*, 35, 60-85.
- KLOTZ, A. C., HMIELESKI, K. M., BRADLEY, B. H. & BUSENITZ, L. W. 2014. New Venture Teams: A Review of the Literature and Roadmap for Future Research. *Journal of Management*, 40, 226-255.
- KNOCKAERT, M., CLARYSSE, B. & WRIGHT, M. 2010. The extent and



- nature of heterogeneity of venture capital selection behaviour in new technology-based firms. *R & D Management*, 40, 357-371.
- KNOCKAERT, M., UCBASARAN, D., WRIGHT, M. & CLARYSSE, B. 2011. The Relationship Between Knowledge Transfer, Top Management Team Composition, and Performance: The Case of Science-Based Entrepreneurial Firms. *Entrepreneurship Theory and Practice*, 35, 777-803.
- KUTNER, M. H., NACHTSHEIM, C. J., NETER, J. & LI, W. 2005. Applied linear statistical models.
- LAWTON SMITH, H. & HO, K. 2006. Measuring the performance of Oxford University, Oxford Brookes University and the government laboratories' spin-off companies. *Research Policy*, 35, 1554-1568.
- LOWE, R. A. 2006. Who develops a university invention? The impact of tacit knowledge and licensing policies. *The Journal of Technology Transfer*, 31, 415-429.
- MARVEL, M. R. 2013. Human Capital and Search-Based Discovery: A Study of High-Tech Entrepreneurship. *Entrepreneurship Theory and Practice*, 37, 403-419.
- MARVEL, M. R. & LUMPKIN, G. T. 2007. Technology entrepreneurs' human capital and its effects on innovation radicalness. *Entrepreneurship Theory and Practice*, 31, 807-828.
- MAYER-HAUG, K., READ, S., BRINCKMANN, J., DEW, N. & GRICHNIK, D. 2013. Entrepreneurial talent and venture performance: A meta-analytic investigation of SMEs. *Research Policy*, 42, 1251-1273.
- MILLER, D. & TOULOUSE, J.-M. 1986. Chief executive personality and corporate strategy and structure in small firms. *Management Science*, 32, 1389-1409.
- MOSEY, S., LOCKETT, A. & WESTHEAD, P. 2006. Creating network bridges for university technology transfer: The medici fellowship programme. *Technology Analysis & Strategic Management*, 18, 71-91.
- MOSEY, S. & WRIGHT, M. 2007. From human capital to social capital: A longitudinal study of technology-based academic entrepreneurs. *Entrepreneurship Theory and Practice*, 31, 909-935.
- MUSTAR, P., RENAULT, M., COLOMBO, M. G., PIVA, E., FONTES, M., LOCKETT, A., WRIGHT, M., CLARYSSE, B. & MORAY, N. 2006. Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy. *Research Policy*, 35, 289-308.
- NERKAR, A. & SHANE, S. 2003. When do start-ups that exploit patented academic knowledge survive? *International Journal of Industrial Organization*, 21, 1391-1410.
- NICOLAOU, N. & BIRLEY, S. 2003. Academic networks in a trichotomous categorisation of university spinouts. *Journal of Business Venturing*, 18, 333-359.
- NOOTEBOOM, B., VAN HAVERBEKE, W., DUYSTERS, G., GILSING, V. & VAN DEN OORD, A. 2007. Optimal cognitive distance and absorptive capacity. *Research Policy*, 36, 1016-1034.
- O'SHEA, R. P., ALLEN, T. J., CHEVALIER, A. & ROCHE, F. 2005. Entrepreneurial orientation, technology transfer and spinoff performance of US universities. *Research Policy*, 34, 994-1009.
- OAKEY, R. P. 2003. Technical entrepreneurship in high technology small firms: some observations on the implications for management. *Technovation*, 23, 679-688.
- OFFSTEIN, E. H. & GNYAWALI, D. R. 2005. CEO compensation and firm competitive behavior: Empirical evidence from the US pharmaceutical industry. *Journal of Engineering and Technology Management*, 22, 201-225.
- PARK, J. S. 2005. Opportunity recognition and product innovation in entrepreneurial hi-tech start-ups: a new perspective and supporting case study. *Technovation*, 25, 739-752.
- PARKER, S. C. 2006. Entrepreneurship, self-employment and the labour market.

- Oxford handbook of entrepreneurship*, 435-460.
- PIRNAY, F., SURLEMONT, B., NLEMVO, F., X00E, X00E & RIC 2003. Toward a Typology of University Spin-offs. *Small Business Economics*, 21, 355-369.
- RASMUSSEN, E., BORLAUG, S. B. & BULANOVA, O. 2013. Verdiskaping i forskningsbaserte selskaper og lisenser støttet av FORNY-programmet.
- RASMUSSEN, E. B. 2012. The Impact of Science-Based Entrepreneurial Firms - a Literature Review and Policy Synthesis. *Unpublished.* -, -.
- ROTHAERMEL, F. T., AGUNG, S. D. & JIANG, L. 2007. University entrepreneurship: a taxonomy of the literature. *Industrial and Corporate Change*, 16, 691-791.
- SANTARELLI, E. & HIEN THU, T. 2013. The interplay of human and social capital in shaping entrepreneurial performance: the case of Vietnam. *Small Business Economics*, 40, 435-458.
- SHANE, S. 2000. Prior knowledge and the discovery of entrepreneurial opportunities. *Organization Science*, 11, 448-469.
- SHANE, S. 2004. Academic Entrepreneurship: University Spinoffs And Wealth Creation. *Book*.
- SHANE, S. & TOBY, S. 2002. Organizational Endowments and the Performance of University Start-Ups. *Management Science*, 48, 154-170.
- SHRADER, R. & SIEGEL, D. S. 2007. Assessing the relationship between human capital and firm performance: Evidence from technology-based new ventures. *Entrepreneurship Theory and Practice*, 31, 893-908.
- SPENDER, J. C. 1996. Making knowledge the basis of a dynamic theory of the firm. *Strategic management journal*, 17, 45-62.
- STINCHCOMBE, A. L. 1965. Social structure and organizations. *Handbook of organizations*, 142, 193.
- STUART, R. W. & ABETTI, P. A. 1990. Impact of Entrepreneurial and Management Experience on Early Performance. *Journal of Business Venturing*, 5, 151-162.
- TYEBJEE, T. T. & BRUNO, A. V. 1984. A model of venture capitalist investment activity. *Management science*, 30, 1051-1066.
- UCBASARAN, D., LOCKETT, A., WRIGHT, M. & WESTHEAD, P. 2003. Entrepreneurial founder teams: Factors associated with member entry and exit. *Entrepreneurship Theory and Practice*, 28, 107-128.
- UCBASARAN, D., WESTHEAD, P. & WRIGHT, M. 2008. Opportunity identification and pursuit: Does an entrepreneur's human capital matter? *Small Business Economics*, 30, 153-173.
- UNGER, J. M., KEITH, N., HILLING, C., GIELNIK, M. M. & FRESE, M. 2009. Deliberate practice among South African small business owners: Relationships with education, cognitive ability, knowledge, and success. *Journal of Occupational and Organizational Psychology*, 82, 21-44.
- UNGER, J. M., RAUCH, A., FRESE, M. & ROSENBUSCH, N. 2011. Human capital and entrepreneurial success: A meta-analytical review. *Journal of Business Venturing*, 26, 341-358.
- UTTERBACK, J. M. 1996. Mastering the dynamics of innovation: How companies can seize opportunities in the face of technological change. *Long Range Planning*, 29, 908-909.
- VOHORA, A., WRIGHT, M. & LOCKETT, A. 2004. Critical junctures in the development of university high-tech spinout companies. *Research Policy*, 33, 147-175.
- VON HIPPEL, E. 1988. The sources of innovation. Oxford University Press, New York.
- WASSERMAN, N. 2003. Founder-CEO succession and the paradox of entrepreneurial success. *Organization Science*, 14, 149-172.
- WIERSEMA, M. F. & BANTEL, K. A. 1992. Top management team demography and corporate strategic change. *Academy of Management journal*, 35, 91-121.
- WRIGHT, M., CLARYSSE, B. & MOSEY, S. 2012. Strategic entrepreneurship,

- resource orchestration and growing spin-offs from universities. *Technology Analysis & Strategic Management*, 24, 911-927.
- WRIGHT, M., CLARYSSE, B., MUSTAR, P. & LOCKETT, A. 2007a. Academic entrepreneurship in Europe.
- WRIGHT, M., HMIELESKI, K. M., SIEGEL, D. S. & ENSLEY, M. D. 2007b. The role of human capital in technological entrepreneurship. *Entrepreneurship Theory and Practice*, 31, 791-806.
- ZUCKER, L. G., DARBY, M. R. & BREWER, M. B. 1999. Intellectual capital and the birth of US biotechnology enterprises. National Bureau of Economic Research.