NTNU – Trondheim
Norwegian University of
Science and Technology

Equity Valuation of University-based Spinoffs: A Literature Review and Empirical Study

Arif Muhammed Mirza
Ole Rønning

NTNU School of Entrepreneurship
Submission date: June 2015
Supervisor: Roger Sørheim, IØT
Co-supervisor: Marius Tuft Mathisen, IØT

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

Problem Description

This study examines valuation of early stage USOs using traditional valuation methods as well as the feasibility of a resource-based valuation framework.

Preface

This study is the master thesis of Arif Mirza and Ole Rønning, two graduate M.Sc. students at the NTNU School of Entrepreneurship. The motivation behind the chosen research topic is grounded in both authors' background in entrepreneurship, and more precisely their personal experience with the difficulties associated with valuing young startups. Further on, the focus on university spinoffs (USOs) was a natural development due to the authors residing in the technological capital of Norway, Trondheim, which is the originating region of many of Norway's USOs.

The purpose of this research is to shed light on the limitations associated with today's valuation methods used in the context of USOs, as well as establish the initial theoretical foundation for an alternative valuation approach that might be better for this type of firms. The research is presented in two separate articles. The work has provided the authors with deep knowledge about valuing new ventures, and the phenomena of university spinoffs. Further on, the empirical analysis provided the authors an opportunity to expand on their limited statistical knowledge. Through this the authors have learned statistical tools we are certain will be useful as we venture into our business careers. As a final remark, it has become evident to the authors that today's valuation methods have significant shortcomings when used in the context of USOs, and that the findings in this study do indeed fill a gap in the literature on both valuation and university spinoffs.

The authors want to thank Ph.D. candidate Marius Tuft Mathisen, from the Norwegian University of Science and Technology. His enthusiastic attitude towards the topic of research has been an important motivator throughout our work, and his inputs and mentoring have been greatly appreciated. We also wish to thank Professor Roger Sørheim and Øystein Widding for providing valuable feedback and advice.

The Authors

Trondheim, June 10, 2015

Contact Information:
Arif Mirza
Ole Rønning

Summary

During the last three decades, there has been a significant growth in the establishment of university spin-offs (USOs), and they have become an important part of the economic landscape. These are companies where it is generally agreed upon that financing is essential in their early stages, yet who face difficulties in raising the necessary capital. This is believed to be due to long development times, and large amounts of uncertainty which makes these companies difficult to value. This master thesis is divided into two articles, where the first examines the applicability of traditional valuation methods on USOs, and the second seeks to investigate the feasibility of a valuation framework based on resource inputs, rather than financial outputs. Together, these two articles aim to lay the foundation on which future research can build to develop better valuation methods, and through this make it easier for investors to assess early stage university spin-offs and close the financing gap these companies face.

Through article 1, the authors investigate, with a basis in a two dimensional theoretical framework based on resource-based theory and risk and uncertainty, how unique resource characteristics in these firms affect the perceived uncertainty seen from the viewpoint of an investor, and subsequently how this uncertainty affects the applicability of traditional valuation methods from corporate finance. It is found that the early-stage, radicalness and significant technical advances of the technologies many of these companies are founded on lead to high fundamental uncertainty, which renders the three most common valuation methods cash flow discounting, balance sheet and income statement inapplicable to early stage USOs. This has important implications for investors, who by blindly using these methods on USOs can make bad investment decisions, or forego valuable investment opportunities.

In light of the findings in article 1, article 2 investigates the feasibility of a resource-based valuation framework, with the underlying argument that when it is difficult to value a company with a basis in financial outputs used in traditional corporate finance, a method based on inputs identified through theories from strategic management that help predict and explain superior firm performance may prove more satisfactory. Followingly, a conceptual framework with a basis in resource-based theory is developed. To test the framework, six hypotheses about the relationship between initial resource endowments in USOs, and their long term equity value are formulated, and empirically tested through regression on a sample of 63 Norwegian USOs. It is found that, ceteris paribus, higher degrees of heterogeneity in the founding team, better quality parent universities as well as more filed and published patents in the early stages of USO are all positively related to the firms long term equity value. With a basis in this it is argued that USOs who exhibit these resource characteristics in their early stages should be valued higher than those that do not. This has implications for investors, who should take into consideration the particular resources a firm holds in their value estimates, and for entrepreneurs who should seek to assemble specific resources to increase the future value of their firm. Although the development of a complete valuation model was outside of the articles scope, the conceptual valuation framework developed proves that a resource-based valuation framework has potential, and future research efforts should be directed towards this topic.

Sammendrag

Oppstartsbedrifter med opphav fra universitetsforskning(USOs) har de siste årene vokst betydelig i antall, og blitt en viktig del av det økonomiske landskapet. Dette er bedrifter hvor det generelt er enighet i at kapital er spesielt viktig i tidligfase, men som møter store utfordringer i å innhente den nødvendige kapitalen. Dette er til dels grunnet lange utviklingstider, og vanskeligheter for investorer i å vurdere verdiene til disse selskapene. Denne masteroppgaven er delt i to artikler, hvor artikkel 1 undersøker hvorvidt eksisterende verdsettelsesmetoder i en tilfredsstillende grad kan brukes til å finne verdien av tidligfase USOs. Artikkel 2 undersøker muligheten for å utvikle et verdsettelsesrammeverk basert på ressurser i selskapet. Sammen søker disse to artiklene å fylle forskningsmangelen på verdsettelse av disse spesielle selskapene, og danne grunnlaget for utvikling av mer robuste verdsettelsesmetoder som letter verdivurderingen, og videre kapitaltilgangen fra investorer.

Gjennom artikkel 1 søker forfatterne, med utgangspunkt i et todimensjonalt teoretiskrammeverk bygd på ressursbasert teori og risiko og usikkerhet, å identifisere hva som gjør disse selskapene unike, hvordan disse unike karakteristikkene påvirker usikkerheten knyttet til USOs sett fra en investorsståsted, og til slutt hvordan dette igjen påvirker muligheten for å bruke tradisjonelle verdsettelsesmetoder. For å svare på disse spørsmålene gjennomføres det et litteratursøk på både verdsetting og ressurser i USOs. Resultatene viser at spesielt tre karakteristikker ved de teknologiske ressursene i tidligfase USOs, nemlig teknologiens tidlige utviklingsstadium, dens radikale natur samt signifikante tekniske fremskritt, øker den fundamentale usikkerheten i selskapene, noe som gjør det umulig å på en pålitelig måte estimere finansielle data tradisjonelle verdsettelsesmetoder er avhengig av. Dette fører til at de har begrenset anvendbarhet på disse selskapene. Dette har viktige implikasjoner for investorer, som ved å blindt bruke disse metodene kan gjennomføre dårlige investeringer, eller gå glipp av gode investeringsobjekt.

I lys av funnene i artikkel 1, undersøker artikkel 2 muligheten for å utvikle et verdsettelsesrammeverk basert på ressurser i selskapet i stedet for finansielle data, med den underliggende logikken at når det er vanskelig å estimere fremtidig ytelse kan muligens en metode med fundament i teorier som forklarer og spår ytelse føre til bedre resultater. Et konseptuelt verdsettelsesrammeverk for sammenhengen mellom ressurser og selskapsverdi utvikles. For å teste rammeverket utvikles seks hypoteser med utgangspunkt i ressurs-ytelsessammenhenger i USOs påvist i tidligere forskning. Disse hypotesene testes gjennom regresjon på et datasett bestående av 63 norske USOs. Resultatene indikerer at USOs som i tidligfase har mer heterogene oppstartsteam, som har opphav i universiteter av høyere kvalitet, og som har flere publiserte og søkte patenter, har, gitt at alt annet holds konstant, høyere verdi i lengden. Det argumenteres følgelig for at USOs som har disse ressurskarateristikkene i tidligfase bør verdsettes høyere enn selskaper som ikke har de. Dette har implikasjoner for investorer, som i sine verdivurderinger kan bihensyna ressurser i selskapene, og for grundere som bør søke å sample visse ressurser for å øke verdien på selskapet sitt. Selv om utviklingen av et komplett verdsettelsesrammeverk er utenfor omfanget til artikkelen, og resultatene kun indikativen, tyder de på at verdsetting basert på ressurser kan være hensiktsmessig. For å verifisere dette er det nødvendig med betydelig fremtidig forskningsfokus på temaet.

Examining Equity Valuation of University Spin-off Companies: A Literature Review

Arif M. Mirza, Ole Rønning

ABSTRACT

University spinoffs have in the last three decades grown considerably in numbers, and have become an important part of the economic landscape. This study investigates how unique characteristics of initial resource endowments of these firms affect the applicability of traditional valuation methods from corporate finance. To answer the research question, a two-dimensional theoretical framework consisting of risk and uncertainty and resource-based theory is used. As an empirical foundation, literature reviews on both valuation and university spinoffs are conducted. Our findings show that the three most common groups of valuation methods, i.e. cash flow discounting, balance sheet and income statement, are not applicable to early-stage USOs. This is primarily due to the technologies these companies are founded on being early-stage, radical and providing significant technical advances, which leads to high fundamental uncertainty. This uncertainty makes it difficult to reliably estimate financial variables on which traditional valuation methods are dependent. The findings have particular implications for investors, who by blindly using traditional valuation methods can overlook interesting prospects or make poor investment decisions.

Introduction

There has been a notable increase in technology transfer from universities to the industry in the last decades (Rothaermel et al., 2007). From 1980 to 1993, American academic institutions saw an increase of 444 percent in the establishment of university spinoff companies (USOs) (Pressman, 2002). The US Bayh-Dole Act of 1980 and its European counterparts, a rise in venture capital, a larger pool and thus mobility of scientists and engineers, and important technological breakthroughs in computing are some of the factors attributed to this growth. Not surprisingly, these significant developments in establishment of university spinoffs, and their potential economic impacts, have attracted an increasing attention of research towards the phenomenon both in the United States and in Europe (Rothaermel et al., 2007).

Some of this research has been on the topic of financing of early-stage USOs, and more specifically, the lack thereof. The majority of startups require access to financing to develop their products and services, and obtain growth. However, researchers have argued that financing, and specifically early-stage financing, might be more crucial for USOs compared to the average start-up (Shane, 2004; Clarysse and Bruneel, 2007). Despite the need for early-stage financing, USOs face an impediment in razing the necessary capital due to high levels of uncertainty associated with these ventures (Widding et al., 2009; Shane, 2004).

> *"Finance is a catalyst of this wealth creation yet access to venture capital is a major impediment faced by these companies"*
>
> – *Wright et al. (2006)*

An important step in obtaining financing for a new venture is determining its value. Tyebjee and Bruno (1984) maintain that establishing the price of venture capital is the heart of any negotiation between the founders of the venture and potential investors. To determine the price, valuation becomes essential, and common valuation methods have traditionally been dependent on future cash flows, assets or valuations of comparative firms (Seppä and Laamanen, 2001). A fundamental assumption underlying these methods is that there is an efficient capital market for ownership in the firm (Timmons and Spinelli, 2004), i.e. that informational asymmetries are uncommon

(Fama, 1991) and that asset prices therefore reflect all publicly known information. For publically traded firms this assumption may hold, but for new ventures with a lack of liquidity of ownership, short operating history and limited/private accounting information, informational asymmetries between the investor and firm can be large, and it does not. Timmons and Spinelli (2004) argue that it is this inefficiency in the venture capital market that makes the most common valuation methods prone to error when used on early-stage companies, because estimating cash flows and discount rates becomes difficult. In agreement with Timmons and Spinelli (2004), Damodaran (2009) points out that young companies are problematic to value due to operating losses or small revenues, multiple claims on equity, the fact that they are illiquid investments and that it is difficult to account for the risk of the company not surviving.

The factors leading to inefficiency highlighted by Timmons and Spinelli (2004) are especially prevalent in USOs, whom lately have become an important part of the economic landscape through the creation of jobs and encouraging local economic development (Shane, 2004; Bonardo et al., 2011). This is a type of company where it is generally agreed upon that the financial needs are greater than those of other firms and that capital is essential for growth (Cohen, 2006; Neck et al., 2004; Sætre et al., 2006; Clarysse and Bruneel, 2007), yet Shane (2004) states that they have difficulty in raising capital in their early stages. This may partially be attributed to problems in valuing these companies. As Keeley et al. (1996) writes, valuation is a central part in deciding whether one should invest in a company or not, but with indications that these firms take on average 10 years before reaching the market (Rasmussen et al., 2013; Lawton Smith and Ho, 2006), liquidity of ownership is a major issue. With many of these companies being founded on research with nothing more than a proof of concept (Shane, 2004) it takes years before operating history is available. Further on, advanced and complex technologies increase informational asymmetries between the USO and possible investors (Shane, 2004). As Rasmussen et al. (2013) points out, USOs face significant uncertainty in their early stages due to unproven technology, uncertainty about market need and organizational uncertainty. Valuing such a company obviously poses new challenges, since parameters that traditionally have been emphasized are cash flows and discount rates, which become increasingly difficult to estimate under higher uncertainty.

This is what motivates this study. Blindly using existing valuation methods for the lack of better approaches might yield significantly misleading valuations, leading investors to make bad investment decisions or generally refrain from investing in early-stage USOs to avoid the risk of inadequately assessing their investment projects. A better understanding of how to value these firms might help solve this problem. Consequently we raise the following research question:

> **RQ:** How do characteristics of initial resource endowments in USOs affect the suitability of using traditional valuation methods?

In order to answer the research question, we draw upon resource-based theory as well as the theory of risk and uncertainty. The logic being that the former helps us to identify the firm characteristics that make these companies unique, and the latter to assess how these characteristics affect the inherent difficulties in assessing the risk in early-stage USOs, and subsequently the difficulties in using traditional valuation methods. In the next part we introduce the theoretical framework underlying this study before we present the research methodology employed. In the subsequent literature review we present relevant literature on both traditional valuation methods as well as resource characteristics of early stage USOs. Finally we discuss how these initial resource characteristics affect the applicability of traditional valuation methods, and what implications this has for investors and entrepreneurs.

Definition of Early-Stage University Based Spinoffs

In the literature on university spinoffs there have been nearly as many names to the phenomenon as there have been researchers studying it. Authors have for example referred to these companies as university startups (Criaco et al., 2013; Powers and McDougall, 2005) or university-based startups (Marion et al., 2012), as university spinoffs (Bigliardi et al., 2013; Wright et al., 2012), new technology-based firms (Fuller and Rothaermel, 2012), research-based scientific organizations (Mustar et al., 2006), academic spinoffs (Clarysse et al., 2007; Festel, 2013) and academic startups (Colombo and Piva, 2012). Defining the phenomenon has been equally inconsistent. Some definitions restrict the term to those companies where the intellectual property is transferred from the university to the new venture (Shane, 2004; Lockett et al., 2005), others also include companies founded on knowledge obtained at the parent university (Rappert et al., 1999), such as consultancy companies.

In this study, university spinoffs are defined as companies that involve transfer of intellectual property rights (IPR) to the new venture, and that are either developed by faculty members based on their own research, or created specifically to capitalize on academic research. This definition is keeping with the literature (Shane, 2004; Colombo et al., 2010; Lockett et al., 2005), and is chosen because firms that involve transfer of IPR are more likely to have larger financial needs, to seek funding in their early stages, and followingly are more impacted by issues related to valuation, than for example consultancy companies founded on implicit knowledge developed at the parent university. Further on, we are interested in investigating early stage valuation, and therefore focus on early-stage USOs. Vohora et al. (2002) finds that USOs develop in five distinct phases: the research phase, opportunity framing phase, pre-organization phase, re-orientation phase and finally sustainable returns phase. The research phase is where the intellectual property is created, and is prior to any commercialization. The opportunity framing phase includes screening of the technology with regards to validity and performance, and research to prove that the technology works outside the laboratory. Vohora et al. (2002) writes that a fundamental problem at this stage is that there is a mismatch between what the university offers, and what venture capitalists want. The new ventures have little proof of concept, no target market or commercial management, and generally lacking resources to further develop the opportunity. It is followingly in this stage that the financing gap (Shane, 2004) starts to develop, and where the problems of valuation become relevant. We therefore focus on USOs in this stage of development, and define them as early-stage USOs.

Theoretical Framework

The topic of valuation is traditionally a field within corporate finance, and most valuation methods are, to some extent, based on accounting information. Valuing any startup using these common methods is an inherently difficult task (Timmons and Spinelli, 2004; Damodaran, 2009), and to investigate whether the valuation of early-stage USOs indeed is a special case, it becomes necessary to understand what makes these firms unique. To investigate this the authors use resource-based theory as the theoretical context to identify the unique resource characteristics of these firms. As Miller (2003) writes, resources are the 'raw material' of business strategy, and therefore provide the basis on which firms can distinguish themselves from others. However, simply identifying these differences will not be adequate to assess the applicability of common valuation methods on early stage USOs. The underlying factor making valuation of new ventures difficult is uncertainty, which in the context of valuation becomes important to clearly separate from risk. To understand this, we use the notion of risk and uncertainty as the second dimension in the theoretical framework.

Risk, Uncertainty and Informational Asymmetries

Knight (1921) defines the concepts of risk and uncertainty as two distinct variables based on three categories of probabilities: A priori probability, statistical probability and estimates. A priori probabilities are derived from absolutely homogenous classification of instances, for example as the case in a dice throw. Statistical probability on the other hand is obtained through analysis: "it is an empirical evaluation of the frequency of association between predicates…" (Knight, 1921). Lastly, estimates are a group of probabilities for which there is no valid basis of any kind for classifying instances. It is this last category of probabilities that Knight defines as uncertainty, while the former two are defined as risk.

> *"The practical difference between the two categories, risk and uncertainty, is that in the former the distribution of the outcome in a group of instances is known (either through calculation a priori or from statistics of past experience), while in the case of uncertainty this is not true, the reason being in general that it is impossible to form a group of instances, because the situation dealt with is in a high degree unique."*
>
> *– Knight (1921)*

Dequech (2000) further distinguishes between fundamental uncertainty and ambiguity. What

Dequech defines as fundamental uncertainty is in accordance with Knight's definition of uncertainty. However, he goes on to argue that one has to distinguish between fundamental uncertainty and ambiguity, where he defines ambiguity in accordance with Camerer and Weber (1992):

> *"Ambiguity is uncertainty about probability, created by missing information that is relevant and could be known. Ambiguity is therefore not uncertainty about the possible outcomes, but rather lack of certainty about probabilities of outcomes being 1, 0 or something in between. Information is hidden, rather than non-existent at the moment of decision"*
>
> *– Dequech (2000)*

Ambiguity therefore, can lead to situations of asymmetric information.Asymmetric information denotes a situation in which one contracting party has superior information compared to another, and has consequences whenever a "principal", who must contract with an "agent" to accomplish some purpose, cannot be sure how well the agent will perform because the agent's effort cannot be determined ex ante (Balakrishnan and Koza, 1993). This can lead to adverse selection, or a "lemons" problem (Akerlof, 1970). Adverse selection refers to a situation in which superior information is used to conduct immoral behavior prior to a transaction, and Shane and Cable (2002) points out that this often results in difficulties for entrepreneurs to obtain financing from investors because they possess information about themselves and their opportunities that potential investors do not (Chan et al., 1990; Gompers, 1995). More specifically, entrepreneurs are reluctant to disclose all information regarding their opportunity because it will make it easier for other people to pursue the same opportunity, which results in the investor receiving less information. Additionally, because of the superior information, entrepreneurs can engage in opportunistic behavior (Shane and Cable, 2002). Consequently, Venkataraman (1997) writes that investors require the entrepreneur to make large, irreversible and credible commitments to the venture, which drives up the entrepreneurs sunk cost, and drives high-quality entrepreneurs from the market. This is what Akerlof (1970) denotes the "lemons" problem, namely that only undesirable deals will be available to investors. Figure 1 depicts the relationship between risk, ambiguity, informational asymmetries, and fundamental uncertainty, where an upwards movement on the Y-axis denotes increasing uncertainty, while a downwards movement indicates increasing risk.

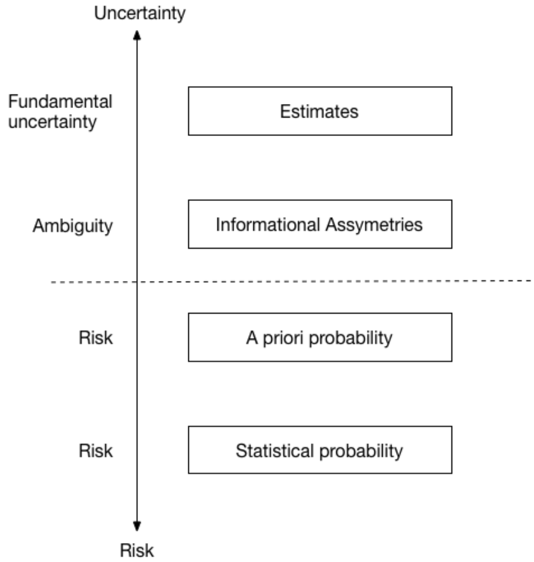


Figure 1. *The relationship between risk, fundamental uncertainty, ambiguity and informational asymmetries.*

The distinction between risk and uncertainty, as well as informational asymmetries, is particularly relevant for USOs. It is generally accepted that as a venture moves to later stages of development, the accompanied risk and uncertainty associated with that firm reduces (Seppä and Laamanen, 2001). Shane (2004) defines early-stage USOs as being at a "minus two" development stage, naturally leading to extraordinary high uncertainty, and Wright et al. (2006) state that informational asymmetries may be particularly significant in new high-tech firms. This has important implications for the suitability of traditional valuation methods – a discussion visited later in this study.

Resource-Based Theory

In the 1959 resource-based view seminal text "The theory of the growth of the firm", Edith T. Penrose introduces the notion of the firm as a bundle of resources, and establishes causal links between unique firm resources and capabilities, and superior firm-level performance compared to rivals (Kor and Mahoney, 2004). Wernerfelt (1984) writes that from a company's point of view, resources and products are two sides of the same coin, arguing that performance is directly affected by products, but indirectly (and primarily) it is driven by the resources that go into producing them. He defined resources as "anything that could be thought of as a strength or weakness for a given firm...". In the 1991 article, Jay Barney expanded the definition of resources to include "all assets, capabilities, organizational processes, firm attributes, information, knowledge etc. controlled by the firm that enable it to conceive of and implement strategies that improve efficiency and effectiveness".

Building on the general assumption in resource-based theory that resources and capabilities are heterogeneous across firms, Barney (1991) argues that sustained competitive advantages are derived from the resources a company controls that are valuable, rare, imperfectly imitable (VRIN) and non-substitutable. Valuable in the sense that they enable the firm to implement strategies that improve its efficiency and effectiveness (Barney, 1991). Rare implying that the resources must be scarce relative to demand. Firms that possess resources that are both valuable and rare often have the first mover advantage. However, to be a source of sustained competitive advantage, they must also be imperfectly imitable, i.e. that other firms cannot copy them, and non-substitutable, meaning that other resources cannot be used to implement equivalent strategies (Barney, 1991). Underpinning this, Crook et al. (2008), conducting a meta-analysis on resources and performance, find that resources that meet the VRIN criteria are more strongly related to performance that those that do not. Scholars have however highlighted that the link between resources and performance is not only dependent on the former being VRIN, but also on the organization's ability to capture the economic value that they can create (Barney and Clark, 2007). Mahoney and Pandian (1992) establish the missing link between resources and their utilization, and write that it is not merely the resources themselves that lead to competitive advantages, but rather the company's distinct competencies in using the resources better than competitors.

Building on the same principle as Mahoney and Pandian (1992), Alvarez and Busenitz (2001) argue that it is through entrepreneurship and the entrepreneurial process of discovering, understanding market opportunities, and coordinating knowledge that inputs become heterogeneous outputs. Brush et al. (2001) write that entrepreneurs must first assemble resources, and then combine and develop them into resources that will yield distinctive capabilities. Their ability to accomplish this will be dependent on individual experiences, educational backgrounds, social ties, initial financial capital, or cognitive ability to combine concepts and information into new ideas. Further on, they write that initial resource decisions made by the entrepreneur has significant implications for survival and growth. Brush et al. (2001) go on to define six categories of resources in new ventures: human, social, financial, physical, technology, and organizational. Among these, human, technological, social and financial resources are highlighted as important for research-based spinoffs (Mustar et al., 2006).

Human resources refer to the people in the company: attributes and experience of the founding team, the management team and personnel (Brush et al., 2001). According to the upper echelon argument, new venture performance, growth and success can be tied to the individual attributes of the companies managerial group (Visintin and Pittino, 2014; Eisenhardt and Schoonhoven, 1996).

Social resources refer to the network of the company, i.e. partners, industry and financial contacts of the founders (Brush et al., 2001). Eisenhardt and Schoonhoven (1996) write that all action, including economic action, is embedded in a social fabric of opportunities, and that interaction, and ultimately cooperation, is likely to happen among people who know one another. Such alliances can prove to be critical resources (Hamel et al., 1989; Pisano and Teece, 1989) when firms are undertaking expensive or risky strategies, as well as provide legitimacy and market power (Wiewel and Hunter, 1985; Hagedoorn, 1993; Baum and Oliver, 1991) that improve strategic position. Stuart et al. (1999) write that third parties, such as investors and employees, rely on the relationships of young companies to assess their quality, and that young companies "supported" by prominent relationships are more likely to perform well. This is because resource holders trust the ability of well-regarded organizations or individuals to assess quality under ambiguous circumstances (Stuart, 1998), and that this "signaling effect" subsequently mitigates the risks of alliance formation such as poor implementation, opportunism, and appropriation of knowledge (Larson, 1992). Eisenhardt and Schoonhoven (1996) go on to write that the advantages of top managers social resources are particularly critical for young firms, because they have not had the time to establish firm-level networks.

Financial resources refer of the amount and type of funding a spinoff has received (Brush et al.,

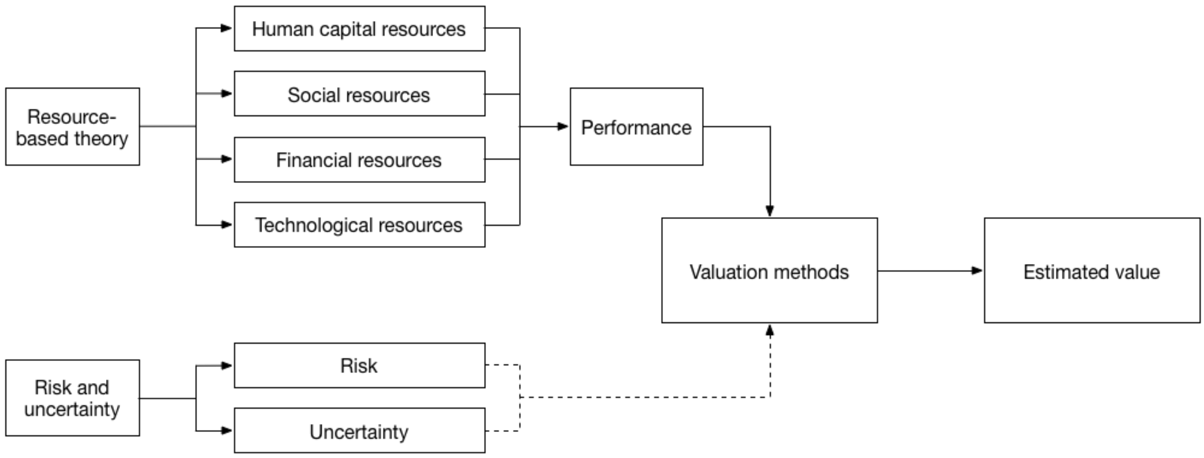


Figure 2. *Theoretical framework*

2001). Brüderl et al. (1992) write that financial resources can act as buffers against random shocks, and Cooper et al. (1994) that capital allows entrepreneurs to learn and overcome problems. Financial capital additionally enables firms to pursue a broader range of activities as well as more ambitious projects (Westhead et al., 2001).

Finally, technological resources refer to the company's products and technology (Borch et al., 1999), as well as technical knowledge associated with the two (Burgers et al., 2008), and intellectual property. Malerba and Orsenigo (1993) write that the factors related to the endowed technological knowledge have an impact on the success of companies, and Shane and Cable (2002) that the strength of a firms technological endowments at founding is an important predictor of its subsequent performance.

With a basis in the above presented theory, the overarching argument that is employed in this study is that resource-based theory can be leveraged to identify unique characteristics to USOs. Further on, the distinction between risk and uncertainty is used to analyze how these unique resource characteristics affect the perceived risk and uncertainty in a USO, and followingly how this affects the applicability of traditional valuation methods. Figure 2 summarizes the theoretical framework.

Methodology

The research methodology employed in this study consists of a semi-structured literature search on valuation methods, as well as a structured search on academic entrepreneurship and USOs. The main results from the integrative reviews (Cooper, 1988) are presented in the next chapter. In this chapter the authors outline the search process.

Semi-Structured Literature Review

The semi-structured search is comprised of two parts: familiarizing with topics surrounding USOs, and a review of general literature on new venture valuation. For the former, the authors started off by reading literature handed out by entrepreneurial scholars at NTNU, namely literature reviews (Mustar et al., 2006; Rothaermel et al., 2007; Djokovic and Souitaris, 2008; O'Shea et al., 2008; Rasmussen et al., 2013; Wright, 2014), article (Widding et al., 2009), and the book (Shane, 2004). For the latter, the authors initially attempted to identify literature on valuation of USOs through a structured search, however the search yielded very limited results. Consequently, the focus was shifted to valuation in general, and a semi-structured search was chosen due to the vast and dispersed amount of literature available on the subject. As a starting point, Fernandez (2002), recommended by scholars at NTNU, was read. This book was used to identify relevant search terms, which are listed in table 1. A starting pool of articles were identified by searching on these terms in the ISI Web of Science-database. To limit the scope of the search, only valuation literature that fulfilled one of the following two criteria was included in the pool of articles: 1) the literature addressed the three most common valuation methods used on new ventures, as identified by Fernandez (2002), or 2) the literature addressed new venture valuation. Thereafter snowballing was used (mainly backwards snowballing).

Terms
Start-up
Firm
Theory
Methods
Venture capitalist
Entrepreneurial

Table 1. *The search phrases used were a combination of the terms listed in the table and the term "valuation*".*

Structured Literature Review

Our structured review comprised of six steps:

Step 1 - Search. The first step of the review comprised of a search in the ISI Web of Science-database. The ISI database covers the leading journals from a broad range of publishers, so the chances of leaving out any important journals were negligible. As previously highlighted, there are many names and terms used to describe the phenomenon of university spinoffs, and the initial semi-structured review was used to identify commonly used terms from among others, Mustar et al. (2006), Rothaermel et al. (2007), Djokovic and Souitaris (2008), O'Shea et al. (2008), Rasmussen et al. (2013) and Wright (2014). The different terms are listed in table 2.

Origin	Nature of Firm
Academic	New venture*
Faculty	Spin-off*
Research-based	Spin-out*
Science-based	Spinoff*
R&D Management	Spinout*
Scientist	New firm*
University	Entrepreneurial
	Entrepreneurship
	Start up*
	Spinning out

Table 2. *USO search terms*

The 60 different combinations of the terms in table 2 were combined to create a search phrase[1]. The search was limited to title, abstract and keywords, and returned 522 results. It would have been possible to further limit the search phrase by including terms describing the scope of this thesis, i.e. "resources" or "characteristics", but to ensure that no articles were missed due to the use of the "wrong" word, the authors chose to manually process the articles with regards to scope. A set of discard criteria was defined to ease the job of deciding what articles to include in the literature review. These criteria were as follows, and were used throughout the article selection process:

1. Wrong unit of analysis
Many of the retrieved articles focused on a different level of analysis, for example on the university itself, on government policies or on TTOs. These articles were discarded.

2. Focus on aspects outside the scope of this thesis
A lot of the retrieved articles did not focus on the primary topic in this study, i.e. resources and resource characteristics. Examples of frequent topics were how universities affect the creation of startups and intellectual property rights in spinoffs. These were discarded.

3. Not adhering to this study's definition of USOs
Articles that focused on firms that did not qualify under the definition of USOs employed in this study were discarded. This included articles that covered other types of spinoffs, such as those with corporations as the originating institution.

Step 2 - Title screening. The first screening of the retrieved articles was based solely on reading their title, and both authors reviewed the search results to reduce subjective bias. Each author read the 522 titles and tagged articles believed to fulfill the above criteria. To merge the authors individual lists the union of the two was taken. This review left 190 articles.

Step 3 - Abstract screening. The next stage included a screening of the articles based on their abstract. All abstracts were thoroughly reviewed, and irrelevant articles in accordance with the above screening criteria were discarded. After

[1] Appendix 1

this, a total of 83 articles remained as relevant for this study.

Step 4 - Article retrieval. All the 83 identified articles were attempted collected, however, 23 articles turned out to be difficult to retrieve despite their listing in the search results from the ISI database. Both authors conducted rigorous Google searches for the articles, and 7 of the missing articles were found. The remaining 16 that were not found were primarily conference proceedings. This left a total of 67 articles for further assessment.

Step 5 - In-depth screening. All the 67 articles were subsequently given a quick read-through to determine if they were relevant for this study. The introductions, research questions and conclusions were given particular focus. With a basis in the three previously defined selection criteria, 26 articles were found to be relevant.

Step 6 - Read-through. All the articles in the "relevant" category were read thoroughly. Backward snowballing was used to further identify literature not uncovered by the literature search. This stage involved reading the literature list in the articles already identified as relevant. If a relevant citation was not included in the literature search, the article was added to the list of articles to read. The pool of literature on university spinoffs is limited in size, so snowballing one or two steps was often enough to return to already known literature. When all articles had been read, and all relevant citations were traced, the literature review ended up containing 44 articles.

Figure 3. *Literature search stages*

Descriptives

The search revealed a total of 44 articles published between 1986 and 2014, and scattered across a total of 20 journals as shown in table 3, where Research Policy has the highest number of published articles, a total of 10. This observation corresponds to the journal distribution found by Rothaermel et al. (2007), and gives this sample validity. Table 3 also includes each journals Impact Factor from 2013, which is an unweighted factor that reflects the average number of citations of the most recent articles in the journals (Garfield, 2006), and is mostly used to show the relative importance of a journal within a field of research. Research Policy has a very high impact factor for a multi-disciplinary social science journal[2], which further strengthens the validity of our results.

Journals: 20	# of articles	Impact Factor
Research Policy	10	3,73
The Journal of Technology Transfer	5	1,67
Technovation	5	4,08
Journal of Business Venturing	3	5,17
R&D Management	2	1,86
Technology Analysis & Strategic Management	2	1,05
Entrepreneurship Theory and Practice	2	3,92
Industrial and Corporate Change	2	1,64
Technological Forecasting and Social Change	1	2,68
Journal of technology management & innovation	1	0,61
Economic Development Quarterly	1	0,81
Strategic Entrepreneurship Journal	1	2,48
Journal of Management Studies	1	4,35
Management science	1	3,1
Economic Inquiry	1	1,2
Science and Public Policy	1	1,23
Tijdschrift voor economische en sociale geografie	1	1,27
The business of biotechnology: from the bench to the street	1	N/A
IEEE Transactions on Engineering Management	1	1,36
Venture Capital	1	0,53

Table 3. *Journal overview*

Methodological Limitations

There are several limitations to the methodology used in this study. As for the unstructured search, it is possible that relevant articles on the topic of valuation have been missed, which might have been identified if a structured search was employed. As for the structured search, only the

[2] http://www.journals.elsevier.com/research-policy

ISI Web of Science database was used in our initial search. This excludes potential relevant articles in journals not covered by the ISI database, however the probability of this is low as the database covers the majority of the leading journals. Further on, backwards snowballing can lead to the identification of articles in journals not covered in the primary database used. A second limitation to the structured search is the limited set of keywords used to conduct the initial search. It is possible that certain relevant terms might have been excluded, and followingly relevant articles left unidentified. A third limitation relates to the method employed to screen the initial 522 articles. The first screening was based solely on titles, and even though subjective bias was attempted reduced by both authors reading all titles, it is possible that false negatives can have occurred, i.e. relevant articles eliminated. A fourth limitation is that after the initial assessment of the titles, only one of the authors reviewed the abstracts for further elimination of articles. This bias could have been avoided if both authors reviewed the abstracts, however, resource limitations prohibited this. A fifth limitation is that we narrowed our focus to literature exclusively focusing on USOs. By excluding other research-based startups, which have many similarities to USOs and are likely to face many of the same valuation problems, we might have overlooked relevant literature.

Literature Review

In this section, we present the main findings from the literature reviews on both valuation and university spinoffs. First, a review of literature on common valuation methods used by venture capitalists as well as literature on new venture valuation is introduced. Thereafter we present literature on USO resources and resource characteristics.

Company Valuation

According to principles in corporate finance, the return an investor should seek on an investment is a function of the investments non-diversifiable risk, measured through the investments Beta (Brealey, 2012). The Beta is a measure of the investments correlation to the market, which represents the only risk an investor cannot eliminate through diversifying her portfolio. Followingly, an investor should not require higher returns for holding investments that have unique or diversifiable risk, because it can be eliminated. Only market risk, which is non-diversifiable, should warrant higher required returns. This is operationalized in the CAPM - model (capital asset pricing model), which establishes that the required return on an investment should be positively correlated to the long term risk-free interest rate, and to the stock market premium (Wright Robbie, 1998):

$$\bar{r}_a = r_f + \beta_a(\bar{r}_m - r_f)$$

where

$$r_f = The\ risk\ free\ rate$$

$$\beta_a = The\ Beta\ of\ the\ security$$

$$\bar{r}_m = Expected\ market\ return$$

In the context of valuation, the CAPM is commonly used by investors to calculate their required return, and when valuing a company, it is applied as the discount rate to estimate its present value. Numerous studies have however highlighted that traditional risk/return models such as the CAPM are difficult to apply when valuing new ventures (Damodaran, 2009; Seppä and Laamanen, 2001; Ge et al., 2005; Landström, 2007; Timmons and Spinelli, 2004). Whilst mature firms generally can exhibit several years of objective operating data, a new venture cannot, which results in high uncertainty and informational asymmetries (Sanders and Boivie, 2004), and consequently increased expected errors in forecasts (Wright Robbie, 1998). Compared to established firms, new ventures are subject to several, qualitatively different sources of risk and uncertainty (Berk et al., 2004), and particularly new technology based firms have overall higher risks than other ventures (Brophy and Haessler, 1994). Whilst mature companies mainly face risks associated with product demand and production costs, new ventures also face “technical” uncertainty regarding the success of the venture itself and the time and cost required to bring the innovation to market, as well as exogenous risks associated with the actions of competitors and possible changes in the market environment prior to launch (Berk et al., 2004). Despite these difficulties, early stage company valuation remains an under researched question, and studies that provide operational guidance on valuing new ventures are lacking (Ge et al., 2005). In fact, no relevant articles aimed specifically at the valuation of early-stage high-tech firms or USOs were identified in our literature review. Admittedly, increasing attention within entrepreneurship literature has been paid to venture capital investments, but this has been on the criteria to screen a deal, i.e. the

Balance Sheet	Income Statement	Mixed (Goodwill)	Cash Flow Discounting	Value Creation	Options
Book value	Multiples	Classic	Free cash flow	EVA	Black and Scholes
Adjusted book value	PER	Union of European Accounting Experts	Equity cash flow	Economic profit	Investment option
	Sales		Dividens	Cash value added	Expand the project
Liquidation value	P/EBITDA	Abbreviated income	Capital cash flow		Delay the investment
Substantial value	Other multiples	Others	APV	CFROI	Alternative uses

Table 4. *Valuation methods*

criteria to invest or not, and not on the valuation process itself or how the criteria relate to firm value (Hudson, 2005; Ge et al., 2005).

Due to the lacking literature on valuation of early stage high-tech firms and USOs, we focus our attention on common valuation methods used by investors on early stage ventures in general. Further on we present associated weaknesses in the context of new venture valuation highlighted in the reviewed literature. The lack of literature on valuation of USOs confirms the lack of research attention this topic has received, and underpins the importance of this paper as the first of its kind.

Valuation Methods

Fernandez (2002), in his book Company Valuation Methods and Shareholder Value Creation, states that methods for valuing companies can be classified into six groups as listed in table 4.

Because the focus of this study is on early stage USOs, only the methods that are most commonly used by investors on early stage ventures are presented, namely cash flow discounting, balance sheet and income statement (Seppä and Laamanen, 2001). For each group of methods, the authors give a brief introduction to the logic underlying it, specific valuation techniques within each group, as well as limitations emphasized by previous researchers on their applicability to early stage ventures.

Cash Flow Discounting Valuation Methods

A well accepted axiom in mainstream finance is that that the economic value of an investment is the present value of all the future cash flows generated by it (Brealey, 2012). Discounted cash flow methods rely on this axiom to define the value of a company as the sum of the uncertain future cash flows from the company discounted at a risk adjusted rate (Petitt and Ferris, 2013).

> *"There appears to be wide agreement that, conceptually, the soundest measures of an assets value is the discounted value of the future cash flow that it will generate "*
>
> *– Lemke (1966)*

Cash flow discounting methods are based on detailed forecasts of the company's assets that are related to the generation of cash flows, for example interest payments, payroll, taxes, revenues, materials etc. (Fernández, 2007). According to Damodaran (2009), there are four key pieces that make up any valuation based on a discounted cash flow: existing assets and the future cash flow generated by them; the expected growth rate of both existing assets and new investments; the risk adjusted discount rate for each of the cash flow streams; and an assessment of when the firm will become a stable growth firm which is used to estimate the terminal value, i.e. the value of all future cash flows after stable growth is reached. The general cash flow discounting method to estimate the present value of a firm can be summarized by the following equation, where the last term represents the terminal value:

$$Value_0 = \sum \frac{CF_i}{(1+r)_i} + \frac{CF_n}{(r-g)*(1+r)_n}$$

where

$CF_i = Cash\,flow\,in\,year\,i$

$r = required\,return$

$CF_n = The\,yearly\,cash\,flow\,expected$
$after\,year\,n, with\,a\,growth\,rate\,g$

Estimating future cash flows can either be done by a top-down approach, where one drills down from the total market for the company's service or product to estimate its expected revenues and earnings, or the bottom-up approach, where one starts out considering the company's production capacity. Discount rates are for mature public firms often calculated using risk/return models such as the CAPM. In the case of new ventures, venture capitalists often apply predetermined discount rates, usually between 40% and 60% (Sahlman, 1990). The high discount rates are justified by investors on the basis that they include the risk free interest rate, the ventures non-diversifiable risk, a market risk premium, an illiquidity discount, and finally compensation for the value added by the investor (Sahlman, 1990). Further on, venture capitalists often use a modified version of the traditional cash flow discounting method known as the venture capital method. Instead of taking the firms perspective, the venture capital method takes the perspective of the investor (Hellman, 2001). There are four basic steps involved; forecast sales or earnings for a period of years, estimate the time at which the investor will exit, value the company at the time of exit based on an assumed multiple, and finally apply an appropriate discount rate. Hellman (2001) points out that it is the simplicity of the venture capital method that makes it advantageous.

In the context of valuing new ventures, Keeley et al. (1996) point out that high levels of risk, which makes it difficult to estimate an appropriate discount rate and to forecast cash flows, as well as multiple investment stages, which provides the investor options to abandon the investment before making all planned payments, makes it difficult to use the discounted cash flow methods. Damodaran (2009) highlights that the absence of historical data makes it difficult to estimate future revenues, assess how revenues from existing assets will change under different macroeconomic conditions as well as estimate the expected return on invested capital. Fernández (2007) emphasizes that determining the discount rate is one of the most important tasks in cash flow discounting methods, yet Damodaran (2009) writes that there is no way to estimate an equity beta, or use the market interest rate on debt, rendering traditional risk return models used to find discount rates useless. As for the venture capital method, Harper and Rose (1993) characterize it as a “rule of thumb”, Gompers and Lerner (2001) write that the method is highly subjective and difficult to justify, and Hellman (2001) concludes that it makes many strong assumptions that limit its usefulness.

Balance Sheet Methods

Valuation methods based on balance sheets consider that the value of a company lies in its assets, and therefore seek to value a company by estimating asset values (Fernandez, 2002). The most common balance sheet approach is the book value (or net asset) method, where the company’s total liabilities are subtracted from its total assets to arrive at the company’s value. The adjusted book value method adjusts the values of the company’s assets and liabilities according to their current market value. Company value according to the liquidation method is the difference between value obtained from selling the company’s assets and paying off its debt, whilst the substantial value method seeks to identify the investment that must be made to form a company having identical conditions and assets as the company being valued.

In contrast to more mature ventures who often have substantial physical assets, intellectual assets such as patents may constitute a significant part of the balance sheet of new technology based firm, and a number of studies have looked at the valuation of these. Parr and Smith (2005) outline three quantitative methods for valuing patents: the cost approach, the market approach and the income approach. The cost approach is based on the replacement cost of the patented invention, the market approach uses comparable patent transactions as a basis to obtain value, and lastly the income approach values a patent based on the estimated future income arising from it over its entire life (Parr and Smith, 2005).

Ge et al. (2005) write that the problem with balance sheet methods, when valuing early stage companies, is that they ignore the value of growth opportunities. Additionally, most new ventures have limited tangible assets, and valuing intangible assets, such as patents for which there has not yet been identified a market application, are according to Clarysse and Bruneel (2007) the most difficult issue in valuation. Fernandez (2002) adds that balance sheet methods do not include factors such as organizational issues or the current situation in the industry.

Income Statement Valuation Methods

These are methods that seek to value a company based on sales, earnings or other indicators stated on its income statement (Fernandez, 2002). Some of the most common methods used are those that rely on different kinds of multiples, for example price/sales, where a company is valued based on its sales. Other common multiples are value of the company over EBIT, EBITDA, operating cash flow or book value. Methods such as these are also called relative valuation methods because the value is derived from what the market is paying for similar firms (Damodaran, 2009), and the fundamental argument underlying relative valuation is that similar assets should be priced equally (Liu et al., 2002). To use the multiples approach, three parameters are required: a scaling factor, a comparable multiple, and a discount rate. The scaling factor used varies greatly, and can be sales, earnings, EBITDA or any other financial measure of the company being valued. The comparable multiples can either be based on private or public transaction prices. Private multiples are preferred by many valuation analysts when valuing young ventures because they claim that they are more representable in terms of illiquidity and risk. Illiquidity is a central issue in new ventures due to few buyers/sellers and therefore substantial transaction costs (Koeplin et al., 2000), and should followingly be reflected in the new ventures value. If a public multiple is used, the analyst can choose an average multiple for the entire industry in question, or a multiple based on a single company. Finally, a discount rate may be necessary, if the scaling factor used is based on income statement forecasts. For new ventures, it is often common to forecast an income statement that is representative of the new ventures steady-state performance, i.e. when it has stable sales and earnings, and use a scaling factor from this forecast. To calculate the present value of the company it then becomes necessary to discount the estimated value. If a public multiple is used it is also common to add an illiquidity discount rate.

Damodaran (2009) writes that multiples are best suited when valuing firms in businesses with many other firms as well as where transactions are common. Following, they are difficult to apply to firms in unique businesses, and he highlights five potential problems with using multiples to value young businesses: first, comparative multiples stem from arms length transactions where side factors specific to the transaction are hidden. Second, because private transactions are infrequent, timing differences occur. Third, to compare different companies, a scaling variable is used, such as sales, earnings or book value. Young companies tend not to have scaling variables that are representative for how the company will perform when fully operational. Fourth, equity claims vary across companies and affect the economic value of each claim, and fifth, it is uncertain if geographical differences render these methods erroneous. Ge et al. (2005) finds three problems with using the multiples approach on startups: lack of earnings, difficulty in defining the boundaries for whom comparable companies are, and lastly, even with a reference group defined, it is still quite subjective which multiple one should choose.

> *"A biased analyst who is allowed to choose the multiple on which the valuation is based and to pick the comparable firms can essentially ensure that almost any value can be justified."*
>
> *– Damodaran (2001)*

Summary of New Venture Valuation

Based on the above literature it is evident that new venture valuation is a difficult task, and that the valuation methods most commonly used are in many cases inadequate for new ventures (Ge et al., 2005; Fernandez, 2002; Damodaran, 2009). Yet, in most cases these methods are readily applied, and in practice, many venture capitalists simply use very high discount rates to hedge against the uncertainty and inaccuracies of using these methods (Sahlman, 1990). This however leads to fewer new ventures receiving funding, because venture capitalists hesitate to fund any new venture that cannot, within reasonable doubt, be expected to at least be valued between \$25 to \$50 million in five years (MacMillan et al., 1986). When new venture valuation is already known to be problematic, to answer the research question in this study, namely the applicability of these methods on early-stage USOs, it then becomes the researcher's task to investigate how USOs differ from other new ventures, and how these differences affect the applicability of traditional valuation methods compared to other new ventures. To identify these differences, the authors review in the following chapter literature on characteristics of initial resource endowments of USOs, who together with the review of literature on new venture valuation constitute the theoretical foundation for answering our research question.

Resource Characteristics of Early Stage University Spinoffs

Mustar et al. (2006) state that four categories of resources are especially important for research-based spinoffs, namely human, technological, social and financial. In the context of early-stage valuation, the authors argue that technological resources are the main source of differences between a USO and other new ventures. This is based on the fact that the literature review revealed a majority of articles pertaining to the technological resources of a USO, and none or few highlighting significant differences between the other three resource categories compared to other new ventures. Also, as Agarwal and Shah (2014) point out, technology is the core of all academic founded firms, and Shane (2004) that these companies are often founded on years of research with nothing more than proof of concepts. The following review is therefore heavily skewed towards a review of characteristics of initial technological resource endowments in USOs. It is worth mentioning that among the few findings on the other resource categories were Ensley and Hmieleski (2005), who for human resources found that top management teams (TMT) of USOs are more homogenous in terms of education, industry experience, functional expertise and skills than those of independent startups. Additionally, USO founders tend to possess deeper technological experience (Colombo and Piva, 2012), but little industry knowledge (Granovetter, 1973) and a lower degree of entrepreneurial and managerial experience compared to those of nonacademic new technology-based firms (Iacobucci et al., 2011; Colombo and Piva, 2012; Criaco et al., 2013; Vohora et al., 2004; Agarwal and Shah, 2014). For social resources it was found that the organizational environment of USOs differentiate them from other independent startups, where the parent university and the associated institutes provide networks that are else hard to acquire. Through the parent university, the spinoff can gain access to laboratories and equipment as well as human resources employed at the institution (Shane, 2004). For financial resources it was found that USOs face challenges in acquiring early stage capital due to the uncertainty associated with these companies (Widding et al., 2009; Wright et al., 2006; Shane, 2004)

Technological Resources

Academic entrepreneurship is heavily based on technological advances in laboratory research, and technical knowledge is the core of all founded firms (Agarwal and Shah, 2014). Six characteristics of initial technological resource endowments are highlighted in the reviewed literature; USOs tend to be founded on early stage technologies that are radical and provide significant technical advances, have general-purpose applications, that provide significant benefits to the customer, and finally that have strong intellectual property protection (Doutriaux and Barker, 1995; Nelsen, 1991; del Campo et al., 1999; Shane, 2004). Followingly each characteristic is reviewed.

Early Stage Technologies

Licensing out unproven, early stage technology is difficult, and Doutriaux and Barker (1995) and Shane (2004) write that early stage inventions therefore tend to result in the creation of spinoffs. Further, these early stage technologies have a number of implications on the new venture. Studies show that the risk of loss associated with investments from venture capitalists steadily decrease as the venture evolves into later development stages (Seppä and Laamanen, 2001), which naturally leads to increased perceived risks associated with early stage technologies. Wright et al. (2006), citing Murray and Lott (1995) and Lockett et al. (2005), write that venture capitalists, especially in Europe, are reluctant to invest in early stage high-tech companies, and that informational asymmetries in companies working with unproven technologies may be significant. Further, due to high levels of uncertainty regarding the technologies potential and the marketability of its functionality, common risk assessment measures are difficult to apply.

> *"Many university inventions lead to the formation of spinoffs because they are early stage technologies that are little more than 'proofs of concept' when the researcher discloses the invention to the university technology licensing office"*
>
> *– Shane (2004)*

Radical Technologies That Provide Significant Technical Advances

There are many definitions for what constitutes radical innovation, and although the literature has yet to converge to a universally accepted definition, common to many of them is that the innovation incorporates technology that there is little previous knowledge about and that is a clear and risky departure from existing practice (Green et al., 1995; Ettlie et al., 1984). Radical technologies are often recognized as engines of growth, productivity and performance (Schumpeter, 1928; Linton and Walsh, 2008; Maine, 2008), and more often than not, university spinoffs are founded to exploit technologies that are radical. Shane (2004) finds that for university spinoffs, it is important that the underlying technology on which the company is founded represents transitions in the marketplace, or makes way for new product or services, and Utterback (1996) states that established firms with a dominant market position rarely adopt radical innovations due to the fear that the new technology will cannibalize their existing products or services. To commercialize university technology spinoffs become necessary, which leads to the technologies underlying these companies being radical in nature. Further on, to offset the uncertainty associated with radical technologies, the technologies need to represent a significant technical advancement (del Campo et al., 1999) because they have greater economic value (Harhoff et al., 1999). Spinoffs commercializing radical technologies that do not provide significant technical advances cannot be justified from an economic standpoint (Shane, 2004).

> *"Several academic studies show that radical technologies tend to provide the basis for the creation of university spinoffs, while incremental technologies are more likely to be licensed by established companies"*
>
> *– Shane (2004)*

General-Purpose Technologies

USOs tend to exploit technologies with broad application areas and multiple fields of use (Nelsen, 1991; del Campo et al., 1999). This is primarily due to two reasons: first, applicability in multiple markets render more market opportunities; and second, established companies have trouble identifying what to use the technologies for (Shane, 2004). General-purpose technologies have important implications for the USO. Nelsen (1991) writes that general-purpose technologies are positively correlated with spinoff performance because they allow spinoffs to pursue multiple application areas, hence diversify risk, and multiple cash flow streams in different points in the ventures development. Shane (2004) writes that investors favor those spinoffs that possess general-purpose technologies. This is because general purpose technology makes the new venture more suited to adapt to changing circumstances, and subsequently provide a higher return to the investor. Clarysse et al. (2011) investigate how technological knowledge-sources in USOs affect performance, and find that broad technology scopes are positively associated with growth, and therefore performance. They go on to write that this might be due to the fact that broader technologies allow the companies to shift between market applications when faced with dead ends. Finally, Increased performance due to broader scope of the technology may be linked to increased possibilities for licensing out the technology, either if the spinoff is not able to leverage the technology themselves, or simultaneously in different markets (Gambardella and Giarratana, 2008).

Significant Customer Value

Because of the technology characteristics mentioned above, commercialization of university technology is a capital intensive task. This is further compounded by the inherent challenges of bringing university technology to the market, such as distance to the end user because of an upstream position in the value chain (Pavitt, 1984; Arora et al., 2001), and requirements to other players in the value chain to adapt entirely new technology (Abernathy and Clark, 1985; Tushman and Anderson, 1986). This implies that creating a spinoff company requires vast amount of financial resources, and university spinoffs cannot afford to exploit technologies that only offer small improvements in customer value that will not provide sufficient financial returns. Shane (2004) followingly writes that a characteristic of the initial technology endowments of USOs is that they provide significant customer value, because they are more likely to result in higher financial returns (Harhoff et al., 1999). In addition, technologies that provide significant technical advances offset the increased uncertainty and risk associated with radical and unproven early stage technologies.

Strong Intellectual Property Protection

Finally, strong intellectual property protection (IPR) is also a characteristic of the initial technology resource endowments of USOs. Nelsen (1991) states that strong intellectual property (IP) protection is important for the creation of USOs, as it is the only competitive advantage the firm has at inception, and Shane (2004) and De Coster and Butler (2005) support this by writing that spinoffs are generally more likely to be founded when the underlying invention is protected by large portfolios of broad-scoped patents. Patent portfolios are valuable as they assert the spinoff greater control over the technology, and patents with broad scopes allow for easier blocking of competitors.

Summary of Literature Review

Based on the above literature reviews on venture valuation and USOs, it is evident that several studies have separately focused on valuing early stage ventures, and the unique characteristics of initial resource endowments in USOs. More specifically it has been seen that valuing these ventures is problematic and that these firms differ especially in their technological resource endowments compared to other new ventures. However, no previous research, to our knowledge, have linked the two together and examined how the unique technological resource characteristics affect the process of valuing these firms. Different types of new ventures naturally are faced with different types of challenges in the valuation process due to unique firm characteristics, and ignoring these differences and assuming that the same methods can be applied to all companies may lead to significant erroneous valuations. In the following the authors seek to fill this literature gap.

Discussion

In light of the literature gap identified above, in this section we discuss how the characteristics of initial resource endowments affect the applicability of traditional valuation methods with a basis in the presented theoretical framework. Because the underlying problem in valuing a new venture is uncertainty, we leverage the previously presented theory on risk and uncertainty (Knight, 1921) to first, argue how specific resource characteristics affect the uncertainty associated with a USO, and second, how that affects the applicability of traditional valuation methods.

University Spinoffs and Uncertainty

The literature review revealed that particularly characteristics of the technical resources in these companies are unique compared to other new ventures. When assessing whether valuation of early-stage USOs is indeed a more difficult task than valuing any other startup, it is necessary to focus our efforts on exactly these characteristics that set these companies apart, and we will therefore primarily focus our discussion on technical resources. To further justify our focus on technical resources we briefly comment on how the other three resource categories affect uncertainty in a USO compared to other new ventures in the context of valuation.

In the reviewed literature, founding team homogeneity in terms of backgrounds and experiences, was identified as a characteristic of human capital resources in USOs that differ from other new ventures. There is obviously, remembering the distinction between risk and uncertainty (Knight, 1921), uncertainty connected to this fact, such as whether the founding team has enough experience and knowledge within all the necessary disciplines to successfully launch the new venture. This is categorized as uncertainty, not risk, because there is no possible way to estimate the probability of the founding team having the necessary combination of skills and experiences. However, this uncertainty can be significantly reduced by investors through funding terms, such as staging investments, hiring external managers, or actively participating in the management team themselves, and so do not in any significant way affect the applicability of traditional valuation methods on these firms.

The authors argue that social resources primarily assist in reducing uncertainty, and do not directly affect the applicability of existing valuation methods on early-stage USOs compared to other new ventures. A social resource such as a relationship between the USO and an investor can significantly reduce informational asymmetries between the two, effectively reducing uncertainty, and making it easier for the investor to value the company. However, the lack of such a relationship does not increase uncertainty for an investor, as the outset is that no relationship exists. As such, there is no significant difference between the social resources in a USO and those in an independent startup that increase uncertainty in the context of valuation.

Finally, financial resources, or more precisely the lack thereof, can affect the valuation of a firm, but do not in any significant way contribute to increased uncertainty compared to other new ventures. In the case of USOs it is likely that several rounds of financing will be needed before the new venture can survive by itself. The possible dilution effects of future financing rounds affect the valuations investors put on companies, however, these effects can be mitigated through contractual agreements (Sahlman, 1990), and should therefore not affect the applicability of traditional valuation methods on these firms.

Technological Resources

Six characteristics of USOs initial technological resource endowments have been highlighted in the literature review, namely that the technology is often early-stage, radical and provides significant technical advances, has general purpose applications, provides significant customer benefits, and has strong intellectual property protection. In the following, we discuss how each of these characteristics affect the uncertainty in a USO from a valuation standpoint.

Early Stage Technologies

USOs are often founded on research, and the underlying technologies are rarely more than proof of concepts (Doutriaux and Barker, 1995). It has been shown in the reviewed literature that early stage technologies are likely to have a negative impact on performance due to higher uncertainty and lower probability of receiving funding, where the latter is previously shown to be the single most important determinant for achieving IPO (Hayter, 2013; Clarysse et al., 2011). The early stages of the technologies have three important implications on the uncertainty in USOs; it leads to uncertainty about the commercial applicability of the research, uncertainty regarding the development time frame, and uncertainty about the financial needs of the company. First, because the underlying factor for developing the technology in question has been research at the university where the USO originated, investors are faced with uncertainty as to whether the technology is applicable in a commercial product. Trying to estimate the probability of achieving this is an impossible task, and can therefore be categorized as fundamental uncertainty. Second, turning the research into a commercial product is a time consuming task, and research indicates that it takes an average of 10 years to commercialize technology in a USO (Rasmussen et al., 2013; Lawton Smith and Ho, 2006). Significant changes in the market environment and customer needs can occur in such a timeframe, which increases the uncertainty as to whether the investor will ever see a return on his investment. Again, estimating the probabilities of such events occurring, either a priori or through statistical analysis, is an impossible task, leading to increased fundamental uncertainty. Finally, because of the two aforementioned reasons, the investor is faced with uncertainty in regards to the financial needs of the company. The longer the development time frame, the larger the error variance in the estimated financial needs is likely to be. Big changes in financial needs after an initial investment can pressure the investor into a situation where they must keep investing to keep their option on a future return, or they must face dilution. The probability of this happening is likely to be smaller in companies that have shorter development timeframes, and followingly the early stages of the technology lead to USOs having higher uncertainty.

Radical Technologies That Provide Significant Technical Advances

Technologies that are radical and provide significant technical advances are by definition more risky to work with than mature technologies because they are previously untested and require new knowledge. USOs, who more often than not work with technologies that exhibit these characteristics, are venturing into uncertain areas where knowledge is undeveloped or lacking, and the undertaking is costly (Green et al., 1995). Further on, research has shown that projects developing radical innovations are less likely to be clearly tied to a market need, and more likely to fail (Baker et al., 1985; Souder, 1987). Distinguishing between risk and uncertainty (Knight, 1921), radical projects that provide significant technical advances clearly increase the uncertainty in a USO. It becomes meaningless to try to estimate the probabilities of a USO succeeding in developing the technology to commercial application, or the probability of finding a target market either a priori or through empirical evaluation because the instances in question are highly unique. The uncertainty in the USOs is further compounded by the fact that these technologies represent new advanced knowledge areas, which investors have difficulty understanding (Shane, 2004). This increases the informational asymmetries between the investor and the entrepreneur, making it even harder for the investor to assess the true potential of the project, and to assess the added value the investor can deliver through other resources than capital, such as advice and guidance. The added uncertainty in USOs due to the technologies these companies are founded on often being radical and leading to significant advances, is likely to decline as the venture matures to later stages of the development because more knowledge and information is accumulated, however, in the early stages, the uncertainty seen from a valuation standpoint will, as we will discuss later, significantly impact investors ability to assess the project's value.

General-Purpose Technologies

General-purpose technologies are in previous research highlighted as being associated with venture growth (Grant, 1996). The authors further argue that general purpose technologies in fact reduce uncertainty seen from the viewpoint of an investor. USOs often work with early-stage and radical technologies that do not have any target markets yet, and where there is uncertainty about ever finding an applicable market. This uncertainty is however reduced when the technology has broad application areas and can be utilized in many different markets and industries. This is substantiated by Nelsen (1991), who points out that general-purpose technologies are positively correlated with spinoff performance because they allow spinoffs to diversify risk and earn multiple cash flows at different points in time during the ventures development. For example, general-purpose technologies permit the USO to license out the technology to certain application areas whilst keeping control over other application areas, which from an investor's viewpoint reduces the uncertainty about ever earning a return due to several parallel development efforts.

Significant Customer Value

As for technologies that provide significant customer benefits, no explanation is needed to conclude that they reduce the uncertainty an investor is faced with when assessing a USO. Technologies that are more worth to customers are more likely to earn higher returns, and they are not faced with the same “market push” problems that new technologies without a specific demand face. It is therefore evident that technologies that provide significant customer benefits reduce the uncertainty associated with a USO.

Strong Intellectual Property Protection

Strong intellectual property protection is yet another technical resource characteristic that, seen from the viewpoint of an investor, should reduce uncertainty. Previous research on patenting has shown that there is a positive correlation between patents and firm performance (Deeds et al., 2000; Zahra and Bogner, 2000; Powers and McDougall, 2005). From an investor’s viewpoint then, because they are more likely to earn higher returns when the USO has stronger intellectual property protection, this characteristic reduces the uncertainty in a USO. Further on, strong intellectual property protection should offset some of the uncertainty associated with long development times. By having strong IPR the USO can protect its technical space from competitors, and reduce the chances of other companies beating them in commercializing the same technology. Finally, if the USO is unsuccessful in commercializing the technology, they will still assert control over it through the IPR, which can be sold off to other companies who might see value in owning the technology for future use.

In the above discussion the authors have presented how characteristics of initial technical resource endowments in USOs affect the uncertainty in these companies seen from the viewpoint of an investor. The authors have argued that three of these characteristics, radical, significant technical advances and early stage, in accordance with Knight's (1921) distinction between risk and uncertainty, lead to high fundamental uncertainty, whilst on the other hand, general purpose technologies that provide significant customer benefits and have strong intellectual property protection in fact reduce it. In the following we discuss how this uncertainty affects the applicability of traditional valuation methods.

University Spinoffs and Traditional Valuation Methods

The problems with using existing valuation methods on startups in general have already been highlighted in entrepreneurship and valuation literature (Ge et al., 2005; Fernandez, 2002; Damodaran, 2009). Despite this, these methods are still commonly used amongst investors due to the lack of better ways. Naturally, an estimate is better than a guess. However, in the case of early stage USOs, using existing valuation methods pose a new set of challenges due to the high uncertainty in these firms. Uncertainty is commonly factored into valuations by venture capitalists through high discount rates, commonly between 40% and 60% (Sahlman, 1990). Using the same underlying logic, and considering that a USO is highly more uncertain than the general startup, discount rates as high as 70%, 80% or 90% could be argued by an investor. This however is in practice unfeasible, and would result in almost all early-stage USOs being categorized as unprofitable ventures. A simple example can explain why. Assuming that a USO takes on average 10 years to commercialize their technology, an investor, on average, has to wait 10 years before a return on their investment can be expected. Further on, assuming an investment of 1 MUSD for a 20% equity stake, and that the investor requires a 35% yearly return over the investments lifetime (Zider, 1998), the present value of his investment needs to be 3,5M. Assuming a 70% discount rate, the USO has to be valued at 3.5 billion USD after 10 years. Such a valuation is highly unlikely. Lets further assume that the investor estimates to be able to sell his equity stake after 5 years, the company still needs be valued at 1.76 billion USD. These are very unlikely valuations, and followingly, few or no USOs are likely to attain funding if such a valuation process is used. This example puts in perspective why these companies face financing problems (Shane, 2004). In the following we discuss how uncertainty affects the applicability of the three most common valuation methods previously presented.

Cash Flow Discounting Methods

There are four key pieces required to use the cash flow discounting method: existing assets and the future cash flow generated by them; the expected growth rate of both existing assets and new investments; the risk adjusted discount rate for each of the cash flow streams; and an assessment of when the firm will become a stable growth firm which is used to estimate the terminal value. However, estimating any of these four key pieces is a significant challenge in early stage USOs.

The first two criteria relate to estimating future cash flows. For estimating future cash flows, the literature review highlighted two common methods: the top-down and bottom-up approach. With the top-down approach, one starts out with the total market for the product, and then narrows down to the attainable market share of the focal firm. This however, because the technology is radical and early stage and followingly does not have a defined market or application area (Wright et al., 2006; Vohora et al., 2004), is not possible. Indeed it can be argued that the spinoff likely has mapped out potential markets, but how do you weight the sizes of each market to reach the total addressable market for the firm? With the bottom-up approach, the starting point is the focal company's capacity constraints, but because the company does not have defined products, it becomes meaningless to use this method. Again, it is possible to assume what the capacity constraints can turn out to be if successful in developing a product, but how do you find the probability of succeeding?

Estimating the discount rate becomes an equally difficult task. Because of the technology’s early stage, investors cannot be certain if it is possible to utilize the technology in a product, or produce the technology at a commercial scale (Shane, 2004). Further on, this uncertainty is compounded with the fact that the technology is radical and represents significant technological breakthroughs, which increases the probability of failing in developing the technology into a commercial product or service. Obviously, this uncertainty should be included in a discount rate, but how do you put a value on it? The situation in question is so highly unique, that it is simply not possible to a priori or statistically estimate the probability of finding an application area or succeeding in developing the technology to a commercial scale, and it is therefore highly difficult to account for in a risk adjusted rate. Moreover, the example in the introduction showed that the common way of handling uncertainty in new ventures by investors, namely applying high discount rates, is not possible in early-stage USOs. Finally, because of the early stages of the technology and the subsequent long development times these companies face, the time over which cash flows should be discounted as well as determining the terminal value is highly challenging. It is likely, as Knight (1921) writes, that people, such as founders and investors, will try to estimate their opinions in terms of probability judgments, however, because the instances in question are so highly unique, and they therefore are facing unique challenges not previously solved, there is simply no way to quantify this uncertainty. Clearly, estimating the parameters necessary to value an early stage USO using discounted cash flow valuation methods pose significant challenges due to high fundamental uncertainty, and these models are therefore poorly suited for valuing such companies. This uncertainty is a result of the initial technological resource endowments being early stage, radical and representing significant technological breakthroughs.

Balance Sheet Methods

Balance sheet valuation methods use the firm's assets and liabilities to calculate its value. In the case of early stage USOs, many are likely to not have any valuable assets in place, and if they do have assets, the majority of these are likely to be in the form of intellectual property. As previously stated, common methods for valuing intellectual property are the cost approach, market approach and income approach. The cost approach values intellectual property based on the investment required to replace its future product or service capability, often using historical requirements to get to the current technological development stage as well as expenses incurred. Because the technologies in USOs in many cases do not have a defined future service or product stemming from the intellectual property, and additionally the research being a result of several years of work at the university where researchers have access to a vast amount of resources such as laboratories with costly equipment (Shane, 2004) or experts in numerous fields, it is difficult to estimate the cost of replicating the research. In the case of the market approach, there are two requisites, an active public market and an exchange of comparable goods, neither of which are likely to exist for the unique and radical technologies which these companies are founded on. An even more compelling argument against valuing the intellectual property of university spinoffs with the use of the cost or market approach is that they don't include the future revenues the intellectual property has the possibility to create, which is where the real value of the patent lies in the case of a USO. Finally, the income method is based on valuing intellectual property on its potential for generating future income, however, this requires the estimation of future cash flows and discount rates, which has already been shown above to pose significant challenges.

Income Statement Methods

Valuation methods based on the firm's income statement are the last group of methods presented in this study, and rely on an income statement that is representative of the company's long term performance, as well as the identification of what the market is paying for comparable firms. Here again, because of the early stages of the technology and the following long development times, estimating what the income statement will look like so far into the future is a nearly impossible task. Further on, because these companies are working with cutting edge technologies that are protected by patents, finding a comparable firm with the same technology characteristics is likely to prove difficult, rendering this group of valuation methods unfeasible on early stage USOs.

As shown in the above discussion, the fact that initial technological resource endowments in USOs tend to be early stage, radical and represent technological breakthroughs, increases the uncertainty in these firms significantly, and make it difficult to estimate future cash flows, discount rates and find comparable firms, which renders the three most common valuation methods unfeasible on early stage USOs. The authors argue that the early stage of the technology, which implies that very limited development towards a finished product has been conducted, is the largest contributor to this uncertainty, and in fact, when succeeding in reaching later stages of the development, i.e. proving the technologies feasibility in a market application, radicalness and significant technological advances may reduce the uncertainty investors perceive when assessing the company because the new venture controls a superior patented technology. It is followingly natural to believe, that as the new venture develops into later stages, the uncertainty will be significantly reduced, and traditional valuation methods will again become applicable. Table 5 summarizes how characteristics of the initial technological resource endowments affect the suitability of the above mentioned valuation methods.

Conclusion and Implications

Valuation is a central part in deciding whether one should invest in a company or not (Keeley et al., 1996), and it is often one of the more challenging discussions between an entrepreneur and the investor (Quindlen, 2000). This study investigates the applicability of traditional valuation methods on the phenomenon of university spinoffs, which in the last three decades have grown considerably in numbers (Rothaermel et al., 2007), and become an important part of the economic landscape (Shane, 2004; Bonardo et al., 2011; Rasmussen et al., 2013). More specifically, this study leverages a theoretical framework comprised of risk and uncertainty and resource-based theory to pinpoint initial resource characteristics of USOs that render common valuation methods from corporate finance less applicable on these firms. To accomplish this, an extensive literature review was conducted to identify the most

Technology Characteristic	Balance Sheet methods	Income Statement methods	Discounted Cash Flow methods
Early-stage	Few assets on balance sheet, and does not incorporate future revenue potential Intellectual property valuation dependent on cash flow estimation, which is uncertain	Difficult to find comparable firms because of undefined market/product Uncertainty regarding steady-state performance, and thereby what "scaling factor" to use Uncertainty regarding development time, and followingly the time over which value derived from multiple should be discounted	Uncertainty about target market and application area, and followingly future cash flows Uncertainty regarding technical feasibility, and followingly difficult to estimate discount rate Uncertainty regarding development time, and followingly the time over which cash flows should be discounted. Uncertainty about scaling technology to commercial production
Radical	Difficult to find comparable transactions to value intellectual property	Difficult to find comparable firms because of unique technology Increases uncertainty regarding technical feasibility, and followingly difficult to estimate discount rate	Increases uncertainty regarding technical feasibility, and followingly difficult to estimate discount rate Uncertainty about scaling technology to commercial production
Significant technical advances	Difficult to find comparable transactions to value intellectual property	Difficult to find comparable firms because of unique technology Increases uncertainty regarding technical feasibility, and followingly difficult to estimate discount rate	Increases uncertainty regarding technical feasibility, and followingly difficult to estimate discount rate Uncertainty about scaling technology to commercial production

Table 5. *USO characteristics and their effects on traditional valuation methods*

common valuation methods used on new ventures, and the unique resource characteristics of USOs that separate these firms from other new ventures.

The findings suggest that indeed, as Brush et al. (2001) defines, the early stage resources of these companies can be divided into four categories: human capital, social, financial technological. Further, using the distinction between risk and uncertainty as defined by Knight (1921), it has been shown that characteristics relating to the initial technological resource endowments, i.e. the early stage, radicalness and significant technical advances, introduce high levels of uncertainty which render valuation methods based on cash flow discounting, balance sheets and income statements unfeasible on early stage USOs. Additionally, the authors have briefly argued that it is the early stage of the technology that introduces the most uncertainty, and as the new venture progresses into more mature development stages and proves the feasibility of the technology, the uncertainty is likely to reduce significantly.

The findings in this study has a vital implication for valuation analysts and investors: using common valuation methods on early-stage USOs may lead to erroneous valuations that do not reflect the true value of the firm, and which subsequently can lead to bad investment decisions. More importantly, they are likely to lead to many foregone investment opportunities, and one should show caution when using them, and at least be aware of their shortcomings. The common denominator for why traditional valuation methods are prone to error while used on early-stage USOs is the high fundamental uncertainty, which makes it impossible to reliably estimate financial outputs necessary to use these methods. This has big implications for USOs, who face the risk of not attracting necessary funding. The authors followingly recommend future research to investigate other valuation approaches than those of corporate finance, for example the applicability of valuation methods based on inputs such as resources, founder characteristics or networks, that can be objectively measured despite the high uncertainty associated with these firms, rather than financial outputs. In our literature search, a large body of literature was found on the relationship between resource endowments in USOs and performance. This literature can be leveraged to investigate the relationships between resources and firm value, with the underlying argument being that resources that lead to higher long term performance should lead to higher valuations. We leave this task to future research.

References

ABERNATHY, W. J. & CLARK, K. B. 1985. Innovation: Mapping the winds of creative destruction. *Research policy,* 14**,** 3-22.

AGARWAL, R. & SHAH, S. K. 2014. Knowledge sources of entrepreneurship: Firm formation by academic, user and employee innovators. *Research Policy*.

AKERLOF, G. A. 1970. The market for" lemons": Quality uncertainty and the market mechanism. *The quarterly journal of economics*, 488-500.

ALVAREZ, S. A. & BUSENITZ, L. W. 2001. The entrepreneurship of resource-based theory. *Journal of management,* 27, 755-775.

ARORA, A., FOSFURI, A. & GAMBARDELLA, A. 2001. *Markets for technology: The economics of innovation and corporate strategy*, MIT press.

BAKER, N., GREEN, S. & BEAN, A. 1985. How management can influence the generation of ideas. *Research Management,* 28, 35-42.

BALAKRISHNAN, S. & KOZA, M. P. 1993. Information asymmetry, adverse selection and joint-ventures: Theory and evidence. *Journal of Economic Behavior & Organization,* 20, 99-117.

BARNEY, J. 1991. Firm resources and sustained competitive advantage. *Journal of management,* 17, 99-120.

BARNEY, J. B. & CLARK, D. N. 2007. *Resource-based theory: Creating and sustaining competitive advantage*, Oxford University Press Oxford.

BAUM, J. A. & OLIVER, C. 1991. Institutional linkages and organizational mortality. *Administrative science quarterly*, 187-218.

BERK, J. B., GREEN, R. C. & NAIK, V. 2004. Valuation and Return Dynamics of New Ventures. *The Review of Financial Studies,* 17, 1-35.

BIGLIARDI, B., GALATI, F. & VERBANO, C. 2013. Evaluating performance of university spin-off companies: Lessons from italy. *Journal of technology management & innovation,* 8, 178-188.

BONARDO, D., PALEARI, S. & VISMARA, S. 2011. Valuing University‐Based Firms: The Effects of Academic Affiliation on IPO Performance. *Entrepreneurship Theory and Practice,* 35, 755-776.

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.

BREALEY, R. A. 2012. *Principles of corporate finance*, Tata McGraw-Hill Education.

BROPHY, D. J. & HAESSLER, M. R. 1994. Evaluating the Venture Capital Fund Agreement. *Managerial Finance,* 20, 53-64.

BRUSH, C. G., GREENE, P. G. & HART, M. M. 2001. From initial idea to unique advantage: The entrepreneurial challenge of constructing a resource base. *The Academy of Management Executive,* 15, 64-78.

BRÜDERL, J., PREISENDÖRFER, P. & ZIEGLER, R. 1992. Survival chances of newly founded business organizations. *American sociological review*, 227-242.

BURGERS, J. H., VAN DEN BOSCH, F. A. & VOLBERDA, H. W. 2008. Why new business development projects fail: coping with the differences of technological versus market knowledge. *Long Range Planning,* 41, 55-73.

CAMERER, C. & WEBER, M. 1992. Recent developments in modeling preferences: Uncertainty and ambiguity. *Journal of Risk and Uncertainty,* 5, 325-370.

CHAN, Y.-S., SIEGEL, D. & THAKOR, A. V. 1990. Learning, corporate control and performance requirements in venture capital contracts. *International Economic Review*, 365-381.

CLARYSSE, B. & BRUNEEL, J. 2007. Nurturing and growing innovative start‐ups: the role of policy as integrator. *R&d Management,* 37, 139-149.

CLARYSSE, B., WRIGHT, M., LOCKETT, A., MUSTAR, P. & KNOCKAERT, M. 2007. Academic spin-offs, formal technology transfer and capital raising. *Industrial and Corporate Change,* 16, 609-640.

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.

COHEN, B. 2006. Sustainable valley entrepreneurial ecosystems. *Business Strategy and the Environment,* 15, 1-14.

COLOMBO, M., MUSTAR, P. & WRIGHT, M. 2010. Dynamics of science-based entrepreneurship. *The Journal of Technology Transfer,* 35, 1-15.

COLOMBO, M. G. & PIVA, E. 2012. Firms' genetic characteristics and competence-enlarging strategies: A comparison between academic and non-academic high-tech start-ups. *Research Policy,* 41, 79-92.

COOPER, A. C., GIMENO-GASCON, F. J. & WOO, C. Y. 1994. Initial human and financial capital as predictors of new venture performance. *Journal of business venturing,* 9, 371-395.

COOPER, H. M. 1988. *The integrative research review: A systematic aproach*, Sage Publications.

CRIACO, G., MINOLA, T., MIGLIORINI, P. & SERAROLS-TARRÉS, C. 2013. "To have and have not": founders' human capital and university start-up survival. *The Journal of Technology Transfer*, 1-27.

CROOK, T. R., KETCHEN, D. J., COMBS, J. G. & TODD, S. Y. 2008. Strategic resources and performance: a meta-analysis. *Strategic Management Journal,* 29, 1141-1154.

DAMODARAN, A. 2001. Corporate finance: theory and practice.

DAMODARAN, A. 2009. Valuing young, start-up and growth companies: estimation issues and valuation challenges. *Stern School of Business, New York University (New York).*

DE COSTER, R. & BUTLER, C. 2005. Assessment of proposals for new technology ventures in the UK: characteristics of university spin-off companies. *Technovation,* 25, 535-543.

DEEDS, D. L., DECAROLIS, D. & COOMBS, J. 2000. Dynamic capabilities and new product development in high technology ventures: an empirical analysis of new biotechnology firms. *Journal of Business venturing,* 15, 211-229.

DEL CAMPO, A. A., SPARKS, A., HILL, R. C. & KELLER, R. T. 1999. The transfer and commercialization of university-developed medical imaging technology: opportunities and problems. *Engineering Management, IEEE Transactions on,* 46, 289-298.

DEQUECH, D. 2000. Fundamental uncertainty and ambiguity. *Eastern Economic Journal*, 41-60.

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.

DOUTRIAUX, J. & BARKER, M. 1995. The university-industry relationship in science and technology. Gouvernement du Canada-Industry Canada.

EISENHARDT, K. M. & SCHOONHOVEN, C. B. 1996. Resource-based view of strategic alliance formation: Strategic and social effects in entrepreneurial firms. *organization Science,* 7, 136-150.

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.

ETTLIE, J. E., BRIDGES, W. P. & O'KEEFE, R. D. 1984. Organization strategy and structural differences for radical versus incremental innovation. *Management science,* 30, 682-695.

FAMA, E. F. 1991. Efficient capital markets: II. *The journal of finance,* 46, 1575-1617.

FERNANDEZ, P. 2002. *Valuation methods and shareholder value creation*, Academic Press.

FERNÁNDEZ, P. 2007. Company valuation methods. The most common errors in valuations. *Research Paper no,* 449.

FESTEL, G. 2013. Academic spin-offs, corporate spin-outs and company internal start-ups as technology transfer approach. *The Journal of Technology Transfer,* 38, 454-470.

FULLER, A. W. & ROTHAERMEL, F. T. 2012. When stars shine: the effects of faculty founders on new technology ventures. *Strategic Entrepreneurship Journal,* 6, 220-235.

GAMBARDELLA, A. & GIARRATANA, M. 2008. General technologies, product market fragmentation, and markets for technology: evidence from the software security industry. *Unpublished manuscript*.

GARFIELD, E. 2006. The history and meaning of the journal impact factor. *Jama,* 295, 90-93.

GE, D., MAHONEY, J. M. & MAHONEY, J. T. 2005. New Venture Valuation by Venture Capitalists: An Integrative Approach. University of Illinois at Urbana-Champaign, College of Business.

GOMPERS, P. & LERNER, J. 2001. The venture capital revolution. *Journal of economic perspectives*, 145-168.

GOMPERS, P. A. 1995. Optimal investment, monitoring, and the staging of venture capital. *The journal of finance,* 50, 1461-1489.

GRANOVETTER, M. S. 1973. The strength of weak ties. *American journal of sociology*, 1360-1380.

GRANT, R. M. 1996. Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization science,* 7, 375-387.

GREEN, S. G., GAVIN, M. B. & AIMAN-SMITH, L. 1995. Assessing a multidimensional measure of radical technological innovation. *Engineering Management, IEEE Transactions on,* 42, 203-214.

HAGEDOORN, J. 1993. Understanding the rationale of strategic technology partnering: Nterorganizational modes of cooperation and sectoral differences. *Strategic management journal,* 14, 371-385.

HAMEL, G., DOZ, Y. L. & PRAHALAD, C. K. 1989. Collaborate with your competitors and win. *Harvard business review,* 67, 133-139.

HARHOFF, D., NARIN, F., SCHERER, F. M. & VOPEL, K. 1999. Citation frequency and the value of patented inventions. *Review of Economics and statistics,* 81, 511-515.

HARPER, C. P. & ROSE, L. C. 1993. Accuracy of appraisers and appraisal methods of closely held companies.

HAYTER, C. S. 2013. Harnessing University Entrepreneurship for Economic Growth Factors of Success Among University Spin-offs. *Economic Development Quarterly,* 27, 18-28.

HELLMAN, T. 2001. A note on Valuation of venture Capital Deals. *Harvard Business Review*.

HUDSON, E. 2005. A Review of Research into Venture Capitalists' Decision Making: Implications for Entrepreneurs, Venture Capitalists and Researchers. *Journal of Economic and Social Policy,* 10, 3.

IACOBUCCI, D., IACOPINI, A., MICOZZI, A. & ORSINI, S. 2011. Fostering entrepreneurship in academic spin-offs. *International Journal of Entrepreneurship and Small Business,* 12, 513-533.

KEELEY, R. H., PUNJABI, S. & TURKI, L. 1996. Valuation of early-stage ventures: option valuation models vs. traditional approaches. *The Journal of Entrepreneurial Finance,* 5, 115-138.

KNIGHT, F. H. 1921. Risk, uncertainty and profit. *New York: Hart, Schaffner and Marx*.

KOEPLIN, J., SARIN, A. & SHAPIRO, A. C. 2000. THE PRIVATE COMPANY DISCOUNT. *Journal of Applied Corporate Finance,* 12, 94-101.

KOR, Y. Y. & MAHONEY, J. T. 2004. Edith Penrose's (1959) Contributions to the Resource-based View of Strategic Management. *Journal of Management Studies,* 41, 183-191.

LANDSTRÖM, H. 2007. *Handbook of research on venture capital*, Edward Elgar Publishing.

LARSON, A. 1992. Network dyads in entrepreneurial settings: A study of the governance of exchange relationships. *Administrative science quarterly*, 76-104.

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.

LEMKE, K. W. 1966. Asset Valuation and Income Theory. *The Accounting Review,* 41, 32-41.

LINTON, J. D. & WALSH, S. T. 2008. Acceleration and extension of opportunity recognition for nanotechnologies and other emerging technologies. *International Small Business Journal,* 26, 83-99.

LIU, J., NISSIM, D. & THOMAS, J. 2002. Equity Valuation Using Multiples. *Journal of Accounting Research,* 40, 135-172.

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.

MACMILLAN, I. C., SIEGEL, R. & NARASIMHA, P. S. 1986. Criteria used by venture capitalists to evaluate new venture proposals. *Journal of Business venturing,* 1, 119-128.

MAHONEY, J. T. & PANDIAN, J. R. 1992. The resource‐based view within the conversation of strategic management. *Strategic management journal,* 13, 363-380.

MAINE, E. 2008. Radical innovation through internal corporate venturing: Degussa's commercialization of nanomaterials. *R&d Management,* 38, 359-371.

MALERBA, F. & ORSENIGO, L. 1993. Technological regimes and firm bebavior. *Industrial and corporate change,* 2, 45-71.

MARION, T. J., DUNLAP, D. R. & FRIAR, J. H. 2012. The university entrepreneur: a census and survey of attributes and outcomes. *R&D Management,* 42, 401-419.

MILLER, D. 2003. An asymmetry‐based view of advantage: towards an attainable sustainability. *Strategic management journal,* 24, 961-976.

MURRAY, G. C. & LOTT, J. 1995. Have UK venture capitalists a bias against investment in new technology-based firms? *Research Policy,* 24, 283-299.

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.

NECK, H. M., MEYER, G. D., COHEN, B. & CORBETT, A. C. 2004. An entrepreneurial system view of new venture creation. *Journal of Small Business Management,* 42, 190-208.

NELSEN, L. L. 1991. The lifeblood of biotechnology: University-industry technology transfer. *The business of* *biotechnology: from the bench to the street*, 39-75.

O'SHEA, R. P., CHUGH, H. & ALLEN, T. J. 2008. Determinants and consequences of university spinoff activity: a conceptual framework. *The Journal of Technology Transfer,* 33, 653-666.

PARR, R. L. & SMITH, G. V. 2005. *Intellectual Property: Valuation, Exploitation, and Infringement Damages*, Wiley.

PAVITT, K. 1984. Sectoral patterns of technical change: towards a taxonomy and a theory. *Research policy,* 13, 343-373.

PETITT, B. & FERRIS, K. R. 2013. *Valuation for mergers and acquisitions*, Pearson Education.

PISANO, G. P. & TEECE, D. 1989. Collaborative Arrangements and Global Technology Strategy: Some Evidence from the Telecommunications Equipment Industry. *Research on Technological Innovation, Management, and Policy,* 4.

POWERS, J. B. & MCDOUGALL, P. P. 2005. University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship. *Journal of Business Venturing,* 20, 291-311.

PRESSMAN, L. 2002. AUTM Licensing Survey: FY 2001. Northbrook, IL: Association of University Technology Managers.

QUINDLEN, R. 2000. *Confessions of a venture capitalist: inside the high-stakes world of start-up financing*, Hachette Digital, Inc.

RAPPERT, B., WEBSTER, A. & CHARLES, D. 1999. Making sense of diversity and reluctance: academic–industrial relations and intellectual property. *Research policy,* 28, 873-890.

RASMUSSEN, E., BORLAUG, S. B. & BULANOVA, O. 2013. Verdiskaping i forskningsbaserte selskaper og lisenser støttet av FORNY-programmet.

ROTHAERMEL, F. T., AGUNG, S. D. & JIANG, L. 2007. University entrepreneurship: a taxonomy of the literature. *Industrial and corporate change,* 16, 691-791.

SAHLMAN, W. A. 1990. The structure and governance of venture-capital organizations. *Journal of financial economics,* 27, 473-521.

SANDERS, W. G. & BOIVIE, S. 2004. Sorting things out: valuation of new firms in uncertain markets. *Strategic Management Journal,* 25, 167-186.

SCHUMPETER, J. 1928. The instability of capitalism. *The economic journal*, 361-386.

SEPPÄ, T. J. & LAAMANEN, T. 2001. Valuation of venture capital investments: empirical evidence. *R&D Management,* 31, 215-230.

SHANE, S. 2004. *Academic entrepreneurship: University spinoffs and wealth creation*, Edward Elgar Publishing.

SHANE, S. & CABLE, D. 2002. Network Ties, Reputation, and the Financing of New Ventures. *Management Science,* 48, 364-381.

SOUDER, W. E. 1987. *Managing new product innovations*, Lexington books Lexington, MA.

STUART, T. E. 1998. Network positions and propensities to collaborate: An investigation of strategic alliance formation in a high-technology industry. *Administrative Science Quarterly*, 668-698.

STUART, T. E., HOANG, H. & HYBELS, R. C. 1999. Interorganizational endorsements and the performance of entrepreneurial ventures. *Administrative science quarterly,* 44, 315-349.

SÆTRE, A. S., ATKINSON, O. T. & ELLERÅS, B. 2006. University spin-offs as technology commercialization: a comparative study between Norway, Sweden and the UnitedStates. Trondheim: NTNU, Department of Industrial Economics and Technology Management.

TIMMONS, J. A. & SPINELLI, S. 2004. *New venture creation: entrepreneurship for the 21st century*, McGraw-Hill/Irwin.

TUSHMAN, M. L. & ANDERSON, P. 1986. Technological discontinuities and organizational environments. *Administrative science quarterly*, 439-465.

TYEBJEE, T. T. & BRUNO, A. V. 1984. A model of venture capitalist investment activity. *Management science,* 30, 1051-1066.

UTTERBACK, J. M. 1996. *Mastering the dynamics of innovation*, Harvard Business Press.

VENKATARAMAN, S. 1997. The distinctive domain of entrepreneurship research. *Advances in entrepreneurship, firm emergence and growth,* 3, 119-138.

VISINTIN, F. & PITTINO, D. 2014. Founding team composition and early performance of university—Based spin-off companies. *Technovation,* 34, 31-43.

VOHORA, A., LOCKETT, A. & WRIGHT, M. Critical junctures in the growth in university high-tech spinout companies. Conference paper at Frontiers of Entrepreneurship Research, University of Colorado, 2002.

VOHORA, A., WRIGHT, M. & LOCKETT, A. 2004. Critical junctures in the development of university high-tech spinout companies. *Research policy,* 33, 147-175.

WERNERFELT, B. 1984. A resource‐based view of the firm. *Strategic management journal,* 5, 171-180.

WESTHEAD, P., WRIGHT, M. & UCBASARAN, D. 2001. The internationalization of new and small firms: A resource-based view. *Journal of Business Venturing,* 16, 333-358.

WIDDING, L. O., MATHISEN, M. T. & MADSEN, O. 2009. University-affiliated venture capital funds: Funding of university spin-off companies. *International Journal of Technology Transfer and Commercialisation,* 8, 229-245.

WIEWEL, W. & HUNTER, A. 1985. The interorganizational network as a resource: A comparative case study on organizational genesis. *Administrative Science Quarterly*, 482-496.

WRIGHT, M. 2014. Academic entrepreneurship, technology transfer and society: where next? *The Journal of Technology Transfer,* 39, 322-334.

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

WRIGHT ROBBIE, M. K. 1998. Venture Capital and Private Equity: A Review and Synthesis. *Journal of Business Finance & Accounting,* 25, 521-570.

ZAHRA, S. A. & BOGNER, W. C. 2000. Technology strategy and software new ventures' performance: exploring the moderating effect of the competitive environment. *Journal of business venturing,* 15, 135-173.

ZIDER, B. 1998. How venture capital works. *Harvard business review,* 76, 131-139.

Resource-based Equity Valuation of University Spin-off Companies: An Empirical Study

Arif M. Mirza, Ole Rønning

Abstract

Company valuation is a critical aspect in any deal concerning funding to new ventures. However, valuing an early-stage university spin-off (USO) using traditional valuation methods from corporate finance is an inherently difficult task. These are companies spun out of universities, often with a basis in early-stage and radical technologies which provide significant technical advances. These technological characteristics lead to high fundamental uncertainty, which makes it difficult to reliably apply valuation methods such as cash flow discounting or relative valuation. This is believed to be one of the reasons these companies struggle to receive financing in their critical early stages. This study leverages research from strategic management in a valuation perspective, and develops a conceptual valuation framework based on inputs (e.g. resources) rather than financial outputs (e.g. cash flows, balance sheets etc.). To test the framework, six hypotheses about the relationship between initial resource endowments and the long term equity value of an USO are developed with a basis in existing research on resource-performance. A sample of 63 Norwegian USOs are used to develop an empirical model to test the hypotheses. It is found that the degree of heterogeneity in the founding teams educational backgrounds and previous work experiences, the quality of the parent university, and the number of filed and published patents in the early stages of a USO are all positively related to its long term equity value. It is followingly argued that USOs who, ceteris paribus, exhibit these resource characteristics in their early stages should receive higher valuations than those that do not. Further on, a valuation framework based on resources as inputs shows promise, however significant future research is required to develop such a tool.

Introduction

Valuation is a central part in deciding whether one should invest in a company or not (Keeley et al., 1996). For venture capitalists, valuation is important because it determines the proportion of shares they receive in return for their investments, guides the overall profitability of their fund and thus also affects their relationship with their fund providers (Miloud et al., 2012). For entrepreneurs, the valuation is important because it sets a value on the efforts and resources they have put into the new venture, and the portion of the firm they must give up to obtain external financing. It has also been shown that fair valuation aligns the ambition of both the investor and entrepreneur, and that it helps to structure the deal between the two through the identification of reasonable financing terms (De Clercq et al., 2006).

Valuing a young venture is however known to be an inherently difficult task (Timmons and Spinelli, 2004; Damodaran, 2009), and valuing an early-stage university spin-off (USO) even harder. Widding et al. (2009) state that high levels of uncertainty and capital requirements in these companies result in investors not having sufficient information to find suitable terms for funding. Mirza and Rønning (2015), examining the applicability of traditional valuation methods on early-stage USOs, conclude that the early stage, the radicalness, and the significant technical advancements offered by the technologies these companies are founded on lead to high fundamental uncertainty, and followingly that valuing a USO using one of the three most common valuation methods, i.e. cash flow discounting, balance sheet and income statement, is infeasible. The infeasibility of these methods can in large be attributed to the lack of operational history necessary to apply them. The outputs that these methods are dependent on, such as cash flows and balance sheets, are non existent for a USO in its early stages, and further on, because of high fundamental uncertainty, they are impossible to reliably estimate. Moreover, as Mirza and Rønning (2015) shows, the common method of applying discount rates as high as 80% to hedge against this uncertainty results in almost all early-stage USOs being categorized as unprofitable investments. These valuation issues are likely to be more prevalent in USOs founded on technology, which require more capital, rather than knowledge (i.e. consultancy companies). Following Mirza and Rønning (2015), we therefore define early stage USOs as companies that involve transfer of intellectual property rights to the new venture, and that are either developed by faculty members based on their own research, or created specifically to capitalize on academic research (Shane, 2001; Colombo et al., 2010; Long, 2002). As for their early stage nature we assume them to be in the opportunity framing phase in Vohora et al. (2002) five phase development model, which is where USOs first face the issue of raising capital.

In the absence of the financial outputs necessary to apply existing valuation methods, following in the footsteps of Ge et al. (2005), we propose to leverage theories within strategic management that help predict and explain firm performance to value a company in its early stages. While traditional corporate finance has focused on the use of cash flows and returns, fields within strategic management have focused on the conditions under which superior returns can be achieved (Barney et al., 2001; Kor and Mahoney, 2004; Scherer and Ross, 1990), and the latter should therefore in theory be suited to identify variables important for valuation when the former cannot be measured. Indeed, when it is difficult to value a company based on outputs (cash flows etc.), a method based on inputs (resources, founder characteristics, network etc.) that can be objectively measured may prove more satisfactory (Ge et al., 2005).

Within the research on USOs, links between initial resource endowments and subsequent performance has received notable attention (Rasmussen et al., 2012). Based on this research the authors investigate whether these initial resource endowments can be used as predictors in the early stages of a USO for what the long term value of the firm will be, and as such lay the foundation for a resource-based valuation framework. It is not the goal of the authors to develop an entire valuation framework. Rather we seek to investigate its feasibility, and develop a conceptual framework to lay the stepping stone for future research on the topic. This study, which to our knowledge is the first of its kind, aims to bring the research on university spin-off performance and equity valuation together. We review existing literature and develop an analytical model to investigate the following research question:

> **RQ**: How can initial resource endowments be used to assess the early-stage value of a USO?

The above research question can further be justified by two important reasons. First, USOs are ventures that require significant amounts of capital in their early stages (Shane, 2004; Clarysse and Bruneel, 2007; Neck et al., 2004), but that find it difficult to acquire the sufficient amount of funding. This is partially due to the long development times associated with USOs (Shane, 2004; Rasmussen et al., 2012), where investors prefer a short time to market, as well as investors not being able to adequately assess the value of the companies due to uncertainty. Through this study the authors therefore hope to establish the initial theoretical linkages for developing a valuation framework with which investors can adequately assess the value of early-stage USOs, and thereby reduce the financing gap these companies experience (Shane, 2004).

Second, USOs, when successful, generate significant economic value (Shane, 2004), and the authors believe that better valuation methods may not only lead to increased flow of financing as well as more appropriate funding terms for these firms, but also greater wealth creation in society. Bonardo et al. (2011), for example, found that one-fourth of the high-tech SMEs that went public in Europe during the period 1995-2003 were USOs, and concludes that university-based firms represent a significant contribution to European financial markets.

This study is divided into five parts, where this introduction constitutes the first part. In the second part we develop hypotheses with a basis in resource-based theory and resource-performance relationships highlighted in existing research streams. In the third part we present the analytical methodology employed to test our hypotheses, and finally in part four we present and discuss our results and finish off with implications and areas for future research in part five.

Theoretical Framework and Hypotheses

Mirza and Rønning (2015) find that high fundamental uncertainty in USOs makes it

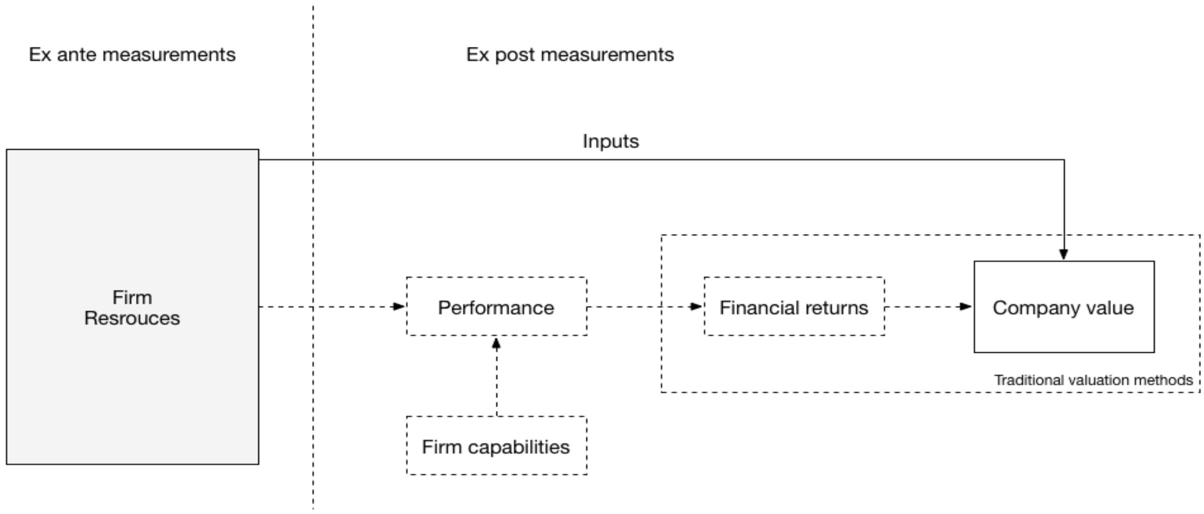


Figure 1. *Conceptual framework*

difficult to reliably forecast financial outputs, which renders traditional valuation methods difficult to apply. The authors argue that the forecasting process can in its simplest form be broken down to a problem of making an assessment under uncertainty, and from cognitive psychology it is known that to cope with such uncertainty, heuristics are commonly applied (Gigerenzer et al., 2011). Heuristics are efficient cognitive processes, or mental shortcuts, used to make decisions without assessing all the necessary information one would want to make an optimal decision, and research on the use of heuristics has in fact shown that they can lead to more accurate judgments than weighing and analyzing information in an uncertain situation (Gigerenzer and Gaissmaier, 2011). Gigerenzer et al. (2011) write that heuristics exploit the information structure of the environment, and that they in a world full of uncertainties and surprises often lead to more accurate assessments than complex methods.

In the context of valuation, instead of calculating highly uncertain cash flows, or estimating probabilities that are impossible to estimate, it then seems logical to cope with uncertainty in the same manner, and value early-stage USOs by applying heuristics. To identify such heuristics, it becomes necessary to look towards theories from strategic management that help predict firm performance, i.e. theories that can be used to ex ante assess the performance, and subsequently the value, of a USO. There are especially two such theories that have received notable attention, namely the resource-based perspective, which views a firm as a bundle of resources that ultimately drives performance (Penrose, 1959), and the Industrial Organization perspective, which emphasizes external forces and the structure of the market as the driver of performance (Porter, 1981). The authors argue that the former of these is best suited in the context of valuing early-stage USOs. Whilst the latter is dependent on many factors outside the new ventures control and can rapidly change, resources define and distinguish a company from others (Miller, 2003; Penrose, 1995), are objectively measurable despite uncertainty, and help explain superior firm performance (Kor and Mahoney, 2004). As Barney (1991) writes, resources that are valuable, rare, inimitable and nonsubstitutable (VRIN) have the potential to create sustained competitive advantages, if the company has the necessary capabilities to utilize them in a value-creating manner (Mahoney and Pandian, 1992; Alvarez and Busenitz, 2001; Brush et al., 2001). Theoretically speaking then, a firm with certain resources, when utilized the right way, should, ceteris paribus, perform better than firms that do not have the same resources because of their competitive advantages. These advantages should lead to higher financial returns, and subsequently higher firm values. A firm that exhibits these resources in its early stages should followingly be valued higher than a firm that does not. The obvious limitation to this approach is that the performance impact of resources are dependent on the USOs capability to utilize them (Barney and Clark, 2007; Mahoney and Pandian, 1992), however, this is difficult to measure ex ante. For the purpose of this study, and in the context of valuation, the closest proxy is then whether the resource is available to the firm or not. These reflections lead us to develop the conceptual framework presented in figure 1, where resources are used as valuation inputs rather than financial data. Whilst traditional valuation methods emphasize the use of financial returns as inputs, our conceptual framework leverages the fundamental drivers of these returns, namely resources. Moreover, resources are ex ante measurements which can be used in even the early stages of a USO, whilst financial returns are ex post measurements and therefore more applicable to mature ventures. As can be seen, the performance of the firm, and subsequently the financial returns, are also dependent on the company's capabilities to utilize the resources. However, this input is not available ex ante.

To test the conceptual framework empirically, we present in the following resource-performance relationships in USOs identified by previous researchers, and use this to hypothesize relationships between initial resource endowments, and the long term equity value of a firm. We further on argue that resources with a proven relationship to a USOs long term equity value can be used as heuristics in the early stages of a USO to predict its early stage value. We build upon the resource-based theory presented by Mirza and Rønning (2015), and structure our discussion in accordance with (Mustar et al., 2006), who find that the four resource categories human, social, financial, and, technology, are especially important for research-based USOs.

Human Resources

Wright et al. (1994) write that human capital can be valuable, rare, inimitable and non-substitutable, and therefore be the source of sustained competitive advantages. Building on the work of Steffy and Maurer (1988), who state that both the demand of labor and the supply of labor is heterogeneous, i.e. that companies require different skills, and that individuals differ in the skills they possess, they argue that individuals contribute differently to a firm, and human capital can therefore create value. It is also generally a consensus amongst researchers that higher quality human resources lead to higher financial value for firms (Boudreau, 1983; Boudreau and Berger, 1985). Wright et al. (1994) go on to write that human capital can indeed be rare, if one proxies the quality of human capital by cognitive abilities, and the fact that these cognitive abilities are normally distributed in the population (Jensen, 1980). Inimitability arises due to unique historical conditions, causal ambiguity and social complexity, which complicate the process of duplicating relevant components of the human capital resource pool and the circumstances under which these resources function. Lastly, Wright et al. (1994) argue that human resources are non-substitutable because they are generalizable, i.e. can constantly be developed to ensure that they do not become obsolete, and therefore the only resources that can substitute them are themselves rare, valuable, inimitable, and non-substitutable.

In the context of new technology ventures, human capital in terms of entrepreneurial roles and capabilities is generally highlighted as a key resource (Colombo and Grilli, 2010; Newbert, 2007), and in early stage USOs, which often have scarce initial resources, human capital in terms of founders and their experience is one of the most important resources the new venture has (Shane and Stuart, 2002; Shane, 2004; Colombo and Piva, 2012). Particularly inventor presence and the diversity in the founding teams background and experience are highlighted as two important human capital factors impacting firm performance.

USOs are usually formed around a technology at embryonic stages (Agarwal and Shah, 2014), and knowledge to develop, modify or tailor the technology and associated products or services to meet customer requirements is essential for startup success (Di Gregorio and Shane, 2003; Zucker et al., 1998; Knockaert et al., 2011). This knowledge is highly tacit, and is typically embodied in the technology inventor (Clarysse et al., 2007; Markman et al., 2008; Wright et al., 1994). Due to the difficulty in communicating tacit knowledge (Polanyi, 2012), the inventor is an important asset to exploit the technology, and numerous studies have highlighted the importance of inventor presence in the new venture founding team to achieve high firm performance (Olofsson and Wahlbin, 1984; Roberts and Hauptman, 1986; Hess and Rothaermel, 2012; Zucker et al., 2002). Olofsson and Wahlbin (1984) and Djokovic and Souitaris (2008) find that the USOs with the highest growth rates are the companies that involve academics who leave the university, and Roberts and Hauptman (1986) argue that the advantage of keeping academics close to the new venture is due to increased effectiveness of the technology transfer process. This is supported by several scholars (Hess and Rothaermel, 2012; Zucker et al., 2002). Knockaert et al. (2010) found that in USOs, where the majority of the initial researchers became a part of the founding team, the tacit knowledge was transferred effectively and at a sufficient speed, which resulted in higher valuations of the firm shares. This leads them to conclude that the greater the proportion of the research team that joins the USO as founders, the greater the performance. Based on these findings we hypothesize:

> ***H_{1a}***: *Ceteris paribus, USOs who in their early stages have the technology inventors on the founding team achieve higher long term equity valuations than those that do not.*

The performance impact of inventors in founding teams is further found to be affected by how renowned the inventor is. USOs that are founded on the research of a "star" researcher or have a "star" on the founding team can benefit from the researcher's reputation. Stars have a strong ability to send a credible signal about unobserved quality of the new venture to external actors (Spence and Michael, 1974). Fuller and Rothaermel (2012), examining 238 USOs in the United States, find that new ventures with star scientists are more likely to achieve IPOs, and Higgins et al. (2011) find that USOs with star researchers achieve higher IPO valuations. Zucker et al. (1998), examining the biotechnology sector, show that star scientists have a direct effect on time to IPO and amount of money obtained at IPO. These findings indicate that the renownedness of the inventor within her field is related to the USOs performance, and subsequently the long term value of the firm. This is primarily due to three reasons: first, the more renowned the inventor is within her field, the more likely it is that the research underlying the technology is cutting edge and of high quality. Second, more renowned inventors have more to lose if they are unsuccessful in starting a new venture due to the reputational impacts. Therefore, the fact that she is willing to bet on the technology sends a strong signal about its quality (Fuller and Rothaermel, 2012), and should ease the process of obtaining funding and establishing partnerships and alliances, which ultimately should increase firm growth. Third, the more renowned the inventor is, the easier it should be to attract additional human resources, particularly technological human resources because of aspiring talent wishing to work with her. This leads us to the following hypothesis:

> ***H_{1b}***: *Ceteris paribus, USOs who in their early stages have more renowned inventors on the founding team achieve higher equity valuations in the long term than those that do not.*

However important the presence of the technology inventors, spinning off a company with people exclusively from the parent university can have negative effects on performance, and an effective combination of top management team with both business and engineering knowledge and experience, is a common denominator for USO performance and successful ventures (Gurdon and Samsom, 2010; Roberts, 1991; Doutriaux and Barker, 1995; Visintin and Pittino, 2014; Heirman and Clarysse, 2004). Shane (2004) writes that it is important for the founding team to have knowledge about business, management, product development, production and markets. Grandi and Grimaldi (2005) conclude that successful academic ventures are dependent on founding teams that combine individuals with different attitudes, which increases interaction and communication within the founding team, as well as the allocation of work tasks based on personal attitudes. Further, they write that academic entrepreneurs should devote time to choosing team members that have different characteristics and are able to take on different roles (Grandi and Grimaldi, 2005). Thus, at least in the startup phase, it is vital to create differentiated team structures where members have both research and business profiles (Visintin and Pittino, 2014) because the team is then better able to adjust to the complex environmental challenges with which they are confronted (Wright et al., 2012). Knockaert et al. (2011) find that it is important for USOs to also have a commercial mindset to be alert to external market movements, and they conclude that incorporating knowledge about the technology and a commercial mindset in the USOs founding team leads to enhanced performance. It logically follows then, that USOs that are able to diversify in educational backgrounds and previous work experiences in the founding team should perform better, and subsequently achieve higher valuations than those that do not.

Being more specific, Rothaermel et al. (2007) write that experience, capabilities, and knowledge from the industry are critical factors to the success of a spin-off, yet many, if not most, management teams lack these capabilities, negatively affecting their ability to recruit new employees and attract early stage capital (Clarysse and Moray, 2004; O'Shea et al., 2005; Hayter, 2013). In agreement, Shane and Stuart (2002) find that industry experience is significantly related to time-to-IPO. Finally, Criaco et al. (2013) show that founders with entrepreneurial education and university experience in terms of research and teaching positively affect firm survival. We hypothesize:

> ***H_2**: Ceteris paribus, USOs who in their early stages have founding teams that are more heterogeneous in educational backgrounds and work experiences achieve higher equity valuations in the long term than those with more homogeneous founding teams.*

Social Resources

It is generally agreed upon that a high level of social capital, in terms of personal relationships, often assist in providing access to venture capitalists, business information and potential customers (Florin et al., 2003), and the social capital of founders has therefore been noted in entrepreneurship literature to have several positive impacts on new ventures. Social resources can be valuable because they can provide access to information and advice (Hoang and Antoncic, 2003), key talent and market information (Freeman, 1999), and as Brush et al. (2001) writes, social resources can be used to create an image of success that can be leveraged to obtain other benefits, such as cooperation and trust, financial resources, or assets and equipment purchased at less expensive prices. Social resources can for obvious reasons be rare as relationships to more prominent entities are more difficult to obtain. Inimitability is likely due to relationships being built over time and being path dependent (Zander and Zander, 2005; Santala and Parvinen, 2007). Finally, social resources can be non-substitutable due to each entity in the relationship being unique in terms of experiences, resources, and networks.

In entrepreneurship literature, social ties of founders are shown to reduce informational asymmetries between founders and potential investors and partners (Shane and Cable, 2002), and resources made available through entrepreneurial networks are shown to greatly enhance the survival and growth of new firms (Brüderl et al., 1992). In new high-tech firms, who are generally believed to have higher informational asymmetries, social ties are especially acknowledged to be critically important (Bidault and Cummings, 1994; Stuart, 2000).

Walter et al. (2006), examining the impact of USOs ability to develop and utilize inter-organizational relationships, highlight relationships to research institutions, legal authorities, customers, and suppliers as particularly important to attain growth due to lacking internal markets and industry knowledge amongst founders. They argue that these relationships allow the USO to target a larger market in less time, learn about customers to develop marketable offerings, and ensure timely and state-of-the-art resources. Followingly they find that sales growth, profit attainment, realized competitive advantages, and long-term survival are influenced by a USOs ability to develop external relationships

Ties to the parent university are particularly highlighted in previous research as important for USO performance. Rothaermel and Thursby (2005) write that USOs with strong ties to their parent organization are less likely to fail. Colombo and Grilli (2010) find that universities influence the growth rates of local USOs, and Bonardo et al. (2011) state that for firms that have chosen to go public, the ones that publicize that they are a university spinoff experience that their origins are beneficial, and that university affiliation is positively recognized by investors through enhanced valuations. University affiliation also enhances the acquisition attractiveness to other companies, and the advantage of the affiliation is correlated with the presence of academics in the top management team (Bonardo et al., 2011). A strong affiliation between the USO and its parent university is further likely to be valuable because the parent can provide access to resources such as talent and critical financial resources (Bigliardi et al., 2013), knowledge and complementary R&D (Lubik et al., 2013), labs, and expensive equipment at low cost (Starr and MacMillan, 1990; Roberts and Malonet, 1996). We therefore hypothesize:

> ***H_{3a}**: Ceteris paribus, USOs who in their early stages have strong ties to the parent university achieve higher long term equity valuations than those with weak ties.*

The performance effect of having strong ties to the parent university is further found to be dependent on the quality of the university. Colombo and Grilli (2010) state that the quality of the research conducted at the university has a positive impact on the growth rate of the spin off, establishing a theoretical link between university quality and USO performance. Powers and McDougall (2005) write that access to people with expert knowledge and talent is a critical human capital resource needed for the development of cutting-edge technology, which are more likely to be present in more renowned universities, and finds that faculty quality impacts the number of USOs from the university that go public. Further on, Di Gregorio and Shane (2003) suggest that it is easier for academics at high ranked universities to get funding for their startups due to their increased credibility. In support, O'Shea et al. (2005) conclude that the presence of top ranked science and engineering students and faculty is positively correlated with USO performance. We therefore hypothesize:

> ***H_{3b}**: Ceteris paribus, USOs originating from high quality universities achieve higher equity valuations in the long term than those originating from lower quality universities.*

Financial Resources

Due to the early stages of the technologies on which many USOs are founded, the development process is long (Rasmussen et al., 2013) and resource demanding (Shane, 2004; Clarysse et al., 2011), and access to financial resources is typically seen as the most important factor for USO growth (Hellman and Puri, 2000; Heirman and Clarysse, 2004; Shane and Stuart, 2002; Clarysse et al., 2011). Financial resources are obviously valuable, as they enable the firm to acquire necessary resources, and can also be rare, because the demand is larger than the supply. However, financial resources are neither inimitable nor non-substitutable, and can therefore not on their own be a source of achieving sustained competitive advantages. They do however enable the firm to acquire other resources that are VRIN, and can therefore from a resource-based perspective indirectly be tied to performance.

Gurdon and Samsom (2010), interviewing 22 US and Canadian USOs find that access to capital was a common denominator amongst the successful ventures, and Hayter (2013) argues that USOs that receive venture capital have a 20% to 26% higher likelihood of commercialization success compared with USOs that do not. In support, Zerbinati et al. (2012), measuring performance in terms of employment growth, find that the higher the amount of capital a USO attracts in its early stages, the higher is the annual employment growth of the new venture, and conclude that initial capital invested in USOs is a major predictor for early growth. Further on, initial capital invested in USOs is tied to the ability to raise capital later in the startup process, which is identified as the single most important factor for achieving an IPO (Hayter, 2013; Clarysse et al., 2011). We followingly propose:

> ***H_4**: Ceteris paribus, USOs that receive investor capital in their early stages achieve higher equity valuations in the long term than those that do not.*

It is important to note here the inherent reverse causality of capital on firm valuation. It is obvious that raising capital will increase the value of a firm equivalent to the amount of capital raised, known as pre-money and post-money valuations. The authors however argue that this is not equivalent to increasing the long-term value of the firm, where the actual utilization of the capital will be the determining factor, which is the relationship this study investigates. Reverse causality followingly does not bias the hypothesis.

Technical Resources

Shane and Stuart (2002), following Merges and Nelson (1990), argue that the strength of a USO’s technological endowments at founding is an important predictor of its subsequent performance because these companies do not have complementary assets in place. From a venture capitalist standpoint, Knockaert et al. (2006) show that strong technology endowments and intellectual property protection are valued when deciding to invest in high-tech startups. Pérez Pérez and Sánchez (2003) summarize by stating that at least initially, USO success is more dependent on technological development (i.e. strong technological resources) than marketing, sales, and distribution.

From a resource-based perspective, technological resources can indeed lead to sustained competitive advantages. The resources can be valuable as they enable a firm to conceive of or implement strategies that improve its efficiency and effectiveness (Barney, 1991). They can be rare in terms of the resources being uniquely owned by the firm, through for example intellectual property rights. Inimitable because of intellectual property rights, or in the case of physical technology, the exploitation may involve socially complex resources where only

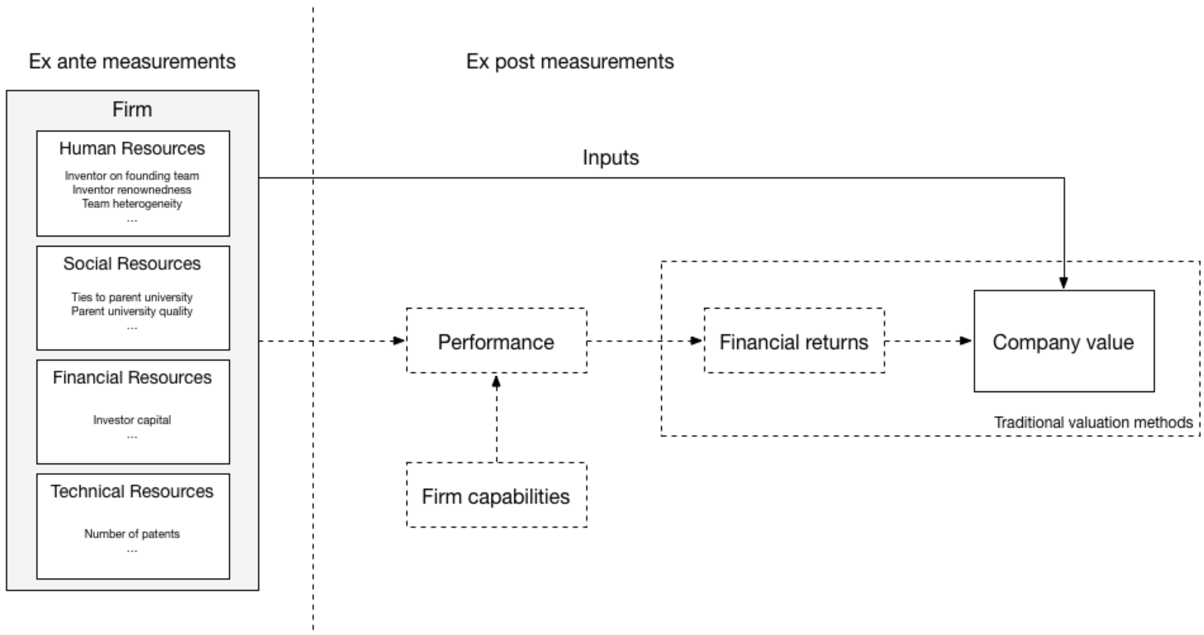


Figure 2. *Conceptual framework*

firms that possess the necessary culture, traditions and social relations can fully exploit the technology (Wilkins, 1989). Further on, Narayanan (2000) characterize the knowledge underlying the endowed technology along three dimensions: scope, newness, and tacitness. The latter of these, i.e. a high degree of tacitness, can make imitation difficult. The two former can lead to non-substitutability, where broad technological scopes in terms of platform applications, and newness in terms of the degree with which the innovation departures from existing technologies (Bierly et al., 2009), can make the technology difficult to substitute.

Investigating patents as technological resources, previous research indicates they can be a valuable organizational resource for competitive advantage, and predictive of firm performance (e.g., Deeds et al. (2000), Zahra and Bogner (2000), Powers and McDougall (2005)). A rational inventor is only likely to patent an invention when the expected payoff from holding the patent outways the cost of obtaining it (Long, 2002). Followingly, patents have important signaling effects towards external resource holders, where more patents signal higher expected returns. Further on, Hsu and Ziedonis (2008) for example finds that patents act as signals towards investors for the venture's quality when they need it most, namely in the early stages of development when uncertainty is at its largest.

In the context of USOs, Shane and Stuart (2002) establish a linkage between patents and performance, arguing that that the larger the number of patents held by a USO at the time of founding, the smaller the chance of failure. Kamiyama and Sheehan (2006) see that firms increasingly are exploiting their patents as a means of tapping into external sources of financing. Ownership of patents can demonstrate to potential investors that a small firm has a novel invention with which it may be able to differentiate its products or services from those of its competitors, as well as the legal means to prevent competitors from implementing their invention in the marketplace. Supporting this, Clarysse et al. (2007) find that the perceived quality of the endowed technology of the USO, measured in number of patents, enable larger amounts of startup capital to be obtained. Thus, because patents can play a large role in enabling firms to attract venture capital investments, they can also affect firm performance, as funding is seen as an important factor for achieving new venture success (Zerbinati et al., 2012; Hellman and Puri, 2000). Therefore we propose:

> ***H_5:*** *Ceteris Paribus, USOs with more patents in their early stages achieve higher equity valuations in the long term than those with less patents.*

The above discussion can be summarized in the conceptual framework presented in figure 2.

Research Methodology

To test the developed hypotheses we employ a cross-sectional quantitative method. More specifically, we use multiple linear regression.

Data Sources and Case Selection

The sample we analyze comprises of 63 firms from the Enter research project which uses the Norwegian FORNY program as its empirical context. Established in 1995, FORNY is a program initiated by The Research Council of Norway to commercialize results from publicly financed research institutions (Rasmussen et al., 2013), with a general objective being to increase wealth creation in Norway (Borlaug and STEP, 2009). EntPro is a project initiated to follow the development of the companies in the FORNY portfolio, which as of mid 2013 consisted of 474 science-based companies (Rasmussen et al., 2013). Due to financial incentives for registering a firm in the program as well as legislative change in Norway in 2003 that, similar to the Bayh-Dole Act of 1980 in the US, grants intellectual property rights to the parent institution instead of the individual researcher, it is reasonable to say that the EntPro database covers the majority of the population of science-based firms in Norway established after 2000. This eliminates sampling biases in our study which are common in entrepreneurial research (Short et al., 2010; Mullen et al., 2009). The database consists of business plans, corporate announcements from the Norwegian business registry, annual reports, news articles, survey data and context-level data on institutional factors. Further on, this data has for the majority of the USOs in the database been structured and coded into a standardized template by a prior research group, as a part of a larger research project between NTNU and Bodø Business School. A great strength in using the EntPro database as a primary source of data is that companies that are no longer in official registers are still in the EntPro database, which eliminates survival bias in our sample.

Seen on an international scale, the EntPro database provides a vast amount of unique data on the USOs in our sample. To supplement this, additional data was collected through online sources. For example, information about the founding team was missing in many business plans, patent information was rarely mentioned, and the latest annual reports where sometimes not available. To retrieve the missing information we used Proff[1] to retrieve financial information, Google Patents for patent information, Google Citations for citation rates, and LinkedIn as well as university websites for information about founders.

The sample of 63 firms was identified through a funneling process. First, because the EntPro database covers the entire population of science-based firms, all firms not originating at a university and not adhering to the definition of USOs used in this paper were excluded. Thereafter, we limited our sample to companies established between 2000 and 2005. This is due to data being insufficient for companies established in 1999 or earlier, and research indicating that USOs take an average of 10 years to commercialize their technology (Rasmussen et al., 2013; Lawton Smith and Ho, 2006). By limiting our sample to companies that have been active at least a certain number of years, we limit the possible bias from including companies that have not come far enough in the commercialization process to be valued properly, and therefore receive erroneous valuations.

After this first step, a total of 72 firms were left in the sample. To retrieve and structure relevant data for our specific research, a codebook was developed where all relevant variables where operationalized into objective measures. This resulted in a total of 65 variables, and the final variable codebook can be found in the appendix[2]. The coding scheme was reviewed with a senior researcher[3] at NTNU to ensure its validity. Each USO was coded by a single researcher on the team to ensure internal coding reliability in each observation, and subsequently saved in a master template containing all the USOs. To reduce possible bias from not having several researchers assess the same venture, the researchers together developed a set of coding criteria for each variable. The coding was conducted in two phases. First, information in the EntPro database was reviewed. In phase two, the missing information was retrieved through additional information sources such as previously mentioned Proff, Google Patents, Google Citations and LinkedIn.

Upon completion of coding the 72 USOs in our sample, 9 USOs were excluded. Five companies were excluded due to difficulties in estimating their values. This was because the companies at

[1] Proff.no is a leading provider of in-debt financial data on Norwegian registered firms.
[2] Appendix 3
[3] PhD-candidate Marius Tuft Mathisen

the time of measurement had not completed their product development, and subsequently had not conducted their first commercial sale. Because these companies had no or low revenues, including these companies in the sample would have resulted in serious valuation errors. Four companies were excluded due to changes in organizational structures that made it impossible to code the original firm and its resources. This left a final sample of 63 firms.

Variable Measurements

When employing a quantitative method, it is necessary to identify relevant variables, relate those variables to the hypothesis in question, and finally use valid and reliable measurements to conduct the analysis (Creswell, 2003). There is no single way to operationalize the variables used in our analysis, however, as far as the availability of data allows it, we follow the established definitions employed in existing research, and acknowledge limitations when that is not possible.

Dependent Variable

This study investigates the relationship between initial resources and firm value, and the dependent variable is followingly firm value. Several limitations, therein access to valuation data as well as the validity of valuations conducted by third parties which are often dependent on contractual terms (Damodaran, 2012), led us to firsthand value each company in our sample. Amongst the three most common valuation methods, the cash flow discounting method requires a greater insight into the company's financials and future growth than what was possible for us to retrieve, whilst valuing the firms using a balance sheet approach would not have included the future profit potential in these firms (Mirza and Rønning, 2015). We therefore opted to use the income statement method relative valuation, also known as the multiples approach. Mirza and Rønning (2015) find that relative valuation is not suitable for early-stage firms. However, as we are assessing the firm values at more mature stages (companies in our sample are founded during or prior to 2005, and the majority of firm values are calculated using data from 2013), one of the major obstacles of lacking financial outputs is removed. Further on, we removed from our sample firms that at the time of measurement had not conducted their first commercial sale to eliminate companies with unrepresentative revenues of normal operations. Although there are several limitations to our measure of firm value, which we return to later in the paper, a great strength is its simplicity. A limited amount of financial data is necessary to apply the method, and it implicitly forecasts future expected cash flows (Baker and Ruback, 1999). Moreover, valuing a mature company using a multiple of an operating or financial measure is a common and popular approach. Using third-party valuations on the other hand, which for private firms are often affected by contractual terms such as vesting of capital and differences in equity claims (Damodaran, 2009), would have biased our dependent variable as we would not be able to identify, and followingly adjust values for, such terms. Lastly it would be difficult to obtain up-to-date valuations on each firm. These limitations restricted our valuation options to relative valuation.

Mirza and Rønning (2015) outline the process of valuing a firm using relative valuation. In this study we use industry multiples to average out the errors that would occur if a multiple from a single comparable firm was used instead. The use of industry classifications to identify multiples is a common practice in valuation research (Liu et al., 2002). The question regarding which specific multiple to use has received a lot of attention in corporate finance, and there seems to be consensus that earnings-multiples perform the best (Liu et al., 2002). However, Damodaran (2012) writes that sales-multiples can be more appropriate when the firm has negative earnings. Further on, many valuation studies focus on enterprise multiples as they ignore the effects of different capital structures by valuing both equity and debt (Deng et al., 2012). Because the companies in our sample are likely to vary in capital structures, we use enterprise value-multiples. Moreover, we use two different scaling factors: in accordance with the established acceptance that earnings-multiples perform better we use EBITDA as a scaling factor on companies that show stable earnings without large extraordinary development expenses. If a company does display such extraordinary expenses, using EBITDA will not be representative of how the company is likely to do financially when the development costs are removed, and using EBITDA as a scaling factor will subsequently result in large valuation errors. In accordance with Damodaran (2012), we use the EV/sales-multiple on these companies instead. A more objective approach would have been to consistently use one specific multiple, or an average of the two, on all companies. However, valuation is a subjective process, and being rigorous on this would likely have resulted in more inaccurate valuations because of the lack of customization. Our process of valuing each firm can be divided into five steps:

Step 1: First, each company was classified as either unsuccessful, still operating, acquired or completed IPO. None of the firms in our sample had completed an IPO, and this category was therefore removed.

Step 2: To retrieve relevant industry multiples, each company in each category was mapped to two industries using industry classifications[4]. Two data sources with different industry classifications were used due to difficulties in placing some of the firms in our sample using only one of the classifications. To assure a good industry match, other companies in the chosen industry were assessed to assure that the core activities matched those of the USO being valued.

Step 3: Each company in each category was thereafter valued at time T, where T represents the earliest point in time an investor could have exited their investment in the USO. For acquired companies, T represents the year the company was acquired. For still operating firms, T represents the year of the latest available annual report.

Table 1 summarizes the valuation method for each category of firms.

Company Status	Definition	Valuation Method
Unsuccessful	1. Company is removed from official business registers and there is no information indicating a merger or aquisition. 2. Company has abondoned original business idea	Firm value set to 0
Still operating	Annual report showing activity and the company has conducted their first commercial sale	Valued using EV/EBITDA or EV/Sales.
Acquired	100% of the company's shares have been bought by another company	Valued equal to the acquisition amount, if available. If not, valued using acquisition or IPO multiples (Price/sales) from similar companies in terms of products or services being sold. The use of multiples to value and acquisition target is used in more than 50% of all acquisitions (Damodaran, 1996).

Table 1. *Valuation method for each category of firms*

Step 4: As previously mentioned, using enterprise-multiples to value a firm results in the enterprise value, which Liu et al. (2002) defines as:

$$
\begin{aligned}
&\mathit{Enterprise\ value} = \\
&\qquad \mathit{Market\ value\ of\ equity} \\
&\qquad + \mathit{book\ value\ of\ debt} \\
&\qquad - (\mathit{cash\ and\ cash\ equivalents})
\end{aligned}
$$

Because we are only interested in the return to a potential investor, the market value of equity for each firm was calculated by subtracting debt in the company from the enterprise value, and subsequently adding in cash and cash equivalents.

$$
\begin{aligned}
&\mathit{Value\ of\ equity} = \\
&\qquad \mathit{Enterprise\ value} \\
&\qquad - \mathit{book\ value\ of\ debt} \\
&\qquad + (\mathit{cash\ and\ cash\ equivalents})
\end{aligned}
$$

Step 5: Because we used public multiples to value the majority of firms in our sample, an illiquidity discount was applied. Compared to public firms, investments in private firms are illiquid because of fewer buyers/sellers and substantial transaction costs when conducting a buy/sale (Damodaran, 2005). Followingly, when valuing equity in a private company based on public company multiples, one should include an illiquidity discount rate. Although illiquidity discounts often are applied as a fixed rate between 25-35%, Damodaran (2005) argues that they are highly firm specific, and although there is no easy way to determine this discount, illiquidity discounts should be adjusted to each firm. Silber (1991) developed an equation[5] to calculate the size of the liquidity discount by analyzing the valuation difference between a company's public and restricted stock. He finds that the illiquidity discount is dependent on the firm’s revenues, the proportion of restricted stock to publically traded stock, if the company has positive earnings, and if there is a customer relationship between the investor and the firm. Although Silber (1991) based his analysis on public firms using restricted stock, Damodaran (2005) points outs that he does provide a roadmap for how to calculate private firm discounts. For the lack of better ways, an illiquidity discount using Silber (1991) equation

[4] Professor Damodaran at Stern University (http://pages.stern.nyu.edu/~adamodar/), as well as Ycharts, an online provider of financial data. Professor Damodaran lists 95 industries, whilst the second data source lists 148.

[5] Appendix 7

was followingly calculated for each firm in our sample and applied to the equity value calculated in the previous step. The final valuation equation used in this study can be summarized as following:

$$V_i = \frac{Equity\ value_i}{Illiquidity\ discount_i}$$

$$Equity\ value_i = Valution\ multiple \times Scaling\ factor - Debt + (Cash\ and\ cash\ equivalents$$

where

Valuation multiple = The multiple used: either EV/EBITDA, EV/Sales or, if acquisition, P/Sales.

Scaling factor = EBITDA or sales in year T for the firm being valued.

$Debt_i$ = Book value of firm i's debt in year T

$(Cash\ \&\ Cash\ equivalents)_i$ = Cash and cash equivalents held by firm i in year T

Independent Variables

The independent variables in our study consist of the resources with which we have hypothesized a relationship to firm value. The variables are measured through proxies, and because we are interested in early-stage predictors of a USOs value, they are measured at the end of the second year of operations. The second year, instead of the first, is chosen to account for differences in time of founding during the first calendar year. Measuring the variables at the end of the second year also limits biases that might occur when companies are registered prior to establishing a proper organization, and that are likely to experience changes in management during the first couple of months. Further on, founding team members are defined as individuals with equity in the new venture.

Inventor on Founding Team (H_{1a})

We use a dummy variable to indicate whether the technology inventor is present in the founding team. The variable is coded 1 if at least one (if there are several) inventor is present in the founding team. This was coded by first identifying the inventor name(s) using the ventures business plan, and subsequently reviewing annual reports to identify if the inventor had an equity stake in the company.

Inventor Renownedness (H_{1b})

Fuller and Rothaermel (2012) proxy the presence of a star inventor by her inclusion in the top one half of one percent of cited scholars in her field. A citation represents evidence that the person being cited has done work that is viewed as relevant to the current research frontier (Jr, 1986). Cole and Cole (1967) argue that citations can be viewed as a form of recognition, and Diamond (1984) that citations can be used as a proxy for a researcher's ability to do quality research. Following this, we use the total number of citations on any article, authored or co-authored by the firm founders, as a proxy for how renowned the inventor is. All founders are included due to difficulties in separating inventors from founders in many of the case firms. For each founder, a "My citations" profile was created in Google Scholar. All articles authored or co-authored by the founders were added to their respective profiles. After adding all articles, each Google Scholar My citations-profile displayed a bar graph with year on the x-axis and the number of citations received that year on the y-axis. For all founders in the firm, all citations up to and including the second year of operations were summed together to a total citation count.

Degree of Heterogeneity in Founding Team (H_2)

Following literature on managerial work behavior and key managerial experiences, backgrounds and skills needed for high performance (Katz, 1974; Kotter, 1982; Whitley, 1989; Hambrick et al., 1996) we focus on common tier 1 positions as well as educational backgrounds and work experiences highlighted as important for performance in USO literature. Founding team heterogeneity is followingly defined in terms of educational backgrounds and work experiences from the industry (Roberts, 1991; Rothaermel et al., 2007; Shane and Stuart, 2002), technical experience (Di Gregorio and Shane, 2003; Zucker et al., 1998; Knockaert et al., 2011), managerial experience (Szilagyi and Schweiger, 1984), entrepreneurial experience (Criaco et al., 2013; Brüderl et al., 1992), financial experience and marketing experience.

A common measure of experience in existing streams of research is to use the number of years of experience the founders have in the field of interest. However, data limitations prohibited us from attaining such detailed information. Instead we follow Shane and Stuart (2002) and Miloud et al. (2012), and use dummy variables. Technological experience is coded 1 if any of the founders have educational backgrounds or work experience related to the technology of the company. Industry experience, marketing experience and finance experience are coded 1 if any of the founders have work experience or an educational background in marketing or finances, respectively. Top management experience is coded 1 if any of the founders have previously held a position in the top two tiers of an organization (Roure and Keeley, 1990; Carpenter and Fredrickson, 2001). That includes positions such as CEO, CFO, CTO, President or Senior Vice President etc. Finally, startup experience is coded 1 if any of the founders have previously started a company. Because we have no theoretical foundation to argue the relative importance of each experience, we make the assumption that they are equally important, and define the degree of heterogeneity as the sum of the dummy variables. To conduct the coding, information about founders educational backgrounds and work experiences was first retrieved from the company's business plans. Missing information was subsequently collected from LinkedIn.

Ties to The Parent University (H_{3a})

There is no single and perfect way to measure the strength of a tie, however, a common and simple proxy for the strength of a social tie is the number of interactions between two people in a given amount of time (Nelson, 1989). Granovetter (1973) expands on this and defines the strength of an interpersonal tie as the linear combination between the amount of time, the emotional intensity, the intimacy and the reciprocal services that characterize each tie. Because such detailed information about the ties between the venture and its parent organization is unavailable to us, we instead use the total number of years the founders have spent at the parent university as a crude proxy. That includes time spent as employee, researcher or PHD-candidate. The rationale being that the longer history a founder has with the parent university, the stronger the founders network is likely to be, and the more the founder is able to draw upon the university's resources.

Quality of Parent University (H_{3b})

Following Di Gregorio and Shane (2003), who proxy university eminence through its ranking published in the Gourman Reports, we proxy the quality of the university through its world ranking published by Webometrics[6], the largest academic ranking of Higher Education Institutions with regards to number of institutions, and the only ranking that covered all the universities in our sample. Webometrics uses link analysis based on a composite indicator that weighs the volume (number of files and pages) of web content, and the impact and visibility of the university's publications in terms of external site citations, to evaluate university quality. A low rank indicates high quality, and to avoid reversed signs in our model, we inverted the rank through the following transformation: 1000/X (1000 instead of 1 is used in the numerator to avoid small fractions being rounded to 0).

Early-Stage Investor Capital (H_4)

Using the data available we were able to identify firms that have received investor capital, however we were only able retrieve the actual investment amounts in 7 of the firms in our sample. Instead of using the actual amount we therefore use the crude proxy of a dummy variable that is coded 1 if the company has received investor capital during the first two years.

Number of Patents (H_5)

Calculated as the total number of patents filed or published during or prior to the first two years of operations where the USO is listed as assignee. To identify relevant patents, business plans were first reviewed for each company. Thereafter, a search on the company name, as well as the inventors, was conducted using Googles patent search engine. Only patents that were filed or published during or prior to the second year of the firm's operations, and where the firm itself was listed as assignee, were included in our results.

Control Variables

There are numerous factors, other than those of primary interest, that can affect the valuation of a company, leading to inflation in the error variance in our model (Mullen et al., 2009). To control for these factors, and reduce this error, we incorporate control variables. In addition, every independent variable in the model acts as a control for the other variables.

[6] http://www.webometrics.info/en/Europe/Norway - an initiative by the Cybermetrics lab belonging to the Consejo Superior de investigaciones Cientificas, the largest public research body in Spain.

Previous research has highlighted several factors that influence valuation. For example, Gompers and Lerner (1999) find a strong correlation between capital infusion into the public market, measured by public stock market indexes, and valuations in the venture capital market. Market size and industry profitability and return on investment are also highlighted. At the firm-level, the development stage, firm age, and type of industry in which the firm is situated have traditionally been controlled for. However, a rule of thumb in regression is to have at least 10 data cases per variable (Field, 2013). As further discussed in the limitations section, with our small sample we are already at the threshold of this value. Therefore, we need to limit the number of control variables in our model. We omit using the OSEBX stock index to control for capital infusion in the public market as our valuations are in 95% of the cases conducted in the same year (2013, which is the year of the most recent annual report available for still operating companies), and the variable would therefore not account for any significant variance in the model. It is reasonable to believe that USOs that target large markets, ceteris paribus, also receive higher valuations because of the larger income potential. We therefore include market size as a control variable at the market-level. Market size is based on the size of the industry in MUSD in which the company was placed during the valuation process, and is retrieved from Ychart[7]. Lastly we include firm age, which is calculated as the difference between the year of the last available annual report, year of failure or year of acquisition, and year of founding.

Model Estimation and Robustness

To summarize the previous discussion, table 2 presents the variables in our model.

Variable	Sign	Measurement
Company value	Dependent	EV/EBITDA, EV/Sales or Price/Sales multiples
Inventor on founding team	+	Dummy variable with '1' indicating the technology inventor being on the founding team
Inventor renownedness	+	Total number of citations on any article authored or co-authored by the founders as calculated by Google Scholar.
Team heterogeneity	+	Sum of dummy variables indicating different backgrounds and experiences in the founding team
Ties to parent university	+	Total number of years the founders have worked/researched at the parent university
Parent university quality	+	The university's world ranking by Webometrics
Investor capital	+	Dummy variable with '1' indicating received investor capital during or prior to the first two years of operations
Number of patents	+	Total number of patents published or filed during or prior to the first two years of
Control Variables		
Company age		Year of last annual report, year of failure or year of acquisition, minus year of founding.

Table 2. *Variable definitions and measurements*

Although only normality of residuals is required in regression, normally distributed variables are more likely to produce normally distributed residuals. We therefore checked all the continuous variables for normality, first by conducting a Shapiro-Wilk W-test, and if it was significant, we reviewed the deviation from normality by assessing the skewness and kurtosis of the distribution. All variables showed significant deviations from normality. Four of the variables showing the largest deviations, including the dependent variable, were transformed to reduce the skewness and kurtosis of their distributions. After trial and error, 'Company value', 'Degree of Heterogeneity' and 'Inventor renownedness' was LN-transformed, whilst 'Number of patents' was transformed using [1-1/(1+Number of patents)]. All the variables still showed a significant deviation from normality after the transformation when assessed using the Shapiro-Wilk W-test. However, a review of the variables skewness and kurtosis revealed a significant reduction in both measures for all transformed variables. The following equation represents the model to be estimated and analyzed:

[7] Ycharts.com is an online provider of financial data.

$$
\begin{aligned}
ln(1 + company\ value) = \alpha \\
&+\beta_1 \times ln(1 + Team\ heterogeneity) \\
&+\beta_2 \times (Ties\ to\ parent\ university) \\
&+\beta_3 \times (1 - \frac{1}{1 + (Number\ of\ patents)} \\
&+\beta_4 \times (Investor\ capital) \\
&+\beta_5 \times (Inventor\ on\ founding\ team) \\
&+\beta_6 \times \left(\frac{1000}{Parent\ university\ quality}\right) \\
&+\beta_7 \times ln(1 + Inventor\ renownedness) \\
&+\beta_8 \times (Company\ age) \\
&+\beta_9 \times (Market\ size)
\end{aligned}
$$

Here, α represents the intercept term, β_1 - β_7 are the coefficients of the independent variables, and β_8 and β_9 the coefficients of the control variables. Prior to conducting the analysis, variables where controlled for data entry errors, and the few single missing values were, following Tabachnick and Fidell (1996), replaced with the variable mean. To control for outliers and cases with undue influence on the model we calculated Cook's Distance, which measures the overall influence of a case on the model, and the DFBetas, which looks at the difference between a parameter estimated using all cases, and estimated when one case is excluded. A Cook's distance greater than 1 (Cook and Weisberg, 1982), or a DFBeta greater than 2 (Stevens, 2012) indicates a case with undue influence on the model. All Cook's distances were well below 1 (highest was 0.176), and the largest DFBeta was 0.86. This indicates no outliers or cases with undue influence in our model. To assure independence of residuals, or lack of autocorrelation, we used the Durbin-Watson statistic which tests for serial correlations between residuals. In a model with 9 regressors and 65 cases[8], a lower bound for the statistic is 1.301 and an upper bound 1.923, at 5-percent significance (Durbin and Watson, 1951). With a value of 1.837 in our model there are no indications of autocorrelation. Inspection of residual plots revealed a random array of evenly dispersed dots around zero which indicates that the variance of the residual terms are constant, and that there is no problem with heteroscedasticity. Finally, to check the assumption of normally distributed errors, we did a Shapiro-Wilk-test on the standardized residuals which was non-significant (p = 0.395).

Methodological Limitations

There are several limitations to the methodology employed in this study, where the measurement of the dependent variable as well as the sample size are the most crucial.

The dependent variable is measured firsthand through the use of valuation multiples, and the value estimations are followingly limited by the availability of information and the shortcomings of relative valuation when applied on young ventures. First, we have ourselves valued the companies based on the limited information we had available. This may have led to other valuations than what more informed analysts would have estimated. Second, the fundamental argument underlying relative valuation is that similar assets should be priced equally (Liu et al., 2002). The validity of our valuation estimates therefore rest on the similarity between the private firm being valued and the industry from which the multiple is derived. USOs are in many cases firms commercializing unique technologies (Shane, 2004) whose comparability to other firms in the same industry may be limited (Mirza and Rønning, 2015). Further on, factors affecting value are likely to be different for private and public firms, so public multiples are not directly transferrable to a private company. Third, the industry multiples used are crude, and in some cases it is difficult to place a firm in the right industry, again because of the unique technologies these firms are founded on. Optimally, the industry classifications used would have been more fine grained to easier separate firms into different industries. Fourth, the value of the firms are calculated at a specific point in time, at which point the firm may or may not have reached its full commercial potential in terms of revenues. The potential future growth in revenues and earnings a firm might experience is followingly not incorporated into our value estimates. The dependent variable also limits the model's generalizability as it is constrained in its measurements, i.e. the value of a company can theoretically speaking be unlimited, whilst the cases in our sample only cover a specific interval.

The use of relative valuation was despite the limitations necessary to conduct this study, and we have to our best ability addressed these issues. Instead of using multiples from a single firm we have opted to use industry multiples to

[8] https://www3.nd.edu/~wevans1/econ30331/Durbin_Watson_tables.pdf

average out the error that would be obtained in using a single firm in the chosen industry, and also added an illiquidity discount to account for the effect of using a public multiple on a private firm. Further on, to cross check that the right industry was chosen, other companies in the same industry were reviewed to verify that they delivered the same type of products or services. We have also excluded firms from our sample that have not completed their first commercial sale to ensure that the firm has revenues from their core activities. In any case, valuing a company is an inherently difficult and subjective task, and although there are severe limitations to the absolute measurement of our dependent variable, the methodological limitations are likely to inflict constant valuation errors across the firms in the sample, and the relative value of each firm should followingly be valid for the purposes of this study.

The second limitation relates to the small sample size. Field (2013) writes that assuming a 5% significance level and the recommended power of a test of 0.8, 783 participants are necessary to detect a small effect size (Pearson correlation = 0.1), 85 participants to detect a medium effect size (Pearson correlation = 0.3) and 28 participants to detect a large effect size (Pearson correlation = 0.5). With 63 participants in our sample we are unlikely to detect small and medium-sized effects. The sample size is however limited by the availability of data, and although the sample is small, it does cover the majority of USOs in Norway established in the period 2000-2005, and should be representative of the Norwegian population of USOs. However, because the sample is confined to Norwegian USOs, the model's generalizability across geographies is limited.

Another important limitation in the overall methodology is the lack of a longitudinal approach, i.e. we do not assess how the variables in question develop over time, but rather assume that the value the USO achieves is due to the presence of initial resource endowments. This is however necessary as we are interested in the explanatory power of these resources ex ante on the future value of the firm.

As for the independent variables, they are measured through proxies. Per definition, a proxy only infers the value of the actual variable of interest, and its fit to be used as a proxy is given by the correlation between the two. We have, as far as the available data has allowed us, used proxies that are verified in previous research, or anchored in theory. The proxies are followingly believed to be a good fit to the variable of interest, however, without estimating the actual correlations, there is risk of poor proxies resulting in invalid and biased results. Finally, the methodology is limited by the reliability of the information sources used. The business plans and annual reports are considered more reliable than online sources such as LinkedIn and Google, nonetheless, to retrieve the information needed to conduct a study of this magnitude, a 360 degree approach to gathering data from all available sources was deemed necessary.

Results

In the following section we present descriptives followed by an inferential discussion on the hypotheses in question.

Descriptives

Variable	Mean	Minimum	Maximum	Std. Deviation
Company value (transformed)	6,884	0,000	20,040	8,360
Human Resources				
Inventor on founding team (binary)	0,890	0,000	1,000	0,317
Inventor renownedness (transformed)	4,234	0,000	9,720	3,193
Team heterogeneity (transformed)	1,057	0,000	1,950	0,411
Social Resources				
Ties to parent university (years)	17,400	0,000	54,000	13,710
Parent university quality (transformed)	5,990	0,150	14,710	4,867
Financial Resources				
Investor capital (binary)	0,210	0,000	1,000	0,408
Technological Resources				
Number of patents (transformed)	0,270	0,000	0,990	0,391
Control Variables				
Company age (years)	8,370	1,000	13,000	3,456
Market size (MUSD)	429 837	25 081	1 415 745	368 828

Table 3. *Descriptives of the variables in the analysis. See appendix 7 for descriptives of the untransformed variables*

Our sample consists of 63 firms. Table 3 shows means, minimum and maximum values for all variables, as well as the standard deviations. 37 of the firms were categorized as unsuccessful and given a value of zero, four firms were acquired, with an average valuation of 162 MNOK, whilst 22 firms were categorized as still operating with a mean value of 59 MNOK. The mean value across all categories was approximately 31 MNOK, and the average company age at the time of valuation was 8.37 years. The relatively high standard deviation of

	1	2	3	4	5	6	7	8	9	10
Company value (transformed) [1]	1									
Human Resources										
Inventor on founding team [2]	0,2*	1								
Inventor renownedness (transformed) [3]	0,25**	0,299***	1							
Team heterogeneity (transformed) [4]	0,284**	0,251**	0,144	1						
Social Resources										
Ties to parent university [5]	0,401****	0,229**	0,393****	0,224**	1					
Parent university quality (transformed) [6]	0,332***	-0,089	0,186*	0,098	0,246**	1				
Financial Resources										
Investor capital [7]	0,097	0,18*	0,111	0,182*	0,054	-0,036	1			
Technological Resources										
Number of patents (transformed) [8]	0,391****	0,047	0,328***	-0,109	0,333***	0,038	0,079	1		
Control Variables										
Company age [9]	0,494****	0,185*	0,182*	0,123	0,168*	0,18*	0,335***	0,323***	1	
Market size (MUSD) [10]	0,025	-0,155	0,166*	-0,08	0,27**	0,324***	-0,001	0,111	-0,027	1

Table 4. *Pearson Correlation Matrix - Correlation significant at: * p < 0,1, ** p < ,05, *** p < ,01, **** p < ,001*

company age (~3,5) indicates that there is a wide spread in how long the companies have been operating which underpins the need to include age as a control variable. The average firm values in each of the outcome categories are as expected, i.e. that firms that are acquired are on average valued higher than firms that are still operating, which are valued higher than firms that have shut down.

The majority of the founding teams had an inventor present (0.89), the founders were on average cited 1219 times, and the degree of heterogeneity was 2.13 out of 6. The latter meaning that on average, firms had founding teams with backgrounds and experiences from 2 out of the 6 fields considered in this study. Moreover, founding teams had an average of 17.40 years of working experience from the parent university. Under 25% (0.21) of the firms in the sample received investor capital during or prior to the first two years of operations, and the mean number of patents filed and published was 3.4 per firm.

Inferential

Table 4 reports the bivariate Pearson correlations between the variables in our model, ordered by resource category.

As can be seen, all correlations between the dependent variable 'Company value' and the independent variables are in the predicted direction, and consistent with the developed hypotheses. Seven out of nine correlations are significant. The only independent variable with an insignificant correlation to 'Company value' is 'Investor capital'. The table also shows that there are significant correlations between independent variables, however this does not necessarily indicate multicollinearity-problems in the model. A Pearson correlation greater than 0.8 between two variables indicates problems of collinearity (Field, 2013), and a variance inflation factor (VIF) greater than 10 should raise concerns (Bowerman and O'Connell, 1990). Further on, if the average VIF is substantially greater than 1, then the regression may be biased (Bowerman and O'Connell, 1990). The largest Pearson correlation between any two variables is 0.357, between 'Inventor renownedness' and 'Ties to parent'. This is somewhat expected as the longer founders have worked/researched at the university, the more papers they are likely to have published and followingly be cited on. The highest VIF was 1.483, with an average VIF of 1.260. Despite significant correlations between independent variables, both the magnitudes of the correlations and the VIF confirm that collinearity is not a problem in our model.

In the following we review pure relationships between the independent variables in our four resource categories and the dependent variable represented by the three outcome categories. It is here assumed, as was shown above, that firms that are categorized as acquired are on average valued higher than firms that are still operating, which again are valued higher than firms that are unsuccessful. It is important to note that the below inferentials are only indicative of what results may be expected from the regression analysis. The graphs represent averages, and may obscure the real relationship between the two variables of interest. Further on, relationships between the different independent variables are not controlled for.

Figure 3 shows the mean values by outcome category for the human capital resources 'Inventor on team', 'Degree of heterogeneity' and 'Inventor renownedness'. The graph shows a positive relationship between the two former variables and firm value, i.e. firm value is increasing with increasing degree of heterogeneity and inventors on the team, which indicates support for hypothesis 1a and 2. There does not seem to be a linear relationship between the latter variable and firm value, which indicates that hypothesis 1b may not be supported. This will be further examined in the next section.

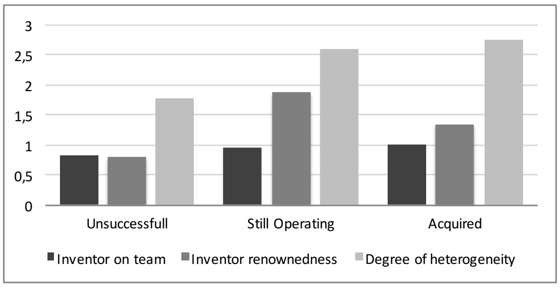


Figure 3. *Mean values for human resources*

Figure 4 shows the mean values by outcome category for the social resources in our study. As can be seen, both the variables 'Ties to parent' and 'Parent ranking' are increasing in firm value, which indicates support for hypothesis 3 and 4.

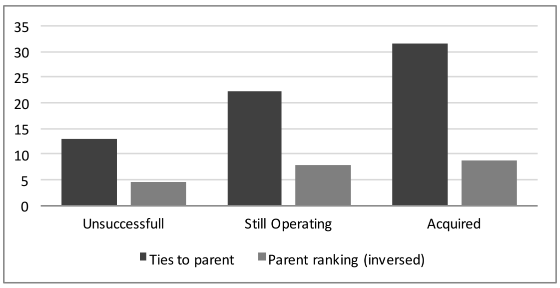


Figure 4. *Mean values for social resources*

Figure 5 shows the mean value by outcome category for the financial resource in our study. The graph indicates a positive relationship between firm value and attained investor capital, where nearly 20% of unsuccessful firms, nearly 23% of still operating firms, and 25% of all acquired firms received investor capital. Although indicative, this underpins hypothesis 5.

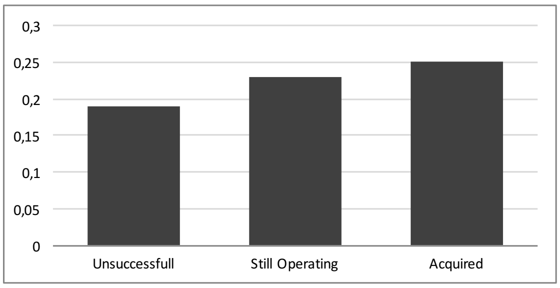


Figure 5. *Mean value for financial resources (investor capital)*

Finally, figure 6 shows the mean value by outcome category for the technical resource in our study, i.e. patents. The graph does not indicate a linear relationship between patents and firm value, which indicates that hypothesis 6 may not be supported.

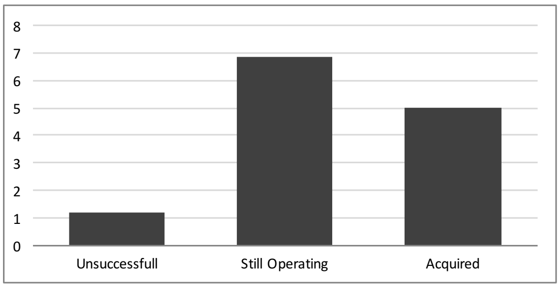


Figure 6. *Mean value for technological resources (number of patents)*

As mentioned, the above inferentials do not control for the effect different independent variables assert on each other. Table 5 presents the complete regression model.

Discussion

Because we are analyzing the hypotheses under the assumption of ceteris paribus, hypotheses related to each resource category are first tested alone in model 2 through model 5 with only control variables. Model 6 is the full model with all independent and control variables included. Because of lacking theory as to the relative importance of each independent variable, all variables are introduced in the full model simultaneously. This is in accordance with researchers believing that this method is the only appropriate method for theory testing

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Human Resources						
Inventor on founding team		0,036				0,067
Inventor renownedness (transformed)		0,123				-0,037
Team heterogeneity (transformed)		0,206*				0,204*
Social Resources						
Ties to parent university			0,312***			0,182
Parent university quality (transformed)			0,222*			0,236**
Financial Resources						
Investor capital				-0,077		-0,08
Technological Resources						
Number of patents (transformed)					0,257**	0,262**
Control Variables						
Company age	0,495****	0,440****	0,398****	0,521****	0,411****	0,330***
Market size (MUSD)	0,039	0,039	-0,120	0,039	0,008	-0,088
Constant	-3,503	-9,064**	-5,593	-3,706	-2,986	-10,008***
N (number of observations)	63	63	63	63	63	63
Adjusted R2	0,22	0,255	0,35	0,212	0,268	0,378

Table 5. *Regression model - Coefficient significant at: * p < 0,1, ** p < ,05, *** p < ,01, **** p < ,001*

(Studenmund, 2011), because stepwise techniques are influenced by random variation in the data and so seldom give replicable results if the model is re-tested. Model 1 represents the baseline model, and includes only the control variables. Given the limitations previously mentioned, we focus our discussion on general relationships between initial resource-endowments of USOs and firm value instead of exact coefficients and effect sizes.

Model 1 only includes the control variables. Age is estimated to have a large and significant effect at the 0.1% level, and is consistently significant across all models (except the full model where it is significant at the 1% level). This is consistent with previous research, and also expected. Firms that have been operating longer are more likely to have finished developing a product and established distribution channels, leading to higher revenues, less uncertainty and higher firm valuations compared to younger firms. The significance level is though surprising considering our small sample size, and to verify the result we reviewed the coding of the variable to identify possible errors, but none were found. The authors argue that this can be seen in context with our model of estimating firm value, where as previously mentioned, the value of future growth is not included. Firms that are older have had more time to grow and increase their revenues, and therefore achieve higher valuations in our model, which is reflected in the high significance level of the control variable age. This however underpins the importance of including age as a control variable, as it will account for the variance this effect has on firm value. Market size is surprisingly, and in contradiction to existing research, found to have a small and insignificant effect. This may indicate that in the context of USOs, market sizes of existing industries are less important when valuing a new venture. USOs often develop novel technology (Shane, 2004), and this technology might unlock new application areas and markets, rendering market sizes of the industries of competitors less representative for the markets targeted by the USO. Another possible and plausible explanation is that the industry classifications chosen for each of the firms in our sample are too broad to be representative of their actual target markets.

Human Resources

In model 2 we test the hypotheses developed about human capital resources and their relation to firm value. Previous research indicates that human capital resources can lead to sustained competitive advantages (Wright et al., 1994), and therefore higher performance and profits. Especially inventor presence on the founding team together with the inventor's renownedness and team heterogeneity are highlighted as positively related to USO performance (Clarysse and Bruneel, 2007; Markman et al., 2008; Wright et al., 1994; Hess and Rothaermel, 2012; Zucker et al., 2002; Knockaert et al., 2010). This led us to respectively develop hypotheses 1a, hypothesis 1b and hypothesis 2.

In hypothesis 1a we proposed that USOs that have the technology inventors on the founding team achieve higher valuations in the long term. In both models 2 and 6, the estimated regression coefficient is positive as proposed, however it is small and insignificant, leading to hypothesis 1a not being supported. The authors propose that the insignificant results might be due to an unfitting operationalization of the inventors presence in the founding team, and not the fact that the engagement of the technology inventor in a USO is not important for the company's success, and subsequently firm value. In our sample, almost 90% of the firms had at least one of the technology inventors in their founding teams. It is this large percentage rate that makes it difficult to use the binary operationalization of inventor presence to differentiate between USOs future firm values, because there simply is not enough variance in the sample. Further on, being named inventor in a business plan and receiving equity in the new venture does not to a satisfying degree represent the different levels an inventor can be engaged in the venture. The effect of the inventors presence on venture performance, and subsequent firm value, is likely to be moderated by other factors such as how much effort and time the inventor dedicates to the startup. The technology inventor may solely be given an equity stake in the company as a compensation for the right to use the intellectual property for commercialization purposes. The new venture can not, to a high degree, exploit the tacit knowledge kept by the inventor if the inventor does not really commit herself to the work of bringing the new product to market. Blair and Hitchens (1998) find that presence of a full-time entrepreneur enhances the performance of USOs due to signaling effects as well as being able to focus solely on the new venture. The same arguments can be applied to the technology inventor in the founding team. We followingly conclude that the binary operationalization of inventor participation in the USO founding team is not suited as a predictor for firm value, and consequently as a heuristic in a resource-based valuation framework, but still argue the importance of inventors in founding teams due to the tacit knowledge she holds about the underlying technology on which the new venture is founded. Parts of this tacit knowledge is likely to be difficult to make explicit, and for that reason, the inventor is a non-substitutable asset. Not only is the successes of the inventors research interesting for the new venture, but the vast amount of knowledge the inventor has gained through failed experiments is likely to be valuable when further developing the technology. Further on, significant technological modifications and developments are likely necessary to bring the early-stage technologies these companies are founded on to commercial applications, which the technology inventor is likely to be best suited to accomplish. Proxies employed in future research should therefore to a better degree measure the actual contribution of the inventor, instead of simply her presence.

In hypothesis 1b we proposed that USOs who have more renowned inventors should achieve higher firm valuations, and proxied how renowned an inventor is through her citation rate. Both models 2 and 6 estimate a small, insignificant regression coefficient for the effect of how renowned the inventor is on firm value, and the coefficient is slightly negative in the full model. The coefficient itself is highly uncertain with a large standard error and 95% confidence interval between -0.716 and 0.520. Hypothesis 1b is followingly not supported. The underlying argument for the hypothesis was the signaling effect a renowned inventor can have on external resource holders. A possible explanation for the small and insignificant regression coefficient is the conflict of interest between research, and commercializing the technology that might arise for an inventor. Inventors that have high citation counts are likely to be avid researchers with a focus on publishing their results for the sake of research, not commercialization. The shift in mindset needed to go from a research-setting to commercialization-setting is followingly likely to be more difficult for more renowned investors, which may affect the performance of the new venture, and subsequently firm valuation. This is likely to be a larger issue for researchers that have been more active, and published more papers. In any case, we do not find support for including the renownedness of an inventor, proxied through her citation count, as a predictor of USO firm value.

In hypothesis 2 we proposed that founding teams that are more heterogeneous in terms of educational backgrounds and previous work experiences should achieve higher valuations. The hypothesis is supported in both model 2 and model 6 at the 10% level. This is in accordance with previous research. Visintin and Pittino (2014) find that USOs with founding teams that have backgrounds from both business and engineering experience higher sales growths, and Knockaert et al. (2011) state that these companies receive higher share valuations. Having both technical and business knowledge is likely to be important in any startup, however, the authors argue that because of the high uncertainty associated with early-stage USOs, and because of the challenges they face in terms of attracting funding and identifying an application and target market for the technology, the combined efforts on both the technological and business front are likely to be more vital than in the average startup. For example, the long development times (Rasmussen et al., 2013) are likely to require a greater degree of synchronization between the development plan and financial plan to assure enough funding throughout the development process. The general-purpose nature of the technologies (Nelsen, 1991; del Campo et al., 1999) require a larger degree of cooperation between business people and technical people to assure that the technology is developed towards applications that provide the largest benefits to the customer as well as the largest markets. Further on, the early-stage nature of the technologies (Shane, 2004) to a greater degree are likely to require these companies to attract partners, be that financial or industrial, and business acumen in the top management team is therefore as important as technical knowledge. In conclusion, our results indicate heterogeneity in the founding team of a USO as a valid predictor for firm value, and that it therefore should be included as a heuristic in a resource-based valuation framework.

Social Resources

Model 3 tests hypotheses developed about the relationship between initial social resource-endowments in a USO and firm value. Social resources refer to the personal networks of the founding team, and in the performance literature on USOs, the degree of university affiliation has been highlighted as correlated with performance, as has the quality of the university itself.

In hypothesis 3a we proposed that USOs with stronger ties to the parent university in their early stages should be valued higher than those with weaker ties. The strength of the tie is proxied through the total number of years the founders have worked/researched at the parent university. The hypothesis is supported in model 3 at the 1% level, but looses its significance in the full model. The loss of significance can be attributed to the correlation between 'Ties to parent' and 'Inventor renownedness', and the variable does indeed keep its significance when the full model is estimated without 'Inventor renownedness' being included. The high correlation between these two variables is natural as founders who have worked/researched longer at the university are likely to have published more papers and received more citations. This correlation might have been reduced if another proxy for 'Ties to parent' was used. (Granovetter, 1973) defines the strength of a tie as the combination between the amount of time, the emotional intensity, the intimacy, and the reciprocal services that characterize each tie, and by only using the time aspect of this definition, we might not represent the strength of the tie adequately. A second reason for the loss of significance may be due to the small sample size. As (Field, 2013) points out, small or medium sized effects will not be significant in our model.

Based on the above discussion, we can not advocate that the strength of ties between a USO and the parent university, proxied through the number of years the founders have worked/done research at the parent, is suited as a heuristic in a resource-based valuation framework, but we do attain our belief that this specific resource can positively affect the performance of an USO, and encourage the search of a more fitting proxy for the relationship. Seen from a resource-based perspective, a strong affiliation between the USO and its parent university can be valuable because the parent can provide access to resources such as talent and critical financial resources (Bigliardi et al., 2013), knowledge and complementary R&D (Lubik et al., 2013), labs and expensive equipment at low cost (Starr and MacMillan, 1990; Roberts and Malonet, 1996). Further on, the university has a limited set of resources, and the authors argue that the stronger the social ties between the founders and the parent, the more likely the USO is to receive a larger share of these resources because the founders can draw upon their network. The affiliation is likely to be rare due to the university only supporting USOs that originate within its own walls. Inimitability is likely due to the relationship between the university and the new venture being built over time and being path dependent (Zander and Zander, 2005; Santala and Parvinen, 2007), i.e. the relationship is built through the work the technology inventor conducted at the university and through the inventors interactions with other people at the university during her time there. Finally, the relationship between the parent university and the USO is non-substitutable due to each university's uniqueness in terms of quality and expertise. Future research should therefore seek to develop better proxies to the strength of social ties between a USO and its parent to test if this variable is suited as a heuristic in a resource-based valuation framework.

In hypothesis 3b we proposed that USOs originating from more renowned, higher quality universities, should achieve higher valuations, and proxied the quality of the university through its world rank. The hypothesis is supported in both model 3 and the full model at the 10% and 5% level respectively. Existing streams of research highlight access to expert knowledge, people (Powers and McDougall, 2005), and funding (Di Gregorio and Shane, 2003) as three reasons for why the quality of the university affects USO performance. The authors further argue that higher quality universities are likely to produce higher quality research, and followingly better technology on which USOs can be founded. Because most of these companies are solely founded around a technology, the quality of the technology is obviously important to firm performance, and subsequently firm value. Higher quality universities are also likely to have stronger signaling effects towards external resource holders. These signaling effects can be particularly valuable for early stage USOs because of no objective operating data, and consequently investors not being able to adequately assess the technology on which the new venture is founded (Wright et al., 2006). Our analysis followingly indicates that the quality of the university should indeed be included as a heuristic in a resource-based valuation framework.

Financial Resources

In model 4 we test hypothesis 4, where we propose that USOs who receive investor capital in their early-stages, proxied as a binary variable, should achieve higher valuations than those that do not. Financial resources are for obvious reasons important for all early stage ventures, however, as highlighted in the literature review, it is especially critical for early stage USOs due to the large development costs they face. Surprisingly the regression coefficient is negative and insignificant in both model 4 and the full model, and we do not find support for hypothesis 4.

Although surprising, the result is consistent with the previous discussion on financial resources not on their own being valuable, rare, inimitable and non-substitutable (VRIN), and should therefore not lead to sustained competitive advantages, and followingly higher profits and higher value. Instead, capital enables firms to acquire other resources that can be VRIN. In agreement with this, our results indicate that the binary operationalization of received investor capital in the early-stages of a USOs life-cycle is not a good predictor for the future value of the firm, which has important implications. Previous research has focused on the relationship between investor capital and performance, and has found that there is a positive significant relationship between the two. However, performance has commonly been measured through sales growth (e.g. Walter et al. (2006), Lubik et al. (2013) and Bigliardi et al. (2013)), firm outcome, i.e. if the firm achieved IPO, got acquired, survived or failed (e.g. Criaco et al. (2013) and Fuller and Rothaermel (2012)), or number of employees and employment growth (e.g. Sternberg (2014), Bigliardi et al. (2013), Zerbinati et al. (2012), Zhang (2009) and Walter et al. (2006)). Some of these measures have obvious positive relationships to a firm attaining investor capital. For example, investor capital enables a company to hire more employees which obviously lead to employee growth, it may boost sales through marketing, or it may keep the company operating longer despite large losses. Our study, which instead of indirect performance measures relates 'Investor capital' in an early-stage to actual firm value, shows that even though capital may increase firm performance on certain measures used by other researchers, it does not necessarily increase firm value. In fact, we find a negative relationship between the two (although the relationship is insignificant).

There are multiple reasons for why early-stage investments may negatively impact the performance, and subsequently value, of USOs. First of all, investors are generally interested in the largest return possible and, considering the time value of money, at the earliest possible time after investing. Early-stage USOs on the other hand have long development times (Rasmussen et al., 2013; Lawton Smith and Ho, 2006). This interest gap may lead to pressure from the investors on the company to speed up development, take shortcuts where possible, make rash decisions, and followingly harm the new venture's performance and value. Another possible reason for the negative relationship is the competence and knowledge gap between investors and founders in USOs. In research on the effect of venture capital it has been highlighted that venture capitalists contribute with more than simply money. Their networks, experience and advice are almost equally, if not more, important in helping the new venture succeed (Hellman and Puri, 2000; Sapienza, 1992). Many USOs on the other hand are working with complex technology that investors may have problems understanding (Shane, 2004). This can make it difficult for the investors to contribute with this added value, and may ultimately lead them to give bad advice.

On the other hand, there can be simple methodological explanations to our results. Our binary operationalization is crude, and does not incorporate the actual amount received, or who the investor is. These two variables are likely to have strong moderating effects on the investment variable. Although our results are surprising, the authors find them plausible. The analysis indicates that investor capital, proxied through a binary variable, is not a good predictor for early-stage USO firm value, and therefore should not be included as a heuristic in a resource-based valuation framework.

Technological Resources

The last category of technological resources are particularly important for early stage USOs, as they are founded to commercialize distinct technological innovations developed at the parent university (O'Shea et al., 2008). In model 5 we test hypothesis 5, where we propose that USOs who publish or file more patents during their early stages achieve higher valuations. The hypothesis is supported in both model 5 and the full model at the 5% level.

The authors argue that patents are positively related to USO value because they are a resource that, in accordance with Mirza and Rønning (2015), can be valuable, rare, inimitable and non-substitutable, and followingly result in a sustained competitive advantage, at least for the duration of the patents validity. The reviewed literature has shown that the patents of the new venture are likely to be valuable (Deeds et al., 2000; Zahra and Bogner, 2000; Powers and McDougall, 2005). The patents protect the new venture from competitors, as well as it is natural to believe that the new venture would not have been founded if the founders did not believe that the underlying technology, protected by the patents, would yield a positive and significant financial return. Further on, the larger the scope and number of patents, the greater is the likelihood of protecting several application areas, which in the future can lead to licensing incomes from others who wish to utilize the patents, or a protected technology in multiple markets, which naturally is valuable. For obvious reasons, and per definition, the patents are likely to be rare and inimitable (Markman et al., 2004). As for the patents non-substitutability, Markman et al. (2004) operationalize non-substitutability as the patents number of claims, with the rationale being that claims define the scope of an invention and distinguish its property from the surrounding technological territory, and once a technology space is protected by a patent, substitution becomes difficult and costly. Our analysis confirms the positive relationship between patents and the long term value of a USO, and establishes a theoretical linkage between the two. We conclude that the number of patents filed or published by a USO during its first two years should be included as a heuristic in a resource-based valuation framework.

Conclusion and Limitations

The topic of valuation has traditionally been a field within corporate finance, with common valuation methods being dependent on future cash flows, assets or valuations of comparative firms (Seppä and Laamanen, 2001). However, as Mirza and Rønning (2015) point out, these methods are poorly suited to be used on early-stage USOs due to a fundamental mismatch between the required inputs and the operating data available for these companies. This study has taken a resource-based perspective on valuation to develop a conceptual framework where resources are used as valuation inputs rather than financial data. The underlying argument being that when it is difficult to value a company based on outputs (cash flows etc.), a method based on inputs (resources, founder characteristics, network etc.) that can be objectively measured, and applied as heuristics, may prove more satisfactory. To empirically test the framework we have leveraged existing research on the resource-performance relationships in USOs. This led us to develop six hypotheses about the relationship between human capital, social, financial and technological resources and firm value. The hypotheses were tested using multiple hierarchical regression on a data sample of 63 Norwegian USOs from the EntPro project founded in the period 2000 - 2005. Our analysis has shown that there is a significant positive relationship between the long term equity value of a USO and the founding teams heterogeneity, the quality of the parent university and the number of patents the new venture has filed or published. We did not find a significant relationship between firm value and inventors on the founding team, USOs with stronger ties to

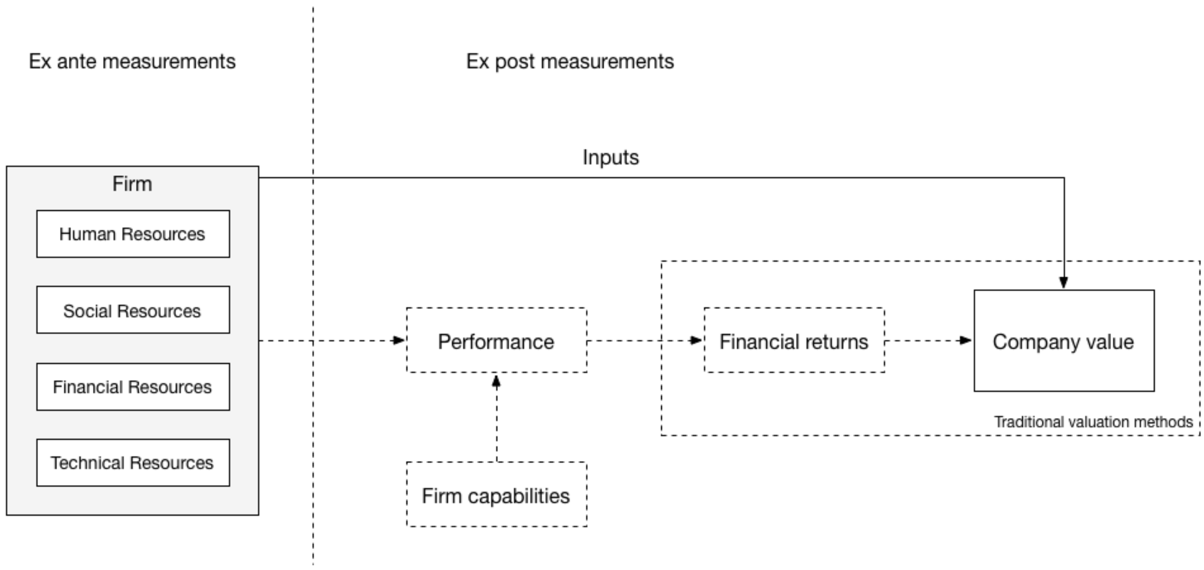


Figure 7. *Conceptual framework*

the parent, or USOs who attain early-stage investor capital. For the latter three hypotheses that were not supported we have argued that this might be due to unrepresentative operationalizations, and further research is therefore necessary to verify our results. For the former three hypotheses, the authors argue that given the significant relationship identified, USOs who have more heterogeneous founding teams, originate from higher quality universities and have more filed or published patents in their early stages, should, ceteris paribus, be valued higher than those that do not.

This is because, as resource-based theory suggests, resources are what ultimately drives value creation in firms, and our analysis indicates that these specific resources are associated with higher long term firm values. Given the uncertain nature of these firms, it makes more sense to use these resources to guide valuations, and distinguish between different investment opportunities, instead of trying to estimate absolute firm values with uncertain cash flows and discount rates. On a conceptual level, this is highlighted in the framework in figure 7, and substantiated, although tentative, through our empirical analysis. As such, these resource characteristics should be applicable to be used as heuristics to value a USO in its early stages regardless of the high fundamental uncertainty surrounding these firms. This is however the first study of its kind, and like traditional valuation methods weren't developed in a single study, neither will a resource-based valuation framework. We set out to prove the feasibility of such a framework, which the authors feel confident they have, but to develop a complete valuation framework based on resources will require significant attention from researchers in both strategic management and corporate finance to adequately bridge the gap between the two.

This study has a number of implications for both investors, entrepreneurs and researchers. For investors, we have established the initial theoretical linkages between initial resource endowments and subsequent firm value, which can be used as heuristics when valuing an early-stage USO. Instead of founders and investors estimating and forecasting cash flows that are impossible to reliably estimate in the early stages (Mirza and Rønning, 2015), and trying to justify uncertain growth- and discount rates where a small change in either can result in large changes in the firm value, using resources which both the investor and the entrepreneurs can objectively measure and agree upon, is likely to be a more effective and fair process. Although we have not developed a complete valuation framework, investors can use the conceptual framework to take into consideration the identified relationships when estimating firm values. Further on, we have shown that resource-performance relationships highlighted in theory are not necessarily good heuristics for predicting the future value of a firm, such as the presence of an investor in the founding team or early-stage investor capital. Rather it is necessary to dig deeper into the resources to assert their effect on firm performance and subsequent firm value. For entrepreneurs, the findings highlight initial resources that the new venture should strive to assemble to increase their performance, and subsequently the value of their firm. We have shown that entrepreneurs should struggle to assemble complementary and heterogeneous founding teams to achieve higher firm valuations, and that asserting control over their technology through patents is positively related to firm value. Moreover, entrepreneurs licensing technology from universities should take into account the quality of the university when deciding on what technology to license. Finally, our results pave the way for an entire new stream of research bridging the gap between strategic management and traditional corporate finance.

Further Research

The limitations previously highlighted limit the generalizability of this study and underpin the need to verify the results obtained using larger samples. Future research on the topic should however not only increase the sample size, in absolute numbers as well as in geographical spread, but also the number of resource-value relationships examined. We have only been able to examine six of these relationships. To develop a complete resource-based valuation framework it will be necessary to significantly expand on this, find better and more detailed proxies which to a greater degree can differentiate between USOs, as well as examine the relative importance of each resource type. It is also necessary to investigate the moderating effect of firm capabilities on the relationship between resources and firm value, and whether it is possible to objectively operationalize these capabilities to be included in a resource-based valuation framework. Further on, we have not incorporated the possible effects of external factors, as highlighted by the Industrial organization perspective, on the value of a firm in our framework. Neither have we included variables such as estimated development times and capital needs which are likely to have strong implications on value estimations. To develop a complete and robust framework, such variables and their effects on early stage value must be investigated.

Amongst our results, although statistically insignificant, we find the negative relationship between early stage investor capital and long term value especially interesting. This finding contradicts existing research on the subject, and researchers should try to verify this, as the implications of this result for entrepreneurs are significant. It is also important to verify our results using different data sources. First of all, valuations should be conducted by impartial venture capitalists. Further on, data regarding founder backgrounds, financing and patents should be collected first hand directly from the USO to avoid information errors.

This study, as the first of its kind, aimed to establish the initial theoretical linkages between resources and firm value, and as such start to bridge the gap between traditional corporate finance, strategic management and USOs. There is significant research necessary to develop a complete standardized valuation framework with a satisfying degree of predictive power. It is however clear that today's valuation methods are not good enough, and that a resource-based valuation framework has potential, so research efforts toward this should be prioritized.

References

AGARWAL, R. & SHAH, S. K. 2014. Knowledge sources of entrepreneurship: Firm formation by academic, user and employee innovators. *Research Policy*.

ALVAREZ, S. A. & BUSENITZ, L. W. 2001. The entrepreneurship of resource-based theory. *Journal of management,* 27**,** 755-775.

BAKER, M. & RUBACK, R. 1999. Estimating industry multiples. *Harvard University, Google Scholar*.

BARNEY, J. 1991. Firm resources and sustained competitive advantage. *Journal of management,* 17**,** 99-120.

BARNEY, J., WRIGHT, M. & KETCHEN, D. J. 2001. The resource-based view of the firm: Ten years after 1991. *Journal of management,* 27**,** 625-641.

BARNEY, J. B. & CLARK, D. N. 2007. *Resource-based theory: Creating and sustaining competitive advantage*, Oxford University Press Oxford.

BIDAULT, F. & CUMMINGS, T. 1994. Innovating through alliances: expectations and limitations. *R&D Management,* 24**,** 033-045.

BIERLY, P. E., DAMANPOUR, F. & SANTORO, M. D. 2009. The application of external knowledge: organizational conditions for exploration and exploitation. *Journal of Management Studies,* 46**,** 481-509.

BIGLIARDI, B., GALATI, F. & VERBANO, C. 2013. Evaluating performance of university spin-off companies: Lessons from italy. *Journal of technology management & innovation,* 8**,** 178-188.

BLAIR, D. M. & HITCHENS, D. M. 1998. *Campus Companies--UK and Ireland*, Ashgate Aldershot, UK.

BONARDO, D., PALEARI, S. & VISMARA, S. 2011. Valuing University‐Based Firms: The Effects of Academic Affiliation on IPO Performance. *Entrepreneurship Theory and Practice,* 35**,** 755-776.

BORLAUG, S. B. & STEP, N. 2009. *Between entrepreneurship and technology transfer: Evaluation of the FORNY programme*, NIFU STEP.

BOUDREAU, J. W. 1983. Economic considerations in estimating the utility of human resource productivity improvement programs. *Personnel Psychology,* 36**,** 551-576.

BOUDREAU, J. W. & BERGER, C. J. 1985. Decision-theoretic utility analysis applied to employee separations and acquisitions. *Journal of Applied Psychology,* 70**,** 581.

BOWERMAN, B. L. & O'CONNELL, R. T. 1990. *Linear statistical models: An applied approach*, PWS-Kent Boston.

BRUSH, C. G., GREENE, P. G. & HART, M. M. 2001. From initial idea to unique advantage: The entrepreneurial challenge of constructing a resource base. *The Academy of Management Executive,* 15**,** 64-78.

BRÜDERL, J., PREISENDÖRFER, P. & ZIEGLER, R. 1992. Survival chances of newly founded business organizations. *American sociological review***,** 227-242.

CARPENTER, M. A. & FREDRICKSON, J. W. 2001. Top management teams, global strategic posture, and the moderating role of uncertainty. *Academy of Management journal,* 44**,** 533-545.

CLARYSSE, B. & BRUNEEL, J. 2007. Nurturing and growing innovative start‐ups: the role of policy as integrator. *R&d Management,* 37**,** 139-149.

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., MUSTAR, P. & KNOCKAERT, M. 2007. Academic spin-offs, formal technology transfer and capital raising. *Industrial and Corporate Change,* 16**,** 609-640.

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.

COLE, S. & COLE, J. R. 1967. Scientific output and recognition: A study in the operation of the reward system in science. *American sociological review***,** 377-390.

COLOMBO, M., MUSTAR, P. & WRIGHT, M. 2010. Dynamics of science-based entrepreneurship. *The Journal of Technology Transfer,* 35**,** 1-15.

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.

COLOMBO, M. G. & PIVA, E. 2012. Firms' genetic characteristics and competence-enlarging strategies: A comparison between academic and non-academic high-tech start-ups. *Research Policy,* 41**,** 79-92.

COOK, R. D. & WEISBERG, S. 1982. Residuals and influence in regression.

CRESWELL, J. W. 2003. Research design. *Qualitative, quantitative and mixed methods approaches*.

CRIACO, G., MINOLA, T., MIGLIORINI, P. & SERAROLS-TARRÉS, C. 2013. "To have and have not": founders' human capital and university start-up survival. *The Journal of Technology Transfer***,** 1-27.

DAMODARAN, A. 2005. Marketability and value: Measuring the illiquidity discount. *Available at SSRN 841484*.

DAMODARAN, A. 2009. Valuing young, start-up and growth companies: estimation issues and valuation challenges. *Stern School of Business, New York University (New York)*.

DAMODARAN, A. 2012. *Investment valuation: Tools and techniques for determining the value of any asset*, John Wiley & Sons.

DE CLERCQ, D., FRIED, V. H., LEHTONEN, O. & SAPIENZA, H. J. 2006. An entrepreneur's guide to the venture capital galaxy. *The Academy of Management Perspectives,* 20**,** 90-112.

DEEDS, D. L., DECAROLIS, D. & COOMBS, J. 2000. Dynamic capabilities and new product development in high technology ventures: an empirical analysis of new biotechnology firms. *Journal of Business venturing,* 15**,** 211-229.

DEL CAMPO, A. A., SPARKS, A., HILL, R. C. & KELLER, R. T. 1999. The transfer and commercialization of university-developed medical imaging technology: opportunities and problems. *Engineering Management, IEEE Transactions on,* 46**,** 289-298.

DENG, M., EASTON, P. D. & YEO, J. 2012. Another look at equity and enterprise valuation based on multiples. *Available at SSRN 1462794*.

DI GREGORIO, D. & SHANE, S. 2003. Why do some universities generate more start-ups than others? *Research policy,* 32**,** 209-227.

DIAMOND, A. M. 1984. An economic model of the life-cycle research productivity of scientists. *Scientometrics,* 6, 189-196.

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.

DOUTRIAUX, J. & BARKER, M. 1995. The university-industry relationship in science and technology. Gouvernement du Canada-Industry Canada.

DURBIN, J. & WATSON, G. S. 1951. Testing for serial correlation in least squares regression. II. *Biometrika*, 159-177.

FIELD, A. 2013. *Discovering statistics using IBM SPSS statistics*, Sage.

FLORIN, J., LUBATKIN, M. & SCHULZE, W. 2003. A social capital model of high-growth ventures. *Academy of Management Journal,* 46, 374-384.

FREEMAN, J. 1999. Venture capital as an economy of time. *Corporate social capital and liability*. Springer.

FULLER, A. W. & ROTHAERMEL, F. T. 2012. When stars shine: the effects of faculty founders on new technology ventures. *Strategic Entrepreneurship Journal,* 6, 220-235.

GE, D., MAHONEY, J. M. & MAHONEY, J. T. 2005. New Venture Valuation by Venture Capitalists: An Integrative Approach. University of Illinois at Urbana-Champaign, College of Business.

GIGERENZER, G. & GAISSMAIER, W. 2011. Heuristic decision making. *Annual review of psychology,* 62, 451-482.

GIGERENZER, G., HERTWIG, R. & PACHUR, T. 2011. *Heuristics: The Foundations of Adaptive Behavior*, Oxford University Press, Inc.

GOMPERS, P. A. & LERNER, J. 1999. What drives venture capital fundraising? : National bureau of economic research.

GRANDI, A. & GRIMALDI, R. 2005. Academics' organizational characteristics and the generation of successful business ideas. *Journal of Business Venturing,* 20, 821-845.

GRANOVETTER, M. S. 1973. The strength of weak ties. *American journal of sociology*, 1360-1380.

GURDON, M. A. & SAMSOM, K. J. 2010. A longitudinal study of success and failure among scientist-started ventures. *Technovation,* 30, 207-214.

HAMBRICK, D. C., CHO, T. S. & CHEN, M.-J. 1996. The influence of top management team heterogeneity on firms' competitive moves. *Administrative science quarterly*, 659-684.

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.

HELLMAN, T. & PURI, M. 2000. The interaction between product market and financing strategy: the role of venture capital. *Review of Financial Studies,* 13, 959-984.

HESS, A. & ROTHAERMEL, F. T. 2012. Intellectual human capital and the emergence of biotechnology: trends and patterns, 1974–2006. *Engineering Management, IEEE Transactions on,* 59, 65-76.

HIGGINS, M. J., STEPHAN, P. E. & THURSBY, J. G. 2011. Conveying quality and value in emerging industries: Star scientists and the role of signals in biotechnology. *Research Policy,* 40, 605-617.

HOANG, H. & ANTONCIC, B. 2003. Network-based research in entrepreneurship: A critical review. *Journal of business venturing,* 18, 165-187.

HSU, D. H. & ZIEDONIS, R. H. PATENTS AS QUALITY SIGNALS FOR ENTREPRENEURIAL VENTURES. Academy of Management Proceedings, 2008. Academy of Management, 1-6.

JENSEN, A. R. 1980. Bias in mental testing.

JR, A. M. D. 1986. What is a Citation Worth? *The Journal of Human Resources,* 21, 200-215.

KAMIYAMA, S. & SHEEHAN, J. 2006. Valuation And Exploitation of Intellectual Property. Statistical Analysis of Science, Technology and Industry. Working Paper 2006/5. Paris, Organisation for Economic Co-operation and Development (OECD).

KATZ, R. L. 1974. *Skills of an effective administrator*, Harvard Business Press.

KEELEY, R. H., PUNJABI, S. & TURKI, L. 1996. Valuation of early-stage ventures: option valuation models vs. traditional approaches. *The Journal of Entrepreneurial Finance,* 5, 115-138.

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., LOCKETT, A., CLARYSSE, B. & WRIGHT, M. 2006. Do human capital and fund characteristics drive follow-up behaviour of early stage high-tech VCs? *International Journal of Technology Management,* 34**,** 7-27.

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.

KOR, Y. Y. & MAHONEY, J. T. 2004. Edith Penrose's (1959) Contributions to the Resource-based View of Strategic Management. *Journal of Management Studies,* 41**,** 183-191.

KOTTER, J. P. 1982. *What effective general managers really do*, Harvard Business Review.

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.

LIU, J., NISSIM, D. & THOMAS, J. 2002. Equity valuation using multiples. *Journal of Accounting Research,* 40**,** 135-172.

LONG, C. 2002. Patent signals. *The University of Chicago Law Review***,** 625-679.

LUBIK, S., GARNSEY, E., MINSHALL, T. & PLATTS, K. 2013. Value creation from the innovation environment: partnership strategies in university spin‐outs. *R&D Management,* 43**,** 136-150.

MAHONEY, J. T. & PANDIAN, J. R. 1992. The resource‐based view within the conversation of strategic management. *Strategic management journal,* 13**,** 363-380.

MARKMAN, G. D., ESPINA, M. I. & PHAN, P. H. 2004. Patents as Surrogates for Inimitable and Non-Substitutable Resources. *Journal of Management,* 30**,** 529-544.

MARKMAN, G. D., SIEGEL, D. S. & WRIGHT, M. 2008. Research and technology commercialization. *Journal of Management Studies,* 45**,** 1401-1423.

MERGES, R. P. & NELSON, R. R. 1990. On the complex economics of patent scope. *Columbia Law Review***,** 839-916.

MILLER, D. 2003. An asymmetry‐based view of advantage: towards an attainable sustainability. *Strategic management journal,* 24**,** 961-976.

MILOUD, T., ASPELUND, A. & CABROL, M. 2012. Startup valuation by venture capitalists: an empirical study. *Venture Capital,* 14**,** 151-174.

MIRZA, A. M. & RØNNING, O. 2015. Examining Equity Valuation of University Spin-off Companies: A Literature Review.

MULLEN, M. R., BUDEVA, D. G. & DONEY, P. M. 2009. Research Methods in the Leading Small Business–Entrepreneurship Journals: A Critical Review with Recommendations for Future Research*. *Journal of Small Business Management,* 47**,** 287-307.

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.

NARAYANAN, V. K. 2000. Managing technology and innovation for competitive advantage.

NECK, H. M., MEYER, G. D., COHEN, B. & CORBETT, A. C. 2004. An entrepreneurial system view of new venture creation. *Journal of Small Business Management,* 42**,** 190-208.

NELSEN, L. L. 1991. The lifeblood of biotechnology: University-industry technology transfer. *The business of biotechnology: from the bench to the street***,** 39-75.

NELSON, R. E. 1989. The Strength of Strong Ties: Social Networks and Intergroup Conflict in Organizations. *Academy of Management Journal,* 32**,** 377-401.

NEWBERT, S. L. 2007. Empirical research on the resource‐based view of the firm: an assessment and suggestions for future research. *Strategic management journal,* 28**,** 121-146.

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.

O'SHEA, R. P., CHUGH, H. & ALLEN, T. J. 2008. Determinants and consequences of university spinoff activity: a conceptual framework. *The Journal of Technology Transfer,* 33**,** 653-666.

OLOFSSON, C. & WAHLBIN, C. 1984. Technology-based new ventures from technical universities: A Swedish case. *Frontiers of entrepreneurship research***,** 192-211.

PENROSE, E. T. 1959. The Theory of the Growth of theFirm. *London: BlackwellsPenroseThe Theory of Growth of the Firm1959.*

PENROSE, E. T. 1995. *The Theory of the Growth of the Firm*, Oxford university press.

PÉREZ PÉREZ, M. & SÁNCHEZ, A. M. 2003. The development of university spin-offs: early dynamics of technology transfer and networking. *Technovation,* 23**,** 823-831.

POLANYI, M. 2012. *Personal knowledge: Towards a post-critical philosophy*, University of Chicago Press.

PORTER, M. E. 1981. The contributions of industrial organization to strategic management. *Academy of management review,* 6**,** 609-620.

POWERS, J. B. & MCDOUGALL, P. P. 2005. University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship. *Journal of Business Venturing,* 20**,** 291-311.

RASMUSSEN, E., BORLAUG, S. B. & BULANOVA, O. 2013. Verdiskaping i forskningsbaserte selskaper og lisenser støttet av FORNY-programmet.

RASMUSSEN, E., BULANOVA, O., JENSEN, A. & CLAUSEN, T. 2012. The Impact of Science-Based Entrepreneurial Firms-a Literature Review and Policy Synthesis. *Report 3-2012***,** 154.

ROBERTS, E. B. 1991. *Entrepreneurs in high technology: Lessons from MIT and beyond*, Oxford University Press New York.

ROBERTS, E. B. & HAUPTMAN, O. 1986. The process of technology transfer to the new biomedical and pharmaceutical firm. *Research Policy,* 15**,** 107-119.

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.

ROTHAERMEL, F. T., AGUNG, S. D. & JIANG, L. 2007. University entrepreneurship: a taxonomy of the literature. *Industrial and corporate change,* 16**,** 691-791.

ROTHAERMEL, F. T. & THURSBY, M. 2005. Incubator firm failure or graduation?: The role of university linkages. *Research policy,* 34**,** 1076-1090.

ROURE, J. B. & KEELEY, R. H. 1990. Predictors of success in new technology based ventures. *Journal of business venturing,* 5**,** 201-220.

SANTALA, M. & PARVINEN, P. 2007. From strategic fit to customer fit. *Management Decision,* 45**,** 582-601.

SAPIENZA, H. J. 1992. When do venture capitalists add value? *Journal of Business Venturing,* 7**,** 9-27.

SCHERER, F. M. & ROSS, D. 1990. Industrial market structure and economic performance. *University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship*.

SEPPÄ, T. J. & LAAMANEN, T. 2001. Valuation of venture capital investments: empirical evidence. *R&D Management,* 31**,** 215-230.

SHANE, S. 2001. Technology regimes and new firm formation. *Management science,* 47**,** 1173-1190.

SHANE, S. 2004. *Academic entrepreneurship: University spinoffs and wealth creation*, Edward Elgar Publishing.

SHANE, S. & CABLE, D. 2002. Network Ties, Reputation, and the Financing of New Ventures. *Management Science,* 48**,** 364-381.

SHANE, S. & STUART, T. 2002. Organizational Endowments and the Performance of University Start-ups. *Management Science,* 48**,** 154-170.

SHORT, J. C., KETCHEN, D. J., COMBS, J. G. & IRELAND, R. D. 2010. Research methods in entrepreneurship Opportunities and challenges. *Organizational Research Methods,* 13**,** 6-15.

SILBER, W. L. 1991. Discounts on restricted stock: The impact of illiquidity on stock prices. *Financial Analysts Journal,* 47**,** 60-64.

SPENCE, A. M. & MICHAEL, A. 1974. *Market signaling: Informational transfer in hiring and related screening processes*, Harvard University Press Cambridge, MA.

STARR, J. A. & MACMILLAN, I. 1990. Resource cooptation via social contracting: Resource acquisition strategies for new ventures. *Strategic Management Journal,* 11**,** 79-92.

STEFFY, B. D. & MAURER, S. D. 1988. Conceptualizing and measuring the economic effectiveness of human resource activities. *Academy of Management Review,* 13**,** 271-286.

STERNBERG, R. 2014. Success factors of university-spin-offs: Regional government support programs versus regional environment. *Technovation,* 34**,** 137-148.

STEVENS, J. P. 2012. *Applied multivariate statistics for the social sciences*, Routledge.

STUART, T. E. 2000. Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. *Strategic management journal,* 21**,** 791-811.

STUDENMUND, A. H. 2011. Using econometrics: A practical guide.

SZILAGYI, A. D., JR. & SCHWEIGER, D. M. 1984. Matching Managers to Strategies: A Review and Suggested Framework. *The Academy of Management Review,* 9, 626-637.

TABACHNICK, B. & FIDELL, L. 1996. Using multivariate statistics.

TIMMONS, J. A. & SPINELLI, S. 2004. *New venture creation: entrepreneurship for the 21st century*, McGraw-Hill/Irwin.

VISINTIN, F. & PITTINO, D. 2014. Founding team composition and early performance of university—Based spin-off companies. *Technovation,* 34, 31-43.

VOHORA, A., LOCKETT, A. & WRIGHT, M. Critical junctures in the growth in university high-tech spinout companies. Conference paper at Frontiers of Entrepreneurship Research, University of Colorado, 2002.

WALTER, A., AUER, M. & RITTER, T. 2006. The impact of network capabilities and entrepreneurial orientation on university spin-off performance. *Journal of Business Venturing,* 21, 541-567.

WHITLEY, R. 1989. On the nature of managerial tasks and skills: their distinguishing characteristics and organization. *Journal of Management Studies,* 26, 209-224.

WIDDING, L. O., MATHISEN, M. T. & MADSEN, O. 2009. University-affiliated venture capital funds: Funding of university spin-off companies. *International Journal of Technology Transfer and Commercialisation,* 8, 229-245.

WILKINS, A. L. 1989. *Developing corporate character: How to successfully change an organization without destroying it*, Jossey-Bass.

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

WRIGHT, P. M., MCMAHAN, G. C. & MCWILLIAMS, A. 1994. Human resources and sustained competitive advantage: a resource-based perspective. *International journal of human resource management,* 5, 301-326.

ZAHRA, S. A. & BOGNER, W. C. 2000. Technology strategy and software new ventures' performance: exploring the moderating effect of the competitive environment. *Journal of business venturing,* 15, 135-173.

ZANDER, I. & ZANDER, U. 2005. The Inside Track: On the Important (But Neglected) Role of Customers in the Resource‐Based View of Strategy and Firm Growth*. *Journal of Management Studies,* 42, 1519-1548.

ZERBINATI, S., SOUITARIS, V. & MORAY, N. 2012. Nurture or nature? The growth paradox of research-based spin-offs. *Technology Analysis & Strategic Management,* 24, 21-35.

ZHANG, J. 2009. The performance of university spin-offs: an exploratory analysis using venture capital data. *The Journal of Technology Transfer,* 34, 255-285.

ZUCKER, L. G., DARBY, M. R. & ARMSTRONG, J. 1998. Geographically localized knowledge: spillovers or markets? *Economic Inquiry,* 36, 65-86.

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

Article 1

Article 2

Appendix 1 - Search Phrase

"academic new venture*" OR "academic spin-off*" OR "academic spin-out*" OR "academic spinoff*" OR "academic spinout*" OR "academic new firm*" OR "academic entrepreneurial" OR "academic entrepreneurship" OR "academic start up*" OR "academic spinning out" OR "faculty new venture*" OR "faculty spin-off*" OR "faculty spin-out*" OR "faculty spinoff*" OR "faculty spinout*" OR "faculty new firm*" OR "faculty entrepreneurial" OR "faculty entrepreneurship" OR "faculty start up*" OR "faculty spinning out" OR "research-based new venture*" OR "research-based spin-off*" OR "research-based spin-out*" OR "research-based spinoff*" OR "research-based spinout*" OR "research-based new firm*" OR "research-based entrepreneurial" OR "research-based entrepreneurship" OR "research-based start up*" OR "research-based spinning out" OR "science-based new venture*" OR "science-based spin-off*" OR "science-based spin-out*" OR "science-based spinoff*" OR "science-based spinout*" OR "science-based new firm*" OR "science-based entrepreneurial" OR "science-based entrepreneurship" OR "science-based start up*" OR "science-based spinning out" OR "scientist new venture*" OR "scientist spin-off*" OR "scientist spin-out*" OR "scientist spinoff*" OR "scientist spinout*" OR "scientist new firm*" OR "scientist entrepreneurial" OR "scientist entrepreneurship" OR "scientist start up*" OR "scientist spinning out" OR "university new venture*" OR "university spin-off*" OR "university spin-out*" OR "university spinoff*" OR "university spinout*" OR "university new firm*" OR "university entrepreneurial" OR "university entrepreneurship" OR "university start up*" OR "university spinning out”

Appendix 2 – Articles from structured literature review

Author(s)	Title	Citations	Journal
Criaco et al. (2013)	''To have and have not'': founders' human capital and university start-up survival	10 GS (1 ISI)	The Journal of Technology Transfer
Sternberg (2014)	Success factors of university-spin-offs: Regional government support programs versus regional environment	7 GS	Technovation
Visintin and Pittino (2014)	Founding team composition and early performance of university—Based spin-off companies	3 GS	Technovation
Hirai et al. (2013)	Empirical analysis of the effect of Japanese university spinoffs' social networks on their performance	2 GS	Technological Forecasting and Social Change
Bigliardi et al. (2013)	Evaluating Performance of University Spin-Off Companies: Lessons from Italy	2 GS	Journal of technology management & innovation
Lubik et al. (2013)	Value creation from the innovation environment: partnership strategies in university spin-outs	5 GS (3 ISI)	R&D Management
Hayter (2013)	Harnessing University Entrepreneurship for Economic Growth: Factors of Success Among University	4 GS (2 ISI)	Economic Development Quarterly
Marion et al. (2012)	The university entrepreneur: a census and survey of attributes and outcomes	6 GS	R&D Management
Fuller and Rothaermel (2012)	When Stars Shine: The Effects Of Faculty Founders On New Technology Ventures	9 GS (2 ISI)	Strategic Entrepreneurship Journal
Wright et al. (2012)	Strategic entrepreneurship, resource orchestration and growing spin-offs from universities	9 GS (1 ISI)	Technology Analysis & Strategic Management
Zerbinati et al. (2012)	Nurture or nature? The growth paradox of research-based spin-offs	1 GS	Technology Analysis & Strategic Management
Wennberg et al. (2011)	The effectiveness of university knowledge spillovers: Performance differences between university spinoffs and corporate spinoffs	52 GS (14 ISI)	Research Policy
Clarysse et al. (2011)	Entrepreneurial Origin, Technological Knowledge, and the Growth of Spin-Off Companies	54 GS (18 ISI)	Journal of Management Studies
Knockaert et al. (2011)	The Relationship Between Knowledge Transfer, Top Management Team Composition, and Performance: The Case of Science-Based Entrepreneurial Firms	48 GS (12 ISI)	Entrepreneurship Theory and Practice

Zhang (2009)	The performance of university spin-offs: an exploratory analysis using venture capital data	85 GS (26 ISI)	The Journal of Technology Transfer
Clarysse et al. (2007)	Academic spin-offs, formal technology transfer and capital raising	97 GS (34 ISI)	Industrial and Corporate Change
Lawton Smith and Ho (2006)	Measuring the performance of Oxford University, Oxford Brookes University and the government laboratories' spin-off companies	82 GS (21 ISI)	Research Policy
Walter et al. (2006)	The impact of network capabilities and entrepreneurial orientation on university spin-off performance	461 GS (116 ISI)	Journal of Business Venturing
Powers and McDougall (2005)	University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship	348 GS (95 ISI)	Journal of Business Venturing
Shane and Stuart (2002)	Organizational Endowments and the Performance of University Start-Ups	975 GS (333 ISI)	Management science
Bonardo et al. (2011)	Valuing University Based Firms: The Effects of Academic Affiliation on IPO Performance	34 GS	Entrepreneurship Theory and Practice
Colombo et al. (2010)	Dynamics of science-based entrepreneurship	42 GS (15 ISI)	The Journal of Technology Transfer
Djokovic and Souitaris (2008)	Spinouts from academic institutions: a literature review with suggestions for further research	178 GS (42 ISI)	The Journal of Technology Transfer
O'Shea et al. (2005)	Entrepreneurial orientation, technology transfer and spinoff performance of US universities	456 GS	Research Policy
Zucker et al. (1998)	Geographically localized knowledge: spillovers or markets?	824 GS	Economic Inquiry
Di Gregorio and Shane (2003)	Why do some universities generate more start-ups than others?	912 GS	Research policy
Roberts and Hauptman (1986)	The process of technology transfer to the new biomedical and pharmaceutical firm	40 GS (16 ISI)	Research Policy
Birley (1986)	The role of networks in the entrepreneurial process	1626 GS	Journal of business venturing
Gurdon and Samsom (2010)	A longitudinal study of success and failure among scientist-started ventures	34 GS	Technovation
Mustar et al. (2008)	University spin-off firms: lessons from ten years of experience in Europe	54 GS	Science and Public Policy
Soetanto and Van Geenhuizen (2010)	Social Capital Through Networks: The Case Of University Spin Off Firms In Different Stages	9 GS (6 ISI)	Tijdschrift voor economische en sociale geografie

Rothaermel and Thursby (2005)	Incubator firm failure or graduation?: The role of university linkages	207 GS	Research policy
Agarwal and Shah (2014)	Knowledge sources of entrepreneurship: Firm formation by academic, user and employee innovators	2 GS	Research Policy
Ortín-Ángel and Vendrell-Herrero (2014)	University spin-offs vs. other NTBFs: Total factor productivity differences at outset and evolution	4 GS	Technovation
Festel (2013)	Academic spin-offs, corporate spin-outs and company internal start-ups as technology transfer approach	11 GS (2 ISI)	The Journal of Technology Transfer
Rothaermel et al. (2007)	University entrepreneurship: a taxonomy of the literature	640 GS (216 ISI)	Industrial and corporate change
De Coster and Butler (2005)	Assessment of proposals for new technology ventures in the UK: characteristics of university spin-off companies	78 GS (20 ISI)	Technovation
Vohora et al. (2004)	Critical junctures in the development of university high-tech spinout companies	606 GS (180 ISI)	Research policy
Shane (2004)	Academic entrepreneurship: University spinoffs and wealth creation	966 GS	
Ensley and Hmieleski (2005)	A comparative study of new venture top management team composition, dynamics and performance between university-based and independent start-ups	214 GS (59 ISI)	Research Policy
Nelsen (1991)	The lifeblood of biotechnology: University-industry technology transfer	33 GS	The business of biotechnology: from the bench to the street
del Campo et al. (1999)	The transfer and commercialization of university-developed medical imaging technology: opportunities and problems	28 (9 ISI)	IEEE Transactions on Engineering Management
Landry et al. (2006)	Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities	172 GS	Research Policy
Ortín-Ángel and Vendrell-Herrero (2010)	Why do university spin-offs attract more venture capitalists?	8 GS	Venture Capital

Appendix 3 - Codebook

Variable	Coding instructions	Variable in analysis	Measure
General information			
Forny ID	Unique ID from FORNY Database		Nominal
OrgNr	Organizational number of the company		Nominal
Initial Name	Name of the company		Nominal
Comment	Comments on coding problems and method of valuation		Nominal
Founded Year	Year of founding		Scale
TTO	Name of TTO involved		Nominal
Year T	Year of shutdown for unsuccessful firms, acquisition for acquired firms, or year of last annual report for companies still operating		Ordinal
Age at T	Year of founding minus year T	Control variable	Scale
M&A Year	Year of acquisition for acquired companies.		Ordinal
Valuation information			
Industry(Damodaran)	Industry mapping in accordance with Damodaran		Nominal
Industry(Ycharts)	Industry mapping in accordance with Ycharts		Nominal
Value Categorical	Coded as either 'unsucessfull', 'Still operating' or 'M&A'		Nominal
Value Integer	Unsuccessfull=0, Still operating=1, M&A=2		Ordinal
OSEBX	Value of OSEBX index on Jan 1st, second year of operations		Scale
Market Size(Ycharts)	Market size of the industry from Ycharts	Control Variable	Scale
EV/EBITDA (Damodaran)	Multiple retrived from Damodaran		Scale
EV/EBITDA (Ycharts)	Multiple retrived from Ycharts		Scale
EV/Revenue (Damodaran)	Multiple retrived from Damodaran		Scale
EV/Revenue (Ycharts)	Multiple retrived from Ycharts		Scale
Yearly revenue between founding and year T	15 variables indicating yearly revenue from founding to year T		Scale
Earnings Year T	Earnings in year T retrieved from Proff		Scale
EBITDA Year T	EBITDA in year T retrieved from Proff		Scale
Year-over-year Growth Between year T and founding	13 variables indicating revenue growth year-over-year from founding til year T		Scale
Geometric Growth	Geometric growth in revenues from first year of sales til year T		Scale
Aritmetic Growth	Arithmetic growth in revenues from first year of sales til Year T		Scale
Value (PEG_Damodaran)	Value of company using PEG multiple retrived from Damodaran		Scale

Value (PEG_Ycharts)	Value of company using PEG multiple retrived from Ycharts		Scale
Value(EV/EBITDA_Damodaran)	Value of company using EV/EBITDA multiple retrived from Damodaran		Scale
Value (EV/EBITDA_Ycharts)	Value of company using EV/EBITDA multiple retrived from Ycharts		Scale
Value(EV/Sales_Damodaran)	Value of company using EV/Sales multiple retrived from Damodaran		Scale
Value(EV/Sales_Ycharts)	Value of company using EV/Sales multiple retrived from Ycharts		Scale
Debt year T	Debt on balance sheet in year T - retrieved from Proff.		Scale
Cash & Equivalents year T	Cash and cash equivalents on balance sheet in year T - retrieved from Proff.		Scale
Value(before discount)	The value of the company based on the chosen multiples.		Scale
Conducted first sale	Coded '1' if the company has conducted their first commercial sale		Ordinal
Iliquidity discount	Illiquidity discount in accordance with Silber (see appendix 6).		Scale
Company Value	The estimated company value after the illiquidity discount is applied.		Scale
Company Value Transformed	1+ln(Company Value)	Dependent variable	Scale
Human Resources			
Team Technical Experience	Coded as either 'student', 'Forskningsassistent', 'PhD. kandidat', 'Amanuensis', 'Førsteamanuensis', 'Professor', 'Departementsleder eller forskningsinstituttleder', or 'Institutt professor', based on the highest academic rank amongst the founders.		Ordinal
Team Technical Experience(integer)	Coded '1' if the company has technical experience in the founding team		Ordinal
Team Marketing Experience	Coded '1' if the company has marketing experience in the founding team		Ordinal
Team Financial Experience	Coded '1' if the company has financial experience in the founding team		Ordinal
Team ManagementExperience	Coded '1' if the company has management experience in the founding team		Ordinal
Team Startup Experience	Coded '1' if the company has startup experience in the founding team		Ordinal
Team Industry Experience	Coded '1' if the company has industry experience in the founding team		Ordinal
Team Heterogeneity	The sum of the binary variables 'Team technical experience(integer)', 'Team marketing experience', 'Team financial experience', 'Team management experience', 'Team startup experience', and 'Team industy experience'.		Scale
Team Heterogeneity Transformed	1+ln(Team Heterogeneity)	Independent variable	Scale
Inventor on Team	Coded '1' if at least one of the technology inventors are on the fouding team	Independent variable	Ordinal
Inventor Renownedness	The total citaton count up until 2 years after the company is founded of all founders as calculate by Google Scholar.		Scale
Inventor Renownedness Transformed	1+ln(Inventor Renownedness)	Independent variable	Scale

Social Resources			
Parent Institution	Name of parent university		Nominal
Parent Ranking	Ranking of parent university in accordance with Webometrics		Scale
Quality of parent university	Inverse of parent ranking (1000/parent_rank)	Independent variable	Scale
Team Years of Employment at Parent	The total number of years the founders have worked/researched at the parent university up until 2 years after the company was founded.	Independent variable	Scale
Financial Resources			
Investor Capital	Coded '1' if the company has received investor funding during its first two years of operations		
Technological Resources			
#Patents Filed	The total number of patents filed during or prior to 2 years after the company being founded where the company is listed as assignee		Scale
#Claims on Patents Filed	The total number of citations on all filed patents		Scale
Name of patents filed	The names on filed patents		Nominal
#Patents Published	The total number of patents published during or prior to 2 years after the company being founded where the company is listed as assignee		Scale
# Claims on Patents Published	The total number of citations on all published patents		Scale
Name of patents published	The names on published patents		Nominal
Number of patents	The sum of #patents filed and #patents published		Scale
Number of patents Transformed	1-1/(1+Number of patents)	Independent variable	Scale

Appendix 4 - Descriptives

Descriptives After Transformation

Variable	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis		Shapiro-Wilk		
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error	Statistic	df	Sig.
Company Value (transformed)	63	0	20,0407519	6,88383237	8,359834129	69,88682667	0,42352599	0,30158857	-1,797988	0,59484062	0,68992287	63	3,0035E-10
Human Resources													
Inventor on founding team	63	0	1	0,88888889	0,316793976	0,100358423	-2,5356501	0,30158857	4,57377049	0,59484062	0,36396492	63	4,8484E-15
Inventor renownedness (transformed)	63	0	9,7217858	4,27373482	3,192697293	10,193316	-0,1792133	0,30158857	-1,3975119	0,59484062	0,88828618	63	3,3944E-05
Team heterogeneity (transformed)	63	0	1,94591015	1,05732398	0,411302857	0,16917004	-0,0257955	0,30158857	0,02511675	0,59484062	0,90809878	63	0,00018432
Social Resources													
Ties to parent university	63	0	54	17,3968254	13,70959128	187,952893	0,67046479	0,30158857	-0,4408559	0,59484062	0,92285007	63	0,00072782
Parent university quality (transformed)	63	0,1496334	14,7058824	5,98954308	4,867322128	23,6908247	0,58323494	0,30158857	-0,5790366	0,59484062	0,83427262	63	6,621E-07
Financial Resources													
Investor capital	63	0	1	0,20634921	0,407934615	0,16641065	1,48689852	0,30158857	0,21672636	0,59484062	0,4968968	63	2,3041E-13
Technological Resources													
Number of patents (transformed)	63	0	0,99047619	0,26945744	0,390995877	0,152877776	0,82089374	0,30158857	-1,2697309	0,59484062	0,64416791	63	4,3562E-11
Control Variables													
Company age	63	1	13	8,36507937	3,456184673	11,94521249	-0,4935447	0,30158857	-0,8438655	0,59484062	0,93212978	63	0,0018282
Market size (MUSD)	63	25081,0071	1415745,12	429837,388	368827,953	1,36034E+11	1,3648623	0,30158857	1,46986127	0,59484062	0,83320955	63	6,1759E-07

Descriptives Before Transformation

Variable	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis		Shapiro-Wilk		
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error	Statistic	df	Sig.
Company Value	63	0	505345000	30847241,8	97404974,1	9,48773E+15	4,05987085	0,30158857	16,0063395	0,59484062	0,34808519	63	3,1831E-15
Human Resources													
Inventor on founding team	63	0	1	0,88888889	0,316793976	0,100358423	-2,5356501	0,30158857	4,57377049	0,59484062	0,36396492	63	4,8484E-15
Inventor renownedness	63	68	6683	934,333333	1512,818551	2288619,968	2,29378973	0,30158857	5,47323294	0,59484062	0,61269135	63	1,2705E-11
Team heterogeneity	63	0	104	3,41269841	13,24780556	175,5043523	7,29071394	0,30158857	55,9121035	0,59484062	0,2389605	63	2,1285E-16
Social Resources													
Ties to parent university	63	0	54	17,3968254	13,70959128	187,952893	0,67046479	0,30158857	-0,4408559	0,59484062	0,92285007	63	0,00072782
Parent university quality (1000/rank)	63	0	6	2,12698413	1,313602084	1,725550435	0,94886563	0,30158857	0,40611251	0,59484062	0,87110329	63	8,8208E-06
Financial Resources													
Investor capital	63	0	1	0,20634921	0,407934615	0,16641065	1,48689852	0,30158857	0,21672636	0,59484062	0,4968968	63	2,3041E-13
Technological Resources													
Number of patents	63	0	16676	1219,22222	2749,235527	7558295,982	3,80719126	0,30158857	17,061174	0,59484062	0,49515381	63	2,1806E-13
Control Variables													
Company age	63	1	13	8,36507937	3,456184673	11,94521249	-0,4935447	0,30158857	-0,8438655	0,59484062	0,93212978	63	0,0018282
Market size (MUSD)	63	25081,0071	1415745,12	429837,388	368827,953	1,36034E+11	1,3648623	0,30158857	1,46986127	0,59484062	0,83320955	63	6,1759E-07

Appendix 5 - SPSS Model Information

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Age_at_T, Market Size_Ycharts[a]	.	Enter
2	Team_ Heterogeneity _Transformed , Inventor_ Renownednes s_ Transformed, Investor_ capital, Quality_Of_ Parent_ Transformed, Inventor_on_ Team, Number_of_ patents_ Transformed, Ties_To_ Parent[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Company_Value_Transformed

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.495[a]	.245	.220	7.38255	.245	9.751	2
2	.685[b]	.469	.378	6.59086	.223	3.183	7

a. Predictors: (Constant), Age_at_T, Market Size_Ycharts

b. Predictors: (Constant), Age_at_T, Market Size_Ycharts, Team_Heterogeneity_Transformed, Inventor_Renownedness_Transformed, Investor_capital, Quality_Of_Parent_Transformed, Inventor_on_Team, Number_of_patents_Transformed, Ties_To_Parent

c. Dependent Variable: Company_Value_Transformed

Model Summary[c]

Model	Change Statistics		Durbin-Watson
	df2	Sig. F Change	
1	60	.000	
2	53	.007	1.837

c. Dependent Variable: Company_Value_Transformed

ANOVA[c]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1062.859	2	531.430	9.751	.000[a]
	Residual	3270.124	60	54.502		
	Total	4332.983	62			
2	Regression	2030.691	9	225.632	5.194	.000[b]
	Residual	2302.292	53	43.439		
	Total	4332.983	62			

a. Predictors: (Constant), Age_at_T, Market Size_Ycharts

b. Predictors: (Constant), Age_at_T, Market Size_Ycharts, Team_Heterogeneity_Transformed, Inventor_Renownedness_Transformed, Investor_capital, Quality_Of_Parent_Transformed, Inventor_on_Team, Number_of_patents_Transformed, Ties_To_Parent

c. Dependent Variable: Company_Value_Transformed

Excluded Variables [b]

Model		Beta In	t	Sig.	Partial Correlation
1	Inventor_on_Team	.122[a]	1.054	.296	.136
	Team_Heterogeneity_ Transformed	.231[a]	2.095	.040	.263
	Number_of_patents_ Transformed	.257[a]	2.223	.030	.278
	Quality_Of_Parent_ Transformed	.268[a]	2.288	.026	.286
	Investor_capital	-.077[a]	-.644	.522	-.084
	Inventor_Renownedness_ Transformed	.164[a]	1.428	.158	.183
	Ties_To_Parent	.343[a]	3.098	.003	.374

a. Predictors in the Model: (Constant), Age_at_T, Market Size_Ycharts

b. Dependent Variable: Company_Value_Transformed

Excluded Variables [b]

Model		Collinearity Statistics		
		Tolerance	VIF	Minimum Tolerance
1	Inventor_on_Team	.943	1.060	.943
	Team_Heterogeneity_ Transformed	.979	1.021	.979
	Number_of_patents_ Transformed	.881	1.135	.881
	Quality_Of_Parent_ Transformed	.860	1.163	.860
	Investor_capital	.888	1.126	.887
	Inventor_Renownedness_ Transformed	.938	1.066	.938
	Ties_To_Parent	.896	1.116	.896

b. Dependent Variable: Company_Value_Transformed

Correlations

Pearson Correlation	Company_Value_Transformed	1.000	.025	.494	.200	.284	.391	.332	.097	.250	.401
	Market Size_Ycharts	.025	1.000	-.027	-.155	-.080	.111	.324	-.001	.166	.270
	Age_at_T	.494	-.027	1.000	.185	.123	.323	.180	.335	.182	.168
	Inventor_on_Team	.200	-.155	.185	1.000	.251	.047	-.089	.180	.299	.229
	Team_Heterogeneity_Transformed	.284	-.080	.123	.251	1.000	-.109	.098	.182	.144	.224
	Number_of_patents_Transformed	.391	.111	.323	.047	-.109	1.000	.038	.079	.328	.333
	Quality_Of_Parent_Transformed	.332	.324	.180	-.089	.098	.038	1.000	-.036	.186	.246
	Investor_capital	.097	-.001	.335	.180	.182	.079	-.036	1.000	.111	.054
	Inventor_Renownedness_Transformed	.250	.166	.182	.299	.144	.328	.186	.111	1.000	.393
	Ties_To_Parent	.401	.270	.168	.229	.224	.333	.246	.054	.393	1.000
Sig. (1-tailed)	Company_Value_Transformed	.	.422	.000	.058	.012	.001	.004	.224	.024	.001
	Market Size_Ycharts	.422	.	.418	.112	.267	.193	.005	.498	.097	.016
	Age_at_T	.000	.418	.	.073	.168	.005	.079	.004	.077	.093
	Inventor_on_Team	.058	.112	.073	.	.024	.357	.243	.079	.009	.035
	Team_Heterogeneity_Transformed	.012	.267	.168	.024	.	.197	.222	.076	.129	.039
	Number_of_patents_Transformed	.001	.193	.005	.357	.197	.	.384	.270	.004	.004
	Quality_Of_Parent_Transformed	.004	.005	.079	.243	.222	.384	.	.389	.072	.026
	Investor_capital	.224	.498	.004	.079	.076	.270	.389	.	.193	.336
	Inventor_Renownedness_Transformed	.024	.097	.077	.009	.129	.004	.072	.193	.	.001
	Ties_To_Parent	.001	.016	.093	.035	.039	.004	.026	.336	.001	.
N	Company_Value_Transformed	63	63	63	63	63	63	63	63	63	63
	Market Size_Ycharts	63	63	63	63	63	63	63	63	63	63
	Age_at_T	63	63	63	63	63	63	63	63	63	63
	Inventor_on_Team	63	63	63	63	63	63	63	63	63	63
	Team_Heterogeneity_Transformed	63	63	63	63	63	63	63	63	63	63
	Number_of_patents_Transformed	63	63	63	63	63	63	63	63	63	63
	Quality_Of_Parent_Transformed	63	63	63	63	63	63	63	63	63	63
	Investor_capital	63	63	63	63	63	63	63	63	63	63
	Inventor_Renownedness_Transformed	63	63	63	63	63	63	63	63	63	63
	Ties_To_Parent	63	63	63	63	63	63	63	63	63	63

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-3.503	2.710		-1.293	.201	-8.924	1.918					
	Market Size_Ycharts	8.736E-7	.000	.039	.344	.732	.000	.000	.025	.044	.039	.999	1.001
	Age_at_T	1.197	.271	.495	4.410	.000	.654	1.740	.494	.495	.495	.999	1.001
2	(Constant)	-10.008	3.746		-2.672	.010	-17.522	-2.495					
	Market Size_Ycharts	-1.985E-6	.000	-.088	-.777	.441	.000	.000	.025	-.106	-.078	.789	1.268
	Age_at_T	.797	.282	.330	2.824	.007	.231	1.364	.494	.362	.283	.736	1.359
	Inventor_on_Team	1.769	3.010	.067	.588	.559	-4.269	7.806	.200	.080	.059	.771	1.298
	Team_Heterogeneity_ Transformed	4.156	2.241	.204	1.854	.069	-.340	8.651	.284	.247	.186	.824	1.213
	Number_of_patents_ Transformed	5.607	2.532	.262	2.214	.031	.528	10.685	.391	.291	.222	.715	1.399
	Quality_Of_Parent_ Transformed	.405	.194	.236	2.089	.042	.016	.793	.332	.276	.209	.788	1.270
	Investor_capital	-1.648	2.236	-.080	-.737	.464	-6.133	2.836	.097	-.101	-.074	.842	1.187
	Inventor_Renownedness _Transformed	-.098	.308	-.037	-.318	.752	-.716	.520	.250	-.044	-.032	.723	1.383
	Ties_To_Parent	.111	.074	.182	1.493	.141	-.038	.260	.401	.201	.150	.674	1.483

a. Dependent Variable: Company_Value_Transformed

Coefficient Correlations[a]

Model			Age_at_T	Market Size_Ycharts	Team_Heterogeneity_Transformed	Inventor_Renownedness_Transformed	Investor_capital	Quality_Of_Parent_Transformed	Inventor_on_Team	Number_of_patents_Transformed	Ties_To_Parent
1	Correlations	Age_at_T	1.000	.027							
		Market Size_Ycharts	.027	1.000							
	Covariances	Age_at_T	.074	1.839E-8							
		Market Size_Ycharts	1.839E-8	6.467E-12							
2	Correlations	Age_at_T	1.000	.111	-.052	.015	-.311	-.232	-.118	-.307	.008
		Market Size_Ycharts	.111	1.000	.132	-.096	-.080	-.264	.177	-.011	-.228
		Team_Heterogeneity_Transformed	-.052	.132	1.000	-.061	-.142	-.085	-.133	.219	-.220
		Inventor_Renownedness_Transformed	.015	-.096	-.061	1.000	-.038	-.128	-.260	-.246	-.179
		Investor_capital	-.311	-.080	-.142	-.038	1.000	.118	-.082	.015	.050
		Quality_Of_Parent_Transformed	-.232	-.264	-.085	-.128	.118	1.000	.160	.131	-.141
		Inventor_on_Team	-.118	.177	-.133	-.260	-.082	.160	1.000	.107	-.181
		Number_of_patents_Transformed	-.307	-.011	.219	-.246	.015	.131	.107	1.000	-.276
		Ties_To_Parent	.008	-.228	-.220	-.179	.050	-.141	-.181	-.276	1.000
	Covariances	Age_at_T	.080	7.987E-8	-.033	.001	-.196	-.013	-.100	-.219	.000
		Market Size_Ycharts	7.987E-8	6.528E-12	7.583E-7	-7.531E-8	-4.592E-7	-1.306E-7	1.360E-6	-7.045E-8	-4.338E-8
		Team_Heterogeneity_Transformed	-.033	7.583E-7	5.024	-.042	-.711	-.037	-.900	1.242	-.037
		Inventor_Renownedness_Transformed	.001	-7.531E-8	-.042	.095	-.026	-.008	-.241	-.192	-.004
		Investor_capital	-.196	-4.592E-7	-.711	-.026	4.998	.051	-.555	.086	.008
		Quality_Of_Parent_Transformed	-.013	-1.306E-7	-.037	-.008	.051	.038	.093	.064	-.002
		Inventor_on_Team	-.100	1.360E-6	-.900	-.241	-.555	.093	9.060	.814	-.041
		Number_of_patents_Transformed	-.219	-7.045E-8	1.242	-.192	.086	.064	.814	6.411	-.052
		Ties_To_Parent	.000	-4.338E-8	-.037	-.004	.008	-.002	-.041	-.052	.006

a. Dependent Variable: Company_Value_Transformed

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions									
				(Constant)	Market Size_Ycharts	Age_at_T	Inventor_on_Team	Team_Heterogeneity_Transformed	Number_of_patents_Transformed	Quality_Of_Parent_Transformed	Investor_capital	Inventor_Renownedness_Transformed	Ties_To_Parent
1	1	2.594	1.000	.02	.05	.02							
	2	.337	2.774	.03	.86	.10							
	3	.069	6.128	.96	.09	.88							
2	1	7.177	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	.784	3.026	.00	.02	.00	.00	.00	.00	.02	.73	.00	.01
	3	.645	3.335	.00	.01	.00	.00	.01	.59	.03	.00	.01	.01
	4	.420	4.134	.00	.39	.01	.03	.02	.00	.09	.13	.01	.00
	5	.282	5.044	.00	.07	.04	.00	.00	.13	.34	.00	.16	.23
	6	.262	5.238	.01	.34	.01	.01	.00	.03	.38	.02	.14	.11
	7	.220	5.709	.00	.02	.00	.00	.01	.00	.00	.00	.59	.53
	8	.096	8.666	.00	.00	.47	.01	.55	.20	.02	.02	.00	.06
	9	.078	9.584	.01	.00	.34	.58	.21	.04	.11	.03	.06	.00
	10	.036	14.162	.97	.15	.14	.37	.19	.01	.00	.06	.01	.05

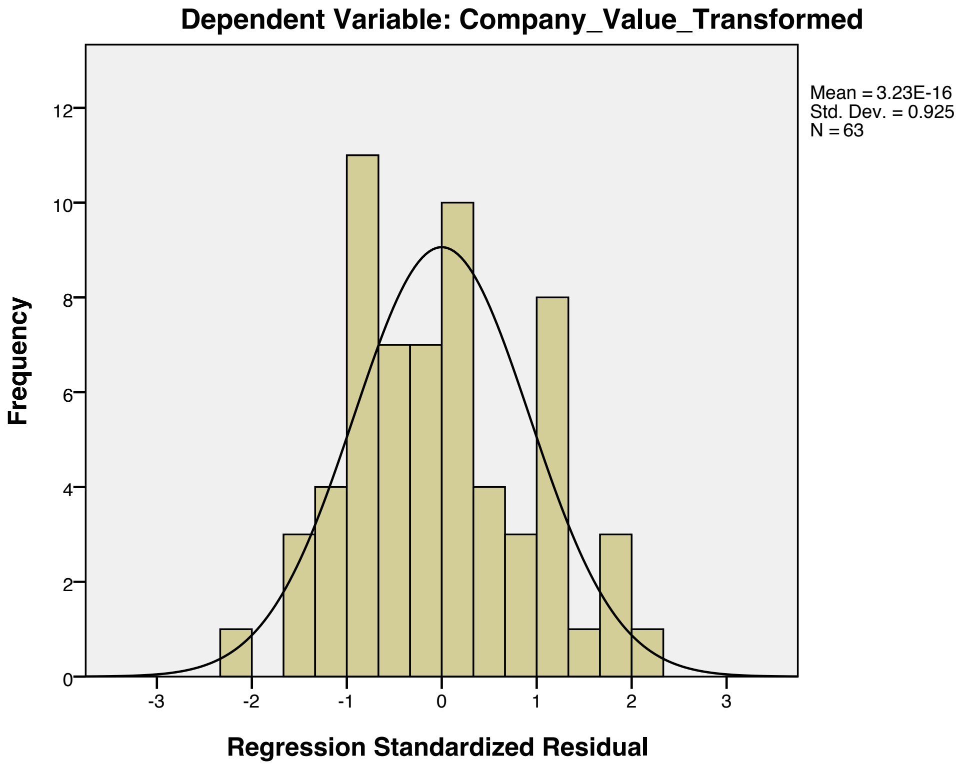
a. Dependent Variable: Company_Value_Transformed

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.6374	22.9894	6.8838	5.72303	63
Std. Predicted Value	-2.013	2.814	.000	1.000	63
Standard Error of Predicted Value	1.645	3.875	2.570	.545	63
Adjusted Predicted Value	-5.2705	26.3584	6.9255	5.99037	63
Residual	-13.28685	13.41070	.00000	6.09375	63
Std. Residual	-2.016	2.035	.000	.925	63
Stud. Residual	-2.157	2.265	-.003	1.017	63
Deleted Residual	-15.21210	16.86695	-.04166	7.39411	63
Stud. Deleted Residual	-2.237	2.360	.000	1.033	63
Mahal. Distance	2.878	20.452	8.857	4.287	63
Cook's Distance	.000	.176	.022	.035	63
Centered Leverage Value	.046	.330	.143	.069	63

a. Dependent Variable: Company_Value_Transformed

Appendix 6 - Normality of Residuals



Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual	.072	63	.200*	.980	63	.395

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

Appendix 7 - Illiquidity Discount

Silber's (1991) equation:

LN(RPRS)=4,33+ 0,036*LN(REV) - 0,142*LN (RBRT) + 0,174*(DERN) + 0,332*DCUST

RPRS: Relative price of restricted stock expressed in percentage terms

$[(p_r/p_c)*100]$

REV: Firms revenues in MUSD

RBRT: Size of the restricted block of shares relative to total common stock (in per cent, and equals 100 in our case of private firms).

DERN: Dummy variable equal to 1 if the firm has positive earnings.

DCUST: Dummy variable equal to 1 if there is a customer relationship between investor and firm.

Calculated illiquidity discount in valuation model:

$$\text{Illiquidity Discount} = \begin{cases} (1+[100 - EXP(4{,}33+ 0{,}036*LN(REV_i) - 0{,}142*LN\ (RBRT_i) + 0{,}174*(DERN_i)+0{,}332*DCUST_i)])/100 & \text{, IF public multiple is used} \\ 1 & \text{,IF private multiple is used} \end{cases}$$