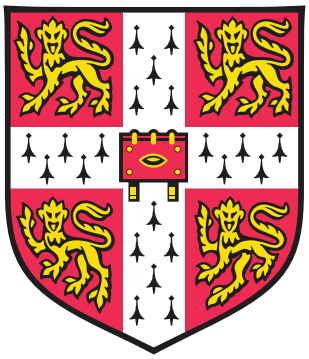
Six degrees of early-stage ventures



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April 2020

This dissertation is submitted for the degree of Doctor of Philosophy

I dedicate this thesis to my loving family...

Declaration

This dissertation is the result of my own work, except for commonly understood ideas or where specific references are made, and includes nothing which is the outcome of work done in collaboration. It is not substantially the same as any work that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or other University.

The dissertation consists of 63273 words, and 36 figures. Therefore, it does not exceed the prescribed word limit of 65,000 words and 150 figures for the relevant Degree Committee of the Department of Engineering.

Marc Felske
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Abstract

Six degrees of early stage ventures

Marc Felske

Private markets investment volume and valuations exceed the level of the dot-com bubble (PwC and CBInsights, 2019). The available amount of capital surges as investors announce new multi-billion dollar funds (Kruppa, 2019). Even large, institutional funds in the Silicon Valley, who are used to investing in later stages, move upstream to invest in fledgling firms to achieve higher ownership and returns (Clark, 2019a)[1]. Despite the high private market liquidity[2], standing out from the crowd is critical and has become more difficult to achieve, even for innovative entrepreneurs (Planko et al., 2017).

Curiously, venture capitalists who expect the latest technology and innovation from new ventures, did not themselves significantly innovate in their approach, including methods of evaluating ventures (Kupor, 2019). Few investors came up with new, differentiated investment strategies, one such example being data-driven investing (Pitchbook, 2018). Although venture capitalists seek to invest in firms which benefit substantially from the notion that "data is the new oil", few practice to leverage data for their investment process (Parkins, 2017; Dance et al., 2018; Arroyo et al., 2019; Gompers et al., 2020). Instead, the overwhelming majority adheres to the motto "picking investments is an art, not science" and relies primarily on its networks as the most valuable resource (Bell, 2014; Huang and Pearce, 2015; Gompers et al., 2020). Venture capitalists' focus on their social networks could not only negatively affect investment decisions and returns, but also promote group-think and stifle the progression of their investment thesis (Wuebker et al., 2015).

Reviewing the previous works on entrepreneurship, venture evaluation, and venture capital revealed a significant gap in the literature. While investors and entrepreneurs depend heavily on their social networks, these networks play an insignificant role

[1] In 2000, 848 early-stage ventures with headquarters in the US, UK, Germany, and France raised $5.5b venture capital funding across 866 funding rounds compared to 2018 when 10,885 early-stage ventures raised $31.0b capital across 12,399 deals. This data represents 62% of early-stage ventures and 63% of the globally committed capital in rounds up to Series A and is inflation adjusted (PitchBook Data, 2019).

[2] In 2000, 669 early-stage venture capital funds with headquarters in the US, UK, Germany, and France raised $193.2b compared to 2018 when 556 early-stage venture capital funds raised $452.4b. This data represents 93% of global early-stage funds and 92% of capital committed and is inflation adjusted (PitchBook Data, 2019).

in venture evaluation. The existing frameworks are inadequate to accurately assess early-stage ventures and thus a rethink of methodology is needed to better capture the networked nature of today's ventures (Miloud et al., 2012; Dusatkova and Zinecker, 2016). This thesis suggests a new perspective for early-stage venture evaluation, with particular focus on formalising the ventures' social networks.

Contributions made by this thesis are fourfold and relevant to entrepreneurs, investors, and academic theorists. Firstly, existing theories that explain venture fundraising success are expanded by adding a social network perspective. Secondly, this research provides a comprehensive overview of stakeholders' roles and their constellation in social networks around the entrepreneurs and their ventures. Thirdly, for entrepreneurs, different modes of leveraging their social networks for critical business functions are identified. Lastly, an evaluation tool for venture capitalists to the investability of early-stage ventures is developed. In summary, results provide new insights into entrepreneurial strategies for leveraging social networks to enhance operations, differentiate from competitors, send positive signals to investors, and ultimately improve the venture's assessment by the private market.

Acknowledgements

First of all, I am overly grateful to my PhD Supervisor, Tim Minshall. Without his close guidance, I would have been lost many times. His encouraging words reassured me that I could complete a nonconformist research project. Most importantly, every conversation with him left me pondering and the feeling that I learned even more about life than research.

My VC fund colleagues gave me a unique chance to work while studying and getting insights into the practitioner side. Such a double role and their willingness to sharing insights allowed me to learn fast and reshape my studies.

The time I spent in Cambridge was unforgettable. I feel fortunate that I was able to maintain existing friendships and forge many new ones. I want them to last forever, wherever our paths may lead. Being able to call the most humble, intelligent, loyal, and amiable quirky people my closest friends is the greatest gift. Listing any names would imply an order - so I will leave it here - you know exactly who you are.

The biggest thanks goes to my family.

Publication

Conference Paper

Felske, M., Foege, J. N., and Minshall, T. (2018). Spiders spinning their webs: Implications of social network constellations for early-stage venture valuation. In *World Open Innovation Conference 2018, Open Innovation and Performance: New Venture, WOIC 2018.*

Keywords

Venture capital, entrepreneurship, early-stage ventures, new business ventures, start-ups, evaluation, valuation, data-driven investing, social capital, social networks, social network analysis, models

Horizon expanding activities

		Industry experience
8/2018 to today	-	Associate with an early-stage VC fund *Starting the fund's European office*
4/2018 to 8/2018	-	Campus Associate with an early-stage VC fund *Deal screening and due diligence*
19x	-	Founder coffee sessions *Advising founders on fundraising*
9/2018	-	Internship with boutique consulting firm *Applying social network analysis in consulting context*
11/2018 to today	-	Member at Google for Startups Campus in London
3/2019 to today	-	Mentor in two early-stage accelerator programs *Mentored >50 founders on various topics*
		Conference attendances
1x	-	Cambridge Artificial Intelligence Summit
8/2019	-	Cambridge Networks Day 2019
2x	-	CUTEC Technology Ventures Conference
4/2019	-	Hannover Messe *Attending the worlds largest industrial trade show*
5/2017	-	IfM Briefing Day *Research presentation to industrial representatives*
2x	-	Tech Day London *Attending the UK's largest start-up roadshow*
11/2018	-	World Open Innovation Conference 2018 *Paper presentation*
		Venture ecosystem visits
2x	-	Aachen
1x	-	Berlin
1x	-	Frankfurt
33x	-	London
1x	-	Los Angeles
2x	-	Munich
1x	-	Paris
2x	-	Silicon Valley
2x	-	Zurich

		Demo day attendances
2x	-	Entrepreneur First Demo Day
3x	-	Founder's Factory Demo Day
1x	-	Hackbridge Demo Day
1x	-	Pitch@Palace
1x	-	Santander University Growth Accelerator Demo Day
2x	-	St. John's Innovation Centre Pitchfest
2x	-	RebelBio Demo Day
		Accelerator/Incubator visits
3x	-	Accelerate Cambridge
1x	-	Accelerate@Babraham
1x	-	AMRC Sheffield Innovation Centre
1x	-	BCG Digital Ventures
2x	-	Entrepreneur First London
1x	-	King's College London Innovation Group
5x	-	Google for Startups Campus
4x	-	IdeaSpace Cambridge
1x	-	Impact Hub Zurich
10x	-	RebelBio London
1x	-	Seedcamp London
1x	-	UCL Hatchery London
1x	-	Welcome Genome Campus Entrepreneurship and Innovation Centre
		Event attendances
1x	-	Camb.ai
1x	-	Cambridge Startup Billion Pound Scale-up
3x	-	Cambridge Tech and Beers
1x	-	Cambridge Startups Failure Party
1x	-	CAMentrepreneurs Launch Event
2x	-	CUE Business Plan Competition
6x	-	DeepTech Monday and DeepTech Friday
11x	-	Judge Business School Enterprise Tuesday
3x	-	Entrepreneurial Postdocs of Cambridge
2x	-	Innovation Forum Cambridge
1x	-	Image&Data: Analysis, Research, Translation day
2x	-	Investing in Deep Tech
1x	-	Venture Creation Weekend
2x	-	SV2Cambridge

Acronyms

AI Artificial intelligence

API Application programming interface

B2B Business to business

B2C Business to consumer

BM Business model

BMI Business model innovation

CEO Chief Executive Officer

CFO Chief Financial Officer

CIO Chief Information Officer

CMO Chief Marketing Officer

COO Chief Operating Officer

CRO Contract research organisation

CTO Chief Technology Officer

CVC Corporate venture capital

DT Decision tree

ESG Environmental, social, and governance factors

ESV Early-stage venture

FinTech Financial technology

GBT Gradient boosted tree

IP Intellectual property

IPO Initial public offering

LP Limited partner

M&A Merger and acquisition

ML Machine learning

OLS Ordinary least squares

PoC Proof of concept

PR Public relations

R&D Research and development

RF Random forest

ROI Return on investment

SEC Securities and Exchange Commission

SME Small and medium-sized enterprise

SNA Social network analysis

TTO Technology transfer officer

UK United Kingdom

US United States

VC Venture capital

VIF Variance inflation factor

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1. Introduction

Contents

1.1 Research problem

Venture capital (VC) has financed the commercial exploitation of some of the most outstanding technologies in the 20th and 21st centuries including several of today's largest corporations by market capitalisation (Gompers et al., 2020). Of the 1,339 United States (US) companies that went public between 1974 and 2015, 41.5% were VC backed (Kaplan and Lerner, 2010). In an average year between 1980 and 2010, these companies created 2.9 million jobs and today directly employ 20% of the US working population plus an additional 30% indirectly (NVCA, 2019). The 556 VC backed companies created a financial value representing 63% of the market capitalisation and account for 85% of total research and development (R&D) spending (Ramsinghani, 2014; Gornall and Strebulaev, 2015). During the 1990s, over 90% of global VC dollars were invested in the US. However, the rest of the world caught up and in 2018 the US accounted for 51% of the VC investment volume (PitchBook, 2020b; Crunchbase, 2020).

Airbnb
ByteDance
Cisco
DJI
Expedia
Facebook
Google
Hulu
Illumina
Juul
Kickstarter
Linkedin
Microsoft
Nvidia
Oculus
PayPal
Qualtrics
Rivian
SpaceX
Twitch
Uber
Venmo
WeWork
Xiaomi
YouTube
Zoom

When looking at the life-cycle of a venture, VCs are among the first investors who get involved as they fund entrepreneurs with ideas but insufficient capital in hopes for high returns (Gompers and Lerner, 1999). This thesis will demonstrate the complexity of investing into this high risk, illiquid asset class. The lead researcher of this thesis worked in the VC industry throughout most of the research period and his key learning was that VC is first and foremost a patience and networking game. Hence, the famous adage *"it's not what you know, it's whom you know"* suitably describes the VC world. The adage applies to both sides of the table, entrepreneurs and VCs, since founding a successful venture is a highly cooperative and multifaceted process, especially during its earliest stages (Hoffmann and Yeh, 2018).

For this thesis, early-stage ventures (ESVs), also commonly referred to as "startups", are understood as companies during their "company childhood" which is defined as the stage before reaching the growth phase and "company adulthood".

During an ESV's fledgling stages, entrepreneurs must look out for many different elements to increase their odds of success. For example, entrepreneurs search for promising ideas, market need, cost-effective development and production processes, efficient distribution channels, and a strong team. On top of this, entrepreneurs need to consider the right timing and location to release their idea into the market. Notably, each of these elements are difficult to quantify and therefore almost

immeasurable for a VC when sizing up the investment opportunity. This presents a research opportunity which into which this thesis delves deeply: *the pre-investment evaluation of ESVs.*

Evaluation of ESVs is not trivial, as a consequence of the lack of insightful and reliable information. Four trends amplify this uncertainty. Firstly, in the aftermath of the Dot-com bubble, VCs increasingly diversified their portfolios to be industry, technology, investment stage, and geography agnostic, as a means of mitigating investment risk (Matusik and Fitza, 2012). This diversification increases the due diligence effort for investment teams, as their domain experience from one evaluation rarely translates to the next. Secondly, the advent of accelerators and use of private market databases creates additional visibility of investment opportunities for investors[1] (Miller and Bound, 2011; Lyons and Zhang, 2018). What follows is a fast-paced environment in which decision-makers are forced to make decisions in very short periods of time. For instance, during pitching contests and demo days, multiple VCs might be bidding for the best deals, which compromises a deliberate, carefully considered investment decision (Hochberg, 2016). In such moments, VCs revert to heuristics and gut-instinct, which may lead to sub-optimal decisions (Zacharakis and Shepherd, 2001; Shepherd et al., 2003; Kahneman, 2013). Thirdly, later-staged VCs became increasingly comfortable investing in less mature ventures and crowded the private market (Kim and Wagman, 2016; Loizos, 2019a). The US enactment of the JOBS Act[2] and advent of equity crowdsourcing around the world were designed to lower the bar to become a VC. Lowering the bar, in turn, has successfully increased the number of investors, fund sizes, and the availability of capital[3]. Critics warn that capital is consequently exposed to higher risk, and the effects are already noticeable as the failure rate and cost of failure increased (Crunchbase, 2019; May, 2019; McMorrow, 2020). At the same time, companies stay private longer and the private market volume grows steadily (Loizos, 2019b). Finally, ESVs increasingly engage with external organisations to develop their products (Knoben and Bakker, 2019). This opening of the company borders can be attractive for ventures by helping alleviate financial constraints while mitigating risk and dependency (Crossley et al., 2015; Ng et al., 2014). While such collaboration is of vital impor-

[1] Before 2005, accelerator programs were not known in their current form. Today the largest association of accelerators, the Global Accelerator Network, counts 105 members who accelerated 1344 ESVs in 2018 (Global Accelerator Network, 2019).

[2] The "Jumpstart Our Business Startups" (JOBS) act is a US legislation that took effect on 16th May 2016, and eases rules that are enforced by the Securities and Exchange Commission (SEC). For instance, the JOBS act allows businesses to issue securities to the public through crowdfunding, changes requirements to become an accredited investor, and increases the maximum number of shareholders a business can have before having to file for going public (SEC, 2019a,b).

[3] For a visualisation of historical data on investment volumes see Figures A.1, A.2, and A.3 in Appendix A on pages 237 to 238.

tance for ventures (Street and Cameron, 2007), evaluation for the VCs becomes more complex. Complexity for VCs increases, as the unit of analysis grows from an isolated ESV to a highly interconnected business where surrounding stakeholders can create opportunities, dependencies, and threats and must, therefore, be taken into consideration (Street and Cameron, 2007; Spinelli et al., 2012; Gompers et al., 2020). In summary, the fast-paced and complex environment makes investment decisions challenging and strengthens the case for formalised and applicable tools to benchmark investments (Zachary and Mishra, 2013).

Searching for a decision-aid for VCs, researchers consistently found that it is difficult to value an ESV based on traditional, tangible evaluation metrics and attested inadequacy in pre-revenue, volatile situations (Venkataraman, 1997; Miloud et al., 2012). While traditional metrics might apply for later-stage investments, they fail when evaluating fledgling firms (Black, 2003; Kumar, 2015). Thus, some researchers suggest that the better alternative would be to evaluate non-traditional, intangible metrics such as the quality of the entrepreneur, product, or social networks allowing for "a better alternative than 'pure guess'" (Sanders and Boivie, 2004; Miloud et al., 2012, p. 153; Sharma, 2015). In response to this gap, this thesis suggests a novel, non-traditional evaluation perspective for ESVs.

1.2 Research relevance

Despite increased liquidity, early-stage VCs have concentrated the invested capital behind a smaller number of ventures, and therefore only a low single-digit percentage of ventures receive external funding (Miles, 2017; Kupor, 2019). Concentrated investments present challenges for entrepreneurs who might not be able to fund their venture. The findings of this research show that entrepreneurs who develop an increased awareness of the importance of social networks can increase their odds when seeking investment from VCs by differentiating their venture from the competition. In response to existing research, the findings suggest that an awareness of non-traditional market differentiators and how to communicate these effectively, online as well as offline, is an important part of the entrepreneurial skill set (Ries, 2011; Yang and Berger, 2017). Besides entrepreneurs, VCs can draw insights from this thesis. The results of the study indicate that VCs could make more informed decisions by understanding investment opportunities from various perspectives, including the social network perspective which the thesis focuses on. Therefore, this thesis adds to existing research on triangulating investment opportunities from multiple perspectives, as well as the use of decision-aids, which both were found to reduce risk and increase returns (Moesel et al., 2001; Townsend and Busenitz, 2015; Gompers et al., 2020). Increasing entrepreneurs' and investors' mutual understanding of evaluation

mechanisms and their underlying assumptions could help to facilitate communication during the investment process. Improving communication has consistently been found to be a driving factor behind closing the funding gap (Peemöller et al., 2001; Mason and Harrison, 2002a; Maxwell et al., 2011; Kupor, 2019)

1.3 Previous research

Evaluation of newly founded ventures is difficult (Audretsch and Link, 2012; Festel et al., 2013). The absence of hard financial data in combination with mostly covert operations, unproven business models, intangible knowledge assets, and the presence of many "unknown unknowns" make the evaluation of ESVs more of an art than a science (Sudek, 2006; Huang and Pearce, 2015; Huang, 2018). Consequently, VCs struggle to evaluate ESVs accurately and identify the most promising investment opportunities (Gompers and Lerner, 2001a; Hoang and Antoncic, 2003; Miloud et al., 2012). Valuation methods for later-stage ventures are well established, but they fail when applied to pre-revenue, early-stage businesses (Miloud et al., 2012). An analysis of non-traditional evaluation methods for the VC industry shows that assessing non-financial information, such as the founding team's composition or previous entrepreneurial history, can provide clues for future performance forecasting (Gompers et al., 2010). Already today, industries such as consumer credit, insurance, online dating, real estate, cybersecurity, epidemiology and wider biolology use intangible metrics in their models (Newman, 2014; Barabási, 2016; Scott, 2017). In these areas, social network analysis (SNA) serves as a useful tool (Barabási, 2016; Hvistendahl, 2018) and, according to recent studies, will continue to move into the field of social sciences (Borgatti et al., 2009; Kwon and Adler, 2014; Barabási, 2016). Applying SNA in an ESV context yields potential, since VCs and entrepreneurs are familiar with the concept and aware that their profession relies on dependable social networks (Starr and Macmillan, 1990; Hsu, 2004; Witt, 2004; Spiegel et al., 2016; Spender et al., 2017; Scott, 2017; Kupor, 2019). Previous research has empirically proven that established partners, who can lend newcomers their reputation, are beneficial for ESVs not only for resource acquisition, but also in overcoming liabilities of newness. (Zimmerman and Zeitz, 2002; Chang, 2004; Freeman and Engel, 2007; Pollock et al., 2010; Ko and McKelvie, 2018). In response to calls from academics in literature and practitioners interviewed as part of the research, this thesis suggests a social network perspective on evaluation and methods specifically designed for ESV evaluation (Sharma, 2015; Arroyo et al., 2019).

1.4 Research gap and contribution

A review of entrepreneurship and VC literature revealed that existing theory provides an incomplete understanding of ESV evaluation. In response to the emerging

trend of data-driven VC investing in VC, recent researchers began to study the novel evaluation methods and incorporated evidence from practice (Gompers et al., 2020). As a result, this thesis is particularly timely.

To date, both the positive and negative notion of ESVs social networks' impact on the perception by private market investors is an under-researched field. This research sets out to understand multiple facets of the social network perspective which are required to bring more clarity to ESV investing, before attempting to build models that serve as decision-aids for practitioners. For theorists and practitioners, the contribution of this work is fourfold. Firstly, the exploratory qualitative studies identify modes of ESV signalling to VCs and determine key stakeholder groups in ESVs' networks. Secondly, these findings informed subsequent qualitative research into different approaches undertaken by ESVs to engage with their network and harness opportunities by leveraging social networks for their individual benefit. In total, ESVs' strategic approaches are investigated based on evidence from over 100 case study interviews that were conducted for this thesis. Thirdly, the subsequent quantitative research enquiries establish actionable guidelines such as favourable social network constellations, which can be understood as the architecture of network patterns in which crucial stakeholders are connected among each other. These findings highlight the consent and dissent of entrepreneurs and VCs regarding constellations which are perceived as favourable, valuable, and informative, including the identification and testing of tangible qualitative metrics to quantify the evaluation. Finally, metrics identified with this research are cast into a bespoke model and subjected to real-world ESV investment data, to examine its usefulness as a decision-aid for practitioners.

1.5 Thesis storyline

As Figure 1.1 shows, following this introduction, Chapter 2 contains a literature review that provides the foundation for this thesis and the positioning in relation to existing works. Next, Chapter 3 outlines the research approach, discusses the research methodology and its implications in a wider philosophical context. Chapter 4 describes a practitioner-oriented, exploratory study that informs subsequent research and ensures its real-world applicability. Of the next three chapters, Chapter 5 takes a qualitative perspective, followed by Chapters 6 and 7 which use quantitative methods. Each chapter thereby discusses the studies' individual limitations and suggests future research opportunities. Finally, Chapter 8 summarises and contrasts the results, and discusses the thesis's contribution to theory and knowledge.

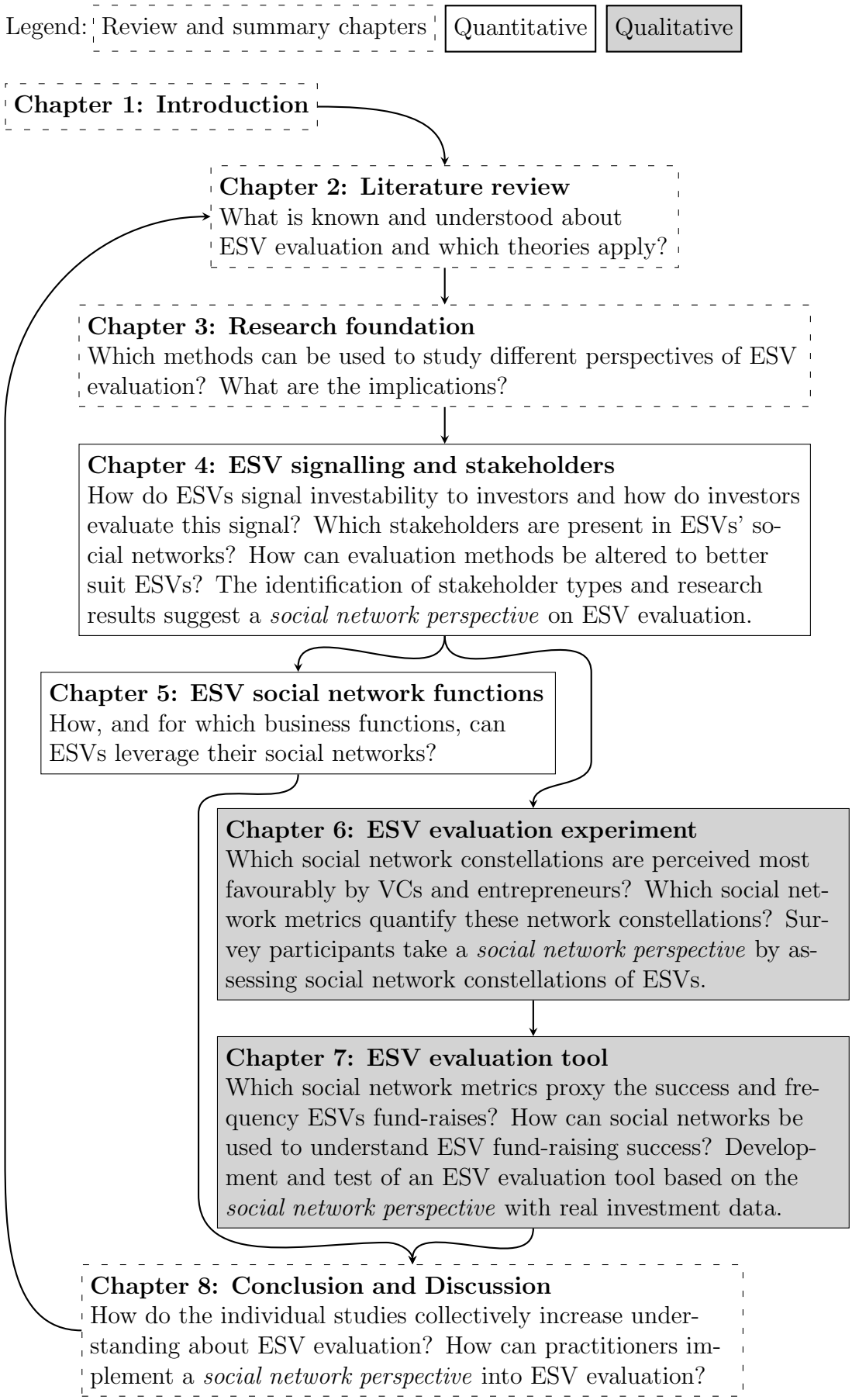


Figure 1.1: Thesis structure

2. Literature review

Contents

This chapter provides a summary of three pertinent literature streams that underpin the theoretical foundation of the thesis and concludes in the identification of a research gap. A review of business venturing (2.2), entrepreneurship (2.3), as well as social capital and social network literature (2.4) provides the context for this study. Together, the three literature streams help bring clarity and structure to the central research problem of this thesis, the evaluation of ESVs.

In the entrepreneurship and business venturing literature, researchers of the two domains often investigate the same research problem from their perspective (Landström, 2007; Huang and Knight, 2017). Figure 2.1 illustrates the mirrored relationship between entrepreneurship and business venturing literature, as the review gradually narrows the focus towards SNA.

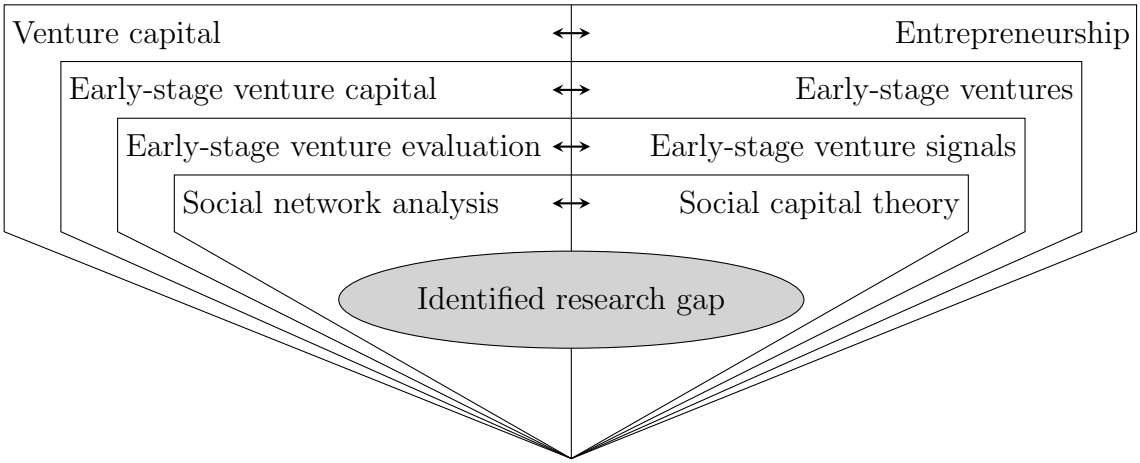


Figure 2.1: Literature synthesis, own illustration.

Academics and practitioners in the investor community aim to understand how VCs can develop tools to assess ESVs, and reach investment decisions in the face of uncertainty (Higashide and Birley, 2002; Sanders and Boivie, 2004; Navis and Glynn, 2011; Gompers et al., 2020). In turn, research on entrepreneurship studies the challenges of entrepreneurs during early stages, the process of seeking investment, and predictors of ESV performance (Sanders and Boivie, 2004; Zacharakis et al., 2010). Ultimately, these two perspectives on entrepreneurial parameters that determine venture performance are of similar interest for the entrepreneurship and VC community (Landström, 2007).

The second literature stream thematises social capital, one of three forms of capital besides human and financial capital (Adler and Kwon, 2002; Semrau and Werner, 2014). Researchers of social capital are concerned with people's engagement in social interaction, the derivable goodwill, and the intricacies of the social networks which provide the structure through which social capital exists (Kwon and Adler, 2014). Furthermore, researchers of social networks, a research field subordinated to social capital, brought forward constructs to qualitatively and quantitatively asses social

networks (Scott, 2017).
The underlying mechanism, which connects the research into entrepreneurship and social capital is that entrepreneurs procure social capital through stakeholders in their social network. This thesis investigates how such ESVs stakeholder networks can be assessed by investors to inform investment decisions and increase confidence (Baum et al., 2000).
Sources reviewed in this literature chapter include English and German texts in journal publications, industry reports, books, databases, as well as newspaper and online articles. A broad array of additional sources was reviewed in addition to implementing recommendations from industry experts, to capture the often contrasting views of different market participants, and to substantiate results with manifold perspectives.

2.1 Relationship of entrepreneurship and VC

When VCs and entrepreneurs create a successful symbiosis, it connects people with ideas to others who created a business around funding innovators (Gompers et al., 2020). The combination of audacious entrepreneurs combined with experienced VCs financing their endeavours had substantial impact on modern society (Kupor, 2019). Historically, most entrepreneurs have been wealthy individuals who can self-support their experiments (Hébert and Link, 2009). A relatively recent advance is in the financing of the entrepreneurial ventures through VC.
Many origin stories include claims to be the first modern VC. Lawrence S. Rockefeller is among the most credited pioneers of early-stage technology investing which later came to be known as VC (Nicholas, 2019). Starting in 1946, Rockefeller Brothers Inc. invested in companies researching and developing nuclear power, jet engines, helicopters, aircraft radio, avionics, and reconnaissance cameras. Later, the focus shifted away from military innovations towards computing, which led to the founding of Venrock in 1969, a VC fund which subsequently invested in companies like Apple and Intel (Winks, 1997). To date, Venrock invested in over 400 companies, of which more than 100 went public through an initial public offering (IPO)[1].
The Dot-com bubble, a financial markets crash in the early 2000s, abruptly shook the industry and hit VC particularly hard. After more than a decade of recovery, the global fundraising activity again reaches levels that are even beyond those in the prequel of the Dot-com bubble.

Interestingly, the duality of entrepreneurs and investors translated into the formation of two academic camps, who are the respective authors of entrepreneurship and business venturing literature. This separation is reflected in the literature review

[1] Investor profile of Venrock obtained from https://pitchbook.com/profiles/investor/11326-33

chapter, with dedicated sections dealing with the investors' (2.2) and entrepreneurs' (2.3) perspective.

2.2 Investors' perspective

Beginning with a broad description of VC, the following sections position VC in the context of other asset classes and further highlight (a) the essential characteristics of different types of VCs and (b) describe specific stages of venture maturity which are important to position the research in the spectrum of early-, growth-, and late-stage investments (Gompers and Lerner, 2001a). Subsequently (c) common structures of VC funds and (d) the resulting duties of VCs are elaborated, particularly focusing on early-stage VCs.

2.2.1 VC asset class

There are four main asset classes to be differentiated (Ang, 2014):

- Public equities, i.e. shares of publicly listed companies
- Fixed income, i.e. bonds and annuities
- Alternative assets, i.e. mostly non-publicly traded and illiquid assets
- Cash equivalents, i.e. short term liquid securities

VC is a subcategory of alternative assets and private equity. Figure 2.2 illustrates the landscape of asset classes and the location of VC within.

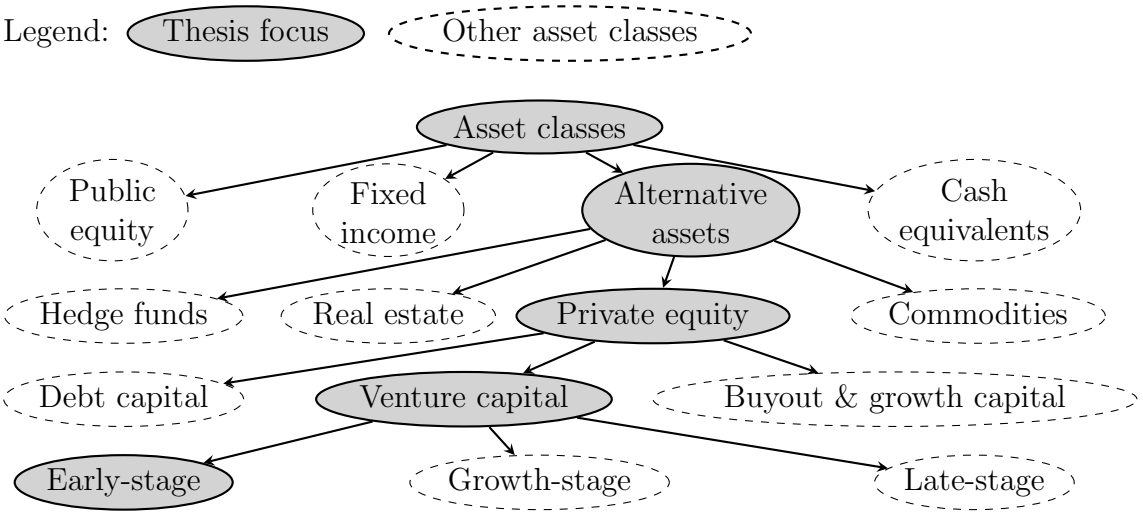


Figure 2.2: Overview of asset classes, own depiction with information from Gompers and Lerner (2001a), Ang (2014), and Ramsinghani (2014).

In contrast to public markets which match buyers and sellers of equities on a stock exchange, in private markets, buyers have to identify sellers and vice versa to negotiate prices and trade. Hence, VC qualifies as a high-risk investment class which potentially locks investors in their investments for years until their portfolio invest-

ment completes its IPO or is acquired by a buyer. As a result, investors have to carefully consider which companies they fund.
Different risk tolerances and investment preferences become evident through an analysis of the profiles of investors who participate in the private market.

(a) VC investor categories

The private markets attract different investor categories. However, during the last decade the boundaries of what constitutes target investments for each category have become more fluid across the investment categories, as some later-stage investors started investing in earlier stages and vice versa (Ramsinghani, 2014; Clark, 2019a). On a high level, four main investor categories, informal VCs, corporate venture capitalists (CVCs), institutional VCs, and banks can be differentiated (Gompers and Lerner, 2001b; Ramsinghani, 2014).

Informal venture capital investor. Informal investors include high-net-worth individuals, also known as "angel investors" or family offices (Freear et al., 1994; Ramsinghani, 2014). Informal investors invest during the earliest stages of a business which have the highest associated risk of failure (Elitzur and Gavious, 2003) This investor catregory often invests as an angel investor syndicate or as part of an angel group to share the risk (Gompers and Lerner, 2001a; Mason and Harrison, 2002a; Wright and Robbie, 1998). Some angel investors have professionalised their operations and belong to a sub-category called micro-VC (Ramsinghani, 2014).
Corporate venture capital investor. CVCs have a corporate limited partner (LP) and act as the investment arm of a larger organisation, also referred to as the corporate venturing unit (Spinelli et al., 2012). These CVCs are often incumbent firms who use their venturing activities as a means of corporate innovation and capture strategic value from external organisations (Gompers and Lerner, 2001b; Chesbrough, 2003; Tidd and Bessant, 2013). Thus, as opposed to traditional VC investments, CVC does not only seek financial return but also strategically valuable insights for the parent company (Weiblen and Chesbrough, 2015).
Institutional venture capital. This form of VC is also called "formal" VC, and is the category that practitioners refer to when using the term "VC". As the following chapters explain in detail, a general partner raises outside capital, sets up a fund, and acts as the VC. Most of the capital is committed by the VC's LPs and deployed over a time-frame of a decade by investing in venture businesses (Sahlman, 1990). Larger investment sums characterise this form of VC, especially when compared to angel investments. Institutional VCs are primarily concerned with financial over strategic objectives as opposed to their CVC counterparts (Bygrave and Timmons, 1992; Barrell et al., 2013).
Private equity investor. This form investing in private equities is comparable to

institutional VC and not to be confused with the name of the asset class in Figure 2.2. Characteristic for this investor category are late-stage investments and leveraged buyouts, during which an entire firm is taken over by a private equity investor, restructured, and sold in the hopes of exceeding the purchase price (Schwarzman, 2019).

Banks. Some specialist banks provide capital to venture business, often during the later funding rounds in the form of debt financing in preparation for an IPO (Spinelli et al., 2012; Ramsinghani, 2014).

It is important to not that this thesis focuses on institutional VC. A further characteristic for VCs, especially early-stage VCs, is the active involvement of investors with portfolio companies compared to banks or other investors who are more hands-off (Elango et al., 1995; Caselli, 2010). In VC industry parlance, investor involvement is also called *active ownership* or *smart money* which captures the idea that VCs buy and build the firm they invest in (Maula et al., 2005; Barrell et al., 2013; Fitzpatrick et al., 2016). For this thesis a VC is defined as:

> **Definition 1:** A "VC" is an investor who provides capital to early-stage ventures which exhibit high growth potential in exchange for an equity stake.

The involvement of VCs along the life-cycle of a company from first fundraise until the exit changes fundamentally, which becomes clear when looking at the different investment stages.

(b) VC investment stages

As ESVs receive funding from an investor, entrepreneurs work towards agreed-upon milestones (Zheng et al., 2010). The following overview shows the main stages a venture can complete on its way to an IPO. In practice, additional sub-stages and terminology exists. However, a description of these would go beyond the scope of the thesis, the terminology used for this research is stated below.

Pre-seed & Seed. Investors fund young firms during the earliest phases of the life-cycle. Entrepreneurs use the funds for early product development and talent hiring (Campbell, 2003). Financiers are in most cases informal investors and early-stage VCs (Spinelli et al., 2012; Bygrave and Timmons, 1992) and help build out the ESV's team, provide mentoring, and manage proof of concept (PoC) pilots (Streletzki and Schulte, 2013; Islam et al., 2018)

Series A. Ventures in this stage are usually still developing their product in which case they are considered an ESV. However, the firm gains some traction with first customers and sales (Campbell, 2003; Feld and Mendelson, 2011).

Series B & C. Series B and C funding are sought when the ESVs completed the

product development, proved the business model, but the customer base is still too small (Campbell, 2003; Gompers and Lerner, 2001a). At this stage, a venture business is not considered an ESV anymore because injected capital is used to expand the market reach, for instance, through acquiring new customers, building facilities, or internationalising (Feld and Mendelson, 2011; Huang and Knight, 2017).

Series D-F. These funding stages are the first ones to be considered private equity investments (BVCA, 2017). They occur pre-IPO, and denote late-stage investments in mature companies in growth, turnaround, distress or management buyout situations (Campbell, 2003; Caselli, 2010). At this stage, VCs invest to promote further growth, for instance, through an internationalisation strategy (Gompers and Lerner, 2001a). The investment mechanism is mostly mezzanine capital, and securities are issued shortly before the company goes public (Gompers and Lerner, 1999).

IPO. The IPO denotes the transition phase of a company from a private into a public equity. Often, VCs divest their shares at this stage (Bygrave and Timmons, 1992; Bussgang, 2010).

M&A, trade sale, and secondary sale. In contrast to the IPO, a secondary sale means the asset is sold from one investor to another within the private market. Such transactions are referred to as merger and acquisition (M&A) or trade sale when the buyers are a corporate entity. In case of corporate M&A the acquisition target is subsequently integrated into the new parent firm (Gompers and Lerner, 2001b; Ramsinghani, 2014).

The central topic of the thesis is the pre-investment evaluation of ESVs by institutional VC investors from a social network perspective. Institutional VC is a sweet-spot for the chosen evaluation perspective of social networks. On the one hand, angel investors who invest even earlier stages conduct less extensive due diligence (Spinelli et al., 2012; Croce et al., 2017). Professional investors who conduct more extensive due diligence could use decision-aids during the pre-investment process (Gompers et al., 2020). On the other hand, later-stage investors perform due diligence that gravitates towards financial analysis which does not directly apply to ESVs for reasons later described in Section 2.2.2. To understand an institutional VC's investment strategy it is necessary to understand their mandate and fund's organisational structure.

(c) VC fund structure

Institutional VC firms are structured as limited partnerships. Figure 2.3 illustrates the relationship of the VC, its LPs, and portfolio companies.

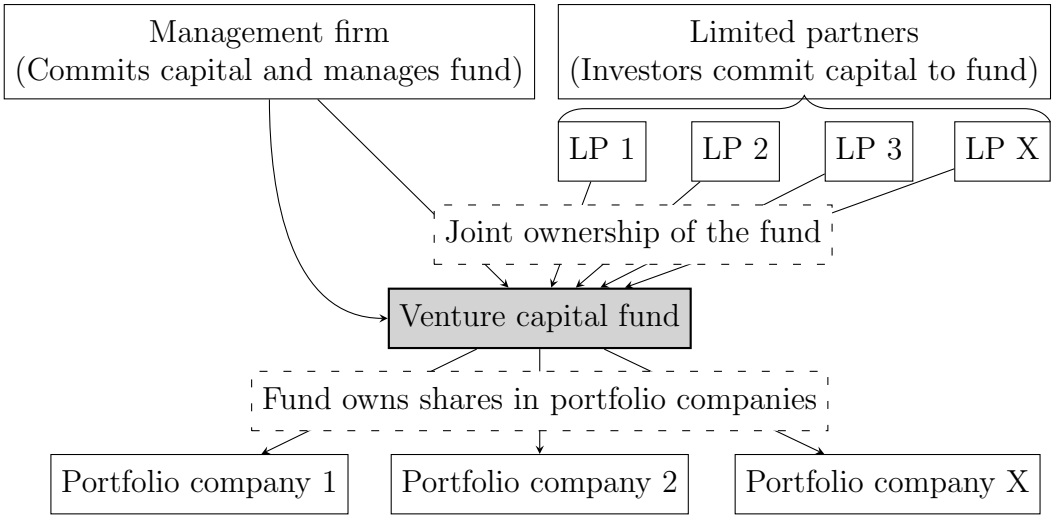


Figure 2.3: VC fund structure, own illustration with information from Ramsinghani (2014).

The management firm raises and manages a VC fund, to which LPs commit their capital, and jointly own the fund. VCs make investment decisions on behalf of their LPs and fund companies which thereby become part of the portfolio. Especially the vetting of an investment opportunity, which occurs during the due diligence phase, and the post-investment involvement differ dramatically across funds and investment stages as the ventures mature (Bygrave and Timmons, 1992; Gompers and Lerner, 2001a; Campbell, 2003; Barrell et al., 2013; Miles, 2017).
Typical examples of LPs are public and corporate pension funds, endowments, foundations, fund-of-funds, sovereign wealth funds, family offices, high-net-worth individuals, finance and insurance companies (Ramsinghani, 2014). LPs are not the focal actors in this thesis, nonetheless, they represent an essential stakeholder group in a VC's social network and will reappear in the networks investigated.
Summing up, to classify a VC, it is crucial to know which investor category they belong to, as well as their investment stage focus. These characteristics determine the level of involvement of a VC and thus the corresponding duties.

(d) Duties of a VC

The main tasks of VCs encompass sourcing venture investment opportunities, conducting due diligence and evaluation of investment prospects, investing and potentially follow-on investing in later rounds, providing post-investment support, and exiting from the investment to return the capital to its LPs (Gorman and Sahlman, 1989; Tyebjee and Bruno, 1984). Figure 2.4 illustrates the relationship of the individual tasks and emphasizes that this thesis focuses on the pre-investment evaluation of ESVs.

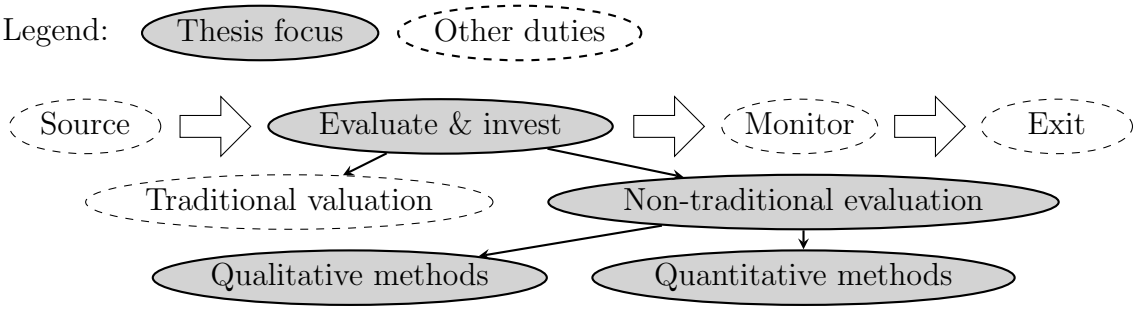


Figure 2.4: Duties of a VC, own illustration with information from Gompers and Lerner (1999), Miloud et al. (2012), and Koller et al. (2015).

2.2.2 Evaluating: due diligence and decision-making in VC

Sizing up an investment opportunity during due diligence is an often unstructured approach with few guidelines to follow (Ramsinghani, 2014). Gompers and Lerner (2001b, p. 154) state that "uncertainty and informational asymmetries often characterise young firms, particularly in high-technology industries." Due diligence is a process widely used by financial market actors to rigorously evaluate an investment opportunity which serves the basis for investment decisions (Gompers and Lerner, 2001b; Ramsinghani, 2014). In early-stage investment due diligence, mainly intangible assets are evaluated which is why it is common practice to triangulate by using different perspectives (Busenitz et al., 2005; Sievers et al., 2013). As part of their due diligence VCs ought to address two systematic problems, (a) unequally distributed levels of information and (b) uncertainty. Over the years, VCs developed their own quantitative and qualitative valuation and evaluation methods and borrowed existing methodologies from other asset classes. These methods include (c) traditional methods that are purely financial and quantitative as opposed to (d) non-traditional methods which can be qualitative or quantitative and describe intangible assets (Gompers and Lerner, 2001a; Audretsch and Link, 2012; Koller et al., 2015; Wu, 2016).

(a) Information asymmetry

Preferably, decision-makers would factor into their decision all available information (Kahneman, 2013). This assumption, called complete information, was elementary in most economic models of the last century (Gompers and Lerner, 1999; Stiglitz, 2000). In the absence of complete information, asymmetric information levels are present among decision-makers (Stiglitz, 2000). The first to recognise that complete information inaccurately represents most economic situations were Akerlof (1970), Spence (1973), and Stiglitz (1985), who were awarded a Nobel prize for their works. Stiglitz (2002, p. 470) states that information asymmetries occur when "different people know different things".

In a VC context, Gompers and Lerner (1999) clarify the relationship between infor-

mation asymmetry and uncertainty in that information asymmetry is a consequence of different levels of uncertainty on the entrepreneur's and investor's side. Few examples of existing business venturing literature address solutions for informational asymmetries, though notable exceptions are Gompers and Lerner (1999) who found that VCs expect an allocation of contractual rights, staged capital investments which increases as the venture is de-risked, as risk is shifted towards entrepreneurs. These measures mitigate the so-called principal-agent problem which will be discussed in Section (b). As a second, alternative approach to reduce information asymmetry, Venkataraman (1997) took a social network perspective and suggested that shared social relationships between entrepreneurs and investors allow not only information exchange but also create an obligation. In line with this argument Coleman (1988), Elitzur and Gavious (2003), and Hoang and Antoncic (2003), ascertain that social ties to multiple, preferably shared connections, act as a sanction mechanism. Coleman (1988) adds, misbehaviour towards one individual in a social network could be swiftly communicated and have wider implications for the remaining social ties. Coleman further theorised this in his concept of network closure, which states that a dense social network allows establishing trust and norms, in which individuals who take advantage are more likely to be exposed. In the VC context, this can be effective prevention for principle-agent issues and opportunistic behaviour (Stuart and Sorenson, 2007). In an ideal situation, connectedness through a social network brings trust and reciprocity to business relationships and enables economic exchange with lower risk and quicker decisions (Uzzi, 1996).

Hitherto, research on reducing information asymmetry mainly focuses on IPOs and analyse the filings disclosed by companies. Additionally, more recent investigations study information asymmetry between investors and ESV in an equity crowdsourcing context and how online social media platforms reduce information asymmetry in addition to the mandatory documentation ventures have to make (Cohen and Dean, 2005; Escobari and Serrano, 2016; Albarrak et al., 2019).
Only a few studies focus on lowering information asymmetry in ESV investing and specifically at the screening and evaluation stage of the pre-investment process (Wang, 2016; Janney and Folta, 2003). An in-depth review of ESV specific signals to reduce information asymmetry is discussed in Section 2.3.3. The next section describes how VCs aim to overcome the inherent uncertainty in early-stage investing.

(b) Overcoming uncertainty

Early-stage investing bears many "unknown unknowns", both for entrepreneurs and investors, which are difficult to mitigate (Diebold et al., 2010). However, there are several known unknowns especially for the investors which they aim to estimate with

their due diligence. As mentioned above, research frames the relationship between entrepreneurs and VCs via the theoretical construct of a principal (entrepreneur) and agent (VC) problem (Grossman and Hart, 1992; Kaplan and Strömberg, 2001). Kaplan and Strömberg (2001) states that VCs have three main levers to mitigate this conflict. Investors can (1) collect information and perform thorough due diligence before investing and potentially defer an investment opportunity, (2) obtain control rights through a contract, or (3) monitor and get involved personally post-investment. It is worth noting that these actions closely match the duties of a VC described in 2.2.1 (d), the sourcing, evaluating, investing, and monitoring before exit. Researchers focusing on all these stages shows that throughout the life cycle, from the first contact to exit of an investment after several years, reducing uncertainty is crucial for VCs (Aldrich and Fiol, 1994; Aldrich and Ruef, 2006; Navis and Glynn, 2011). Of the three levers available to VCs this section focuses on the mitigation of uncertainty through (1) pre-investment due diligence.
The uncertainty associated with an investment decision depends largely on the availability of reliable information about a company's assets, especially of financial and other quantifiable, measurable assets. Scholars distinguish between hard and soft as well as tangible and intangible assets (Adams and Oleksak, 2010; Koller et al., 2015). Table 2.1 explains the terminology.

Table 2.1: Asset classification by hard and soft, tangible and intangible based on, International Accounting Standards in Adams and Oleksak (2010) and IFRS Org. (2017a,b).

Soft assets	**Hard assets**
• Can have physical substance	• Can have physical substance
• Hard to measure or unmeasurable	• Measurable
• Has no intrinsic value	• Has intrinsic value
• Not listed on the balance sheet	• Listed on balance sheet
• Employees, reputation	• Liquidity, contractual liabilities
Intangible assets	**Tangible assets**
• No physical substance, indiscernible	• Physical substance, discernible
• Non-monetary but identifiable	• Measurable
• Can be listed on the balance sheet	• Listed on balance sheet
• Patents, brand	• Cash, real estate, equipment

ESVs start their life cycle almost without tangible assets and increase these over time (Shane and Stuart, 2002). Therefore, information about available assets correlates to the maturity of the venture. Investors in later-, and growth-stage companies determine the company's valuation according to accounting standards and elements include sales revenue, product quality, customer retention, intellectual property (IP), brand, real estate, equipment, accounts payable, and liquidity. An ESV has at best

little defensible IP, an early prototype, and few customers (Gompers and Lerner, 2001b; Campbell, 2003; Gupta et al., 2004; Brealey et al., 2014; Gompers and Lerner, 1999; Audretsch and Link, 2012). Huang and Knight (2017, p. 92) states that "[a]s a venture progresses from an early to a late developmental stage, the knowledge-to-assumption ratio increases, thus reducing ambiguity." Figure 2.5 depicts the increasing availability of measurable quantitative data with increasing venture maturity.

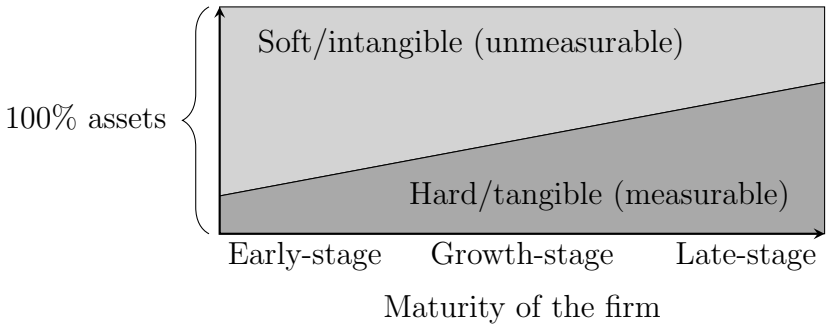


Figure 2.5: Measurable and unmeasurable assets with increasing venture maturity, own schematic illustration.

This approach of assessing later-stage firms based on hard and tangible assets, however, is not applicable for ESVs. Campbell (2003, p. 169) further states that "[t]he earlier the stage, the less any sort of metric can apply", which confirms that purely quantitative financial analysis in an ESV context is impossible (Dusatkova and Zinecker, 2016).
By definition, ESVs have no financial history and engage in the discovery of a new product (Miloud et al., 2012). Hence, the required parameters to build models does not yet exist and would be purely speculative (Campbell, 2003; Audretsch and Link, 2012).

(c) Traditional (e)valuation approaches

The term "valuation" in the venture context has two meanings. First, to describe the present financial value which an investor is willing to pay if they were to acquire the entire company and second, as well the process of determining this value.
By contrast, "evaluation" is the process vetting of an investment opportunity from multiple different perspectives, which can also include a valuation component (Bygrave and Zacharakis, 2010). Investors developed several evaluation methods which find application in different stages of VC funding. On a higher level, traditional evaluation approaches are divided into market-, asset-, and income-based approaches and can make use of qualitative and quantitative metrics (Anderson, 2013)[2]. In their application to ESVs none of these valuation procedures are immune to criticism be-

[2] A summary of traditional valuation approaches is presented by Table B.1 in Appendix B on page 239.

cause these models predict the future development of a company based on existing metrics. Predicting future development based on past metrics can cause problems for instance when analysts use quantitative metrics designed to model post-revenue companies to evaluate pre-revenue companies, or when forecasting revenues with multiple year horizon based on vague assumptions. Such practices are very speculative and therefore highly criticised (Audretsch and Link, 2012; Miloud et al., 2012; Festel et al., 2013). Consequently, traditional quantitative valuation is reserved for mature companies, and common examples include discounted cash flow analysis, leveraged buyout and recapitalisation analysis, or risk analysis (Kumar, 2015; Gompers et al., 2020).

A mixed qualitative and quantitative method which finds application in ESV assessment is the comparable method (Freeman and Engel, 2007; Bygrave and Zacharakis, 2010; Sievers et al., 2013). This method relies upon the fact that a similar business which transitioned through the current stage of the ESV exists and can be identified. Applying the model means drawing parallels to the reference business, assuming the investigated and reference business develop in tandem, which then allows predictions to be made. Audretsch and Link (2012) criticise the comparable method, since assuming parallel development of two companies could be unreliable. Audretsch and Link state that especially when considering a genuinely entrepreneurial venture, the pursued idea must by definition not have a predecessor which would invalidate the core assumption of the comparable method. Because ESVs do not mature in controlled conditions, but from a process driven by chance and serendipity, "[t]he practice of startup valuation by venture capitalists remains a 'guess' and 'alchemy'."(Miloud et al., 2012, p. 152). The result of an evaluation is primarily dependent on the VC's perception, because the evaluation through traditional metrics entails making speculative assumptions. Therefore, the evaluation through traditional metrics and the usefulness of the result is debated (Audretsch and Link, 2012).

(d) Non-traditional evaluation approaches

Partly as a consequence of the limited financial information available and partly as a means of differentiating their investment strategy from that of other funds, VCs attempt to find alternative evaluation methods (Gompers et al., 2020). Some non-traditional evaluation models have been disclosed to the public[3], however, researching these methods is challenging as most VCs keep their data-models confidential. In contrast to the traditional models described above, non-traditional models measure the firm-internal, soft and intangible assets as well as the firm-external characteristics. Several of these metrics are only available in qualitative form, and reliable

[3] A summary of non-traditional valuation approaches is presented by Table B.2 in in Appendix B on page 240.

quantifying metrics have yet to be identified. In most cases, the formulation of quantitative metrics follows that of qualitative metrics (Bernard, 2012).
An exemplary evaluation method which transitioned from employing qualitative to quantitative metrics are environmental, social, and governance factors (ESG). Today ESG factors are the primary method to quantify the sustainability, ethics, and societal impact of any undertakings, for instance, investments (Knoepfel, 2004; Lehner, 2016; Vörösmarty et al., 2018). Two decades ago, ESG concepts, both qualitative and quantitative, were not known in practice. Since then, corporations adopted ESG factors, and investors created one of the fastest-growing investment categories, "impact investing" (Kell, 2018; Bass et al., 2018). Some researchers argue ESG metrics were a contributing factor to the rise of the investment class since they allowed to benchmark investments in an environment which aims to optimise for measurable societal impact while achieving financial returns. (Orsagh, 2019; Tett et al., 2019).
In VC such standardised quantitative metrics comparable to ESG factors have not yet been established. Nonetheless, VC literature contains multiple studies which argue for the adoption intangible and soft assets as evaluation criteria specifically for ESVs. Stuart et al. (1999, p. 315) states that "[b]ecause the quality of young companies often cannot be observed directly, evaluators must appraise the company based on observable attributes that are thought to covary with its underlying but unknown quality." Table 2.2 shows a categorisation of literature that argues for intangible and soft assets into six categories.

Table 2.2: Qualitative and quantitative ESV investment criteria.

Category	**Investment criteria**	**Source**
Entrepreneur and ESV team	Parents and family	Lindquist et al. (2015)
	Leadership capabilities	Wales et al. (2013); Haynes et al. (2015); Renko et al. (2015)
	Commitment and ownership	Erikson (2002); Robson et al. (2006); Bygrave and Zacharakis (2010); Busenitz et al. (2005)
	Team completeness and heterogeneity	Amason et al. (2006); Hmieleski and Ensley (2007); Franke et al. (2008); Visintin and Pittino (2014); Klotz et al. (2014)
	Social competence	Chandler and Hanks (1994); Baron (2000); Baron and Markman (2003)
	Founding experience	Flynn (1991); Van Gelderen et al. (2006); Hsu (2007); Gompers et al. (2010); Gimmon and Levie (2010)
	Industry experience	Mitteness et al. (2012); Cassar (2014)

Continued on next page

Category	Investment criteria	Source
	Technical knowledge	Chorev and Anderson (2006); Franke et al. (2006); Mueller and Murmann (2016)
	Education	Backes-Gellner and Werner (2007); Dickson et al. (2008); Quan (2012)
	Creativity	Ko and Butler (2007)
	Business and marketing experience	Brinckmann et al. (2011); Elmuti et al. (2012); Staniewski (2016)
	Employee growth	Davila et al. (2003)
Product	Novelty and innovation	Leutner et al. (2014)
	Patents	Baum and Silverman (2004); Mann and Sager (2007); Hoenig and Henkel (2015)
	Differentiation	Mason and Stark (2004); Miloud et al. (2012)
Business model	Uniqueness	Zott and Amit (2007); Spiegel et al. (2016)
Market and industry	Volume and growth	Macmillan et al. (1985); Zider (1998)
	Timing	Schlichte et al. (2019)
	Match VC's investment thesis	Muzyka et al. (1996); Clark (2008); Mitteness et al. (2012)
Financial metrics	Return on investment	Mason and Harrison (2002b); Gompers et al. (2020)
	Exit possibilities	Streletzki and Schulte (2013); Bernstein et al. (2016)
Social network	Inter-firm networks, prestige, and reputation	Stuart et al. (1999); Baum et al. (2000); Shane and Cable (2002); Fischer and Reuber (2007)
	Affiliation with VC	Hsu (2004); Pollock and Gulati (2007); Alexy et al. (2012)
	Alumni networks	Nann et al. (2011)
	Online social networks	Gloor et al. (2013); Yang and Berger (2017)
	Advisers, directors, and board	Certo (2003); Deutsch and Ross (2003); Lehtonen and Lahti (2009); Higgins et al. (2011); Wincent et al. (2014); Amornsiripanitch et al. (2019)
	Customers	Franke et al. (2006); Wang et al. (2014); Meiseberg (2015)
	Suppliers	Brüderl and Preisendörfer (1998); La Rocca et al. (2019)

It is important to note that the evaluation categories above encompass the core features of ESVs and identify potential upside and downside of investments. As a

consequence of the intangible nature of ESV assets, valuations are rather negotiated between entrepreneurs and VCs than determined by calculation. Entrepreneurs who signal credible features in these categories, will be perceived and evaluated more favourably (Hsu, 2004; Ko and McKelvie, 2018). A relevant observation for this thesis is that the non-traditional evaluation categories remained similar for decades (Macmillan et al., 1985), however, the level of attention regarding the social network increased only in the last two decades (Hsu et al., 2014; Ko and McKelvie, 2018).

The description of evaluation criteria, specifically focused on ESV investments, that are utilised by VCs, concludes the review of literature on the investors' perspective.

2.3 Entrepreneurs' perspective

"Venture: to risk going somewhere or doing something that might be dangerous or unpleasant, [...] [such] as an activity or plan of action, often in business, that involves risk or uncertainty." (Cambridge Dictionary, 2019)

Nacent firms can be differentiated into new ventures and new small businesses (Murphy et al., 1996; Hoang and Antoncic, 2003; Ireland et al., 2005). This study focuses on new ventures. Gompers and Lerner (1999) stress that early-stage VC funded businesses and their characteristics differ strongly from new small businesses and small and medium-sized enterprises (SMEs) on the one end, and late-stage private equity and public markets on the other end. A categorical difference of the new ventures compared to SMEs can be attributed to the information asymmetry between entrepreneurs and VCs at the point of investment, high levels of uncertainty and risk, unproven technology, volatile and unsaturated markets, and the illiquidity of the asset class (Ramsinghani, 2014).
For this thesis, the definition of ESVs is adopted from the British Venture Capital and Private Equity Association (BVCA, 2012; for fundraising stages confer Section 2.2 (b)):

Definition 2: An "ESV" is a venture investable firm, less than five years old that has not yet achieved the growth stage.

During early phases, the initial business concept is developed, first research and development conducted, a prototype or first iteration of a product product built, PoC[4] take place, and the first customers acquired as the product reaches the market. Before the growth stage starts, the product is not yet sold at scale, and the aim is to reach product-market fit (Ries, 2011; Ramsinghani, 2014).
For an ESV to succeed, it must have access to collaborators and partners (Pollock and Gulati, 2007), customers (Elfring and Hulsink, 2003), financing (Gulati and

[4] A PoC, is an initial test run of the early product on a client's site or system.

Higgins, 2003), and media coverage (Santos and Eisenhardt, 2009). Once access is established, ESVs must procure and allocate the relevant resources (Alvarez et al., 2001), convince VC to fund their business (Bruno and Tyebjee, 1985) and execute on their plan and reach milestones (Steier and Greenwood, 1995) before they seek funding to repeat the cycle (Murray, 1999; Zheng et al., 2010). In her seminal work on the theory of the growth of firms Penrose states:

> *"New, small, and unknown firms do not have the same facilities for raising capital as do established, large, and known firms. [...] successful fundraising of capital depends on an entrepreneur's ability to create confidence. [...] [This] entrepreneurial ability is required to launch a new firm successfully on a shoestring or to keep up the rate of net new investment required to enable it to reach a size and position where its general credit standing is well established." (Penrose, 1959, p. 38)*

Multiple theories are used to describe the success of young firms in this quasi-cyclic process. Of these theories, (1) resource-based view describes the procurement of resources, (2) dynamic capabilities explain how founders must constantly adapt to new challenges, and (3) signalling theory models the process of convincing VCs. Additionally, these theories help understand how ESVs can reduce the VCs' perceived information asymmetry. Research over the past decades has shown that firms can no longer be viewed in isolation but rather through a networked, stakeholder perspective, which affects ventures from ideation through to phases of maturity (Street and Cameron, 2007; Freeman, 2010). Palmer and Richards claim that in the 21st century, organisations ought to evolve by:

> *"[a]dapting to the new environment of network-based business models, [which] necessitates a move away from familiar organisational behaviour to a new behaviour network behaviour. Network behaviour requires a different mind-set, a mind-set that transcends boundaries and realises our aptitude for connecting with others, whether at personal, group or enterprise levels." Palmer and Richards (1999, p. 192)*

The concept of a networked organisation and social network resources are an integral element of this research. Thus, Section 2.4 later presents a dedicated review of ESVs' social capital, which frames resources embedded in the social networks around the ESVs.

Procuring and allocating resources, learning new skills to adapt to challenges, and signalling these qualities to external entities to ESVs can be summarised as overcoming the "liabilities of newness and smallness" (Freeman et al., 1983, p. 706;

Stinchcombe, 1965; Aldrich and Auster, 1986). The literature on liabilities of newness and smallness describes an interesting tension: the more unconventional and novel an ESV's innovation, the higher the potential upside but also the difficulty in convincing stakeholders to support or join their mission (Baker et al., 2003; Navis and Glynn, 2011). The following section presents a review of literature on the resource position of ESVs.

2.3.1 Resource-based view

Wernerfelt (1984, p. 172) defines a firm's resources as "tangible and intangible assets which are tied semi-permanently to the firm". Those resources can be categorised in financial, material, intellectual, or human resources (Ng et al., 2014). Resources, both material and immaterial, are indispensable for firms to operate, an idea conceptualised by the resource-based view (Barney, 1991; Venkataraman, 1997; Ng et al., 2014). Past empirical research showed that resources can serve as a source of competitive advantage for ESVs (Florin et al., 2003; Lavie, 2006). The notion that firms competitiveness can stem from resources in addition to their products and intellectual capital was a novel idea in the 1980s. Later, Wernerfelt's research and subsequent studies found these insights particularly relevant for ESVs who in their first years have hardly any tangible products and output at all (Ng et al., 2014). Previous studies found that depending on the industry, among financial, human, and social capital the latter can be the most important resource for ESVs, as illustrated in Figure 2.6 (Ostgaard and Birley, 1994; Greene et al., 1997; Shane and Delmar, 2004; Bosma et al., 2004; Khaire, 2010; Unger et al., 2011; Stam et al., 2014).

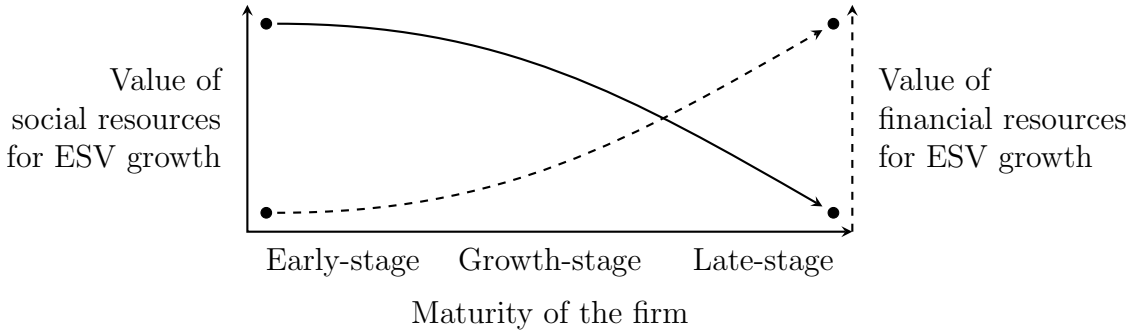


Figure 2.6: Value of social and financial resources with increasing venture maturity, modified from Huang and Knight (2017).

Huang and Knight (2017) state that social resources are better suited to address vaguely defined problem settings, whereas financial resources are better for well-defined ones. One direct benefit of social embeddedness is more direct access to capital. VCs see strategic alliances both as directly beneficial to the ESV and the presence of alliances also demonstrates to VCs that other entities trust the en-

trepreneurs long-term (Das and Teng, 2000; Shane and Stuart, 2002; Hochberg et al., 2007). Gulati (1998, p. 293) defines strategic alliances to network partners as "voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services". Podolny (2001) best describes the benefits derived from such special ties to stakeholders, stating that ties have not only a transferring but also a perceptual effect, respectively referred to as "pipes" that carry resources and information, and "prisms" that differentiate market participants. Such informational clues about the ESV's quality can help ESVs to overcome growth bottlenecks (Podolny, 2001; Rothaermel and Deeds, 2006). The majority of research focuses on the benefits of resource procurement through a social network (Alvarez et al., 2006), the main caveat mentioned in literature is that an overdependence on few partners can have negative effects (Street and Cameron, 2007; Knoben and Bakker, 2019).

One of the most common characteristics found in ESVs, is that they are notoriously resource-scarce (Stuart and Sorenson, 2007; Lehtonen and Lahti, 2009; Zheng et al., 2010; Khaire, 2010) and struggle for access to capital (Bruno and Tyebjee, 1985; Cassar, 2004; Martens et al., 2011). Previous research has shown that the process of creating value from few resources, also known as "bricolage" is a cue for a skilled entrepreneur (Baker and Nelson, 2005). Multiple studies which focus on resolving this problem find that social ties to VCs and stakeholders who lend the ESV their reputation and enhance credibility, both of which are features firms that are absent in early stages, and aid the fundraising process (Batjargal and Liu, 2004; Denis, 2004; Cassar, 2004; Zhang, 2015; Wang, 2016). Some researchers criticised work on the procurement of resources and sustained competitive advantage for focusing too much on firm-internal capabilities. The critics emphasised that most "resources inhere not so much within the firm but reside in the inter-firm networks in which firms are placed." (Gulati, 1999, p. 397; Lavie, 2006). With their studies, Gulati (1998), Dyer and Singh (1998), and Lavie (2006) extend the resource-based view by integrating social network theory and thereby make the adapted theory suitable to explain how ESVs can gain competitive advantage by leveraging their networks. The main advantage of this perspective is that it captures resources required for entrepreneurship, such as emotional support (Brüderl and Preisendörfer, 1998), reputation (Shane and Cable, 2002; Fischer and Reuber, 2011), and third-party endorsements (Stuart et al., 1999), which the traditional perspective does not include. As a result, entrepreneurs increased awareness of the wealth of resources that existss beyond their company's borders and calibrated their focus to include strategic alliances with network partners (Hoang and Antoncic, 2003).

Subsequent research taking a social-network perspective on firm-resources shows two benefits which further improve the ESV's perceived value. First, ESV can enhance

their performance when they have the necessary capabilities to harness resources made available by external entities (Lee et al., 2001; Zaheer and Bell, 2005; Hochberg et al., 2007; Wu, 2007; Neyens et al., 2010; Ng et al., 2017). Second, through embeddedness in larger networks resource dependency can be de-risked (Pangarkar and Wu, 2013). These mentions link the resource-based network view with the skills and dynamic capabilities of entrepreneurs while demonstrating their the social network's contribution to entrepreneurial success (Wu, 2007; Augier and Teece, 2009; Srećković, 2018).
The previously discussed fast-paced environment in which ESVs are nurtured requires organisational and managerial changes to adapt. An overview of such adjustments is discussed in the next section.

2.3.2 Dynamic capabilities

Dynamic capabilities can be used as a theoretical construct to explain how path-dependent, managerial and organisational adjustments have to be performed by ESVs as the mature, especially in fast-paced environments (Rothaermel and Deeds, 2006). In his research on dynamic capabilities, Teece (1997; 2007; 2010) states that firms have to constantly adapt across all business functions. Besides changes in execution, also the input factors, such as required resources, change as ESVs mature (Huang and Knight, 2017).
Research mentions specific capabilities that ESVs must develop, including absorptive capacity, innovative capability, and alliance management capabilities (Gulati et al., 2000; Lee et al., 2001; Zheng et al., 2010). These three capabilities relate to the above-mentioned network resources of ESVs. To harness pecuniary or non-pecuniary influx from external entities, ESVs must absorb and implement learnings and products of collaborations (Nahapiet and Ghoshal, 1998). An additional element of dynamism is introduced through the fact that social network resources are not "solid, durable, and independent" of their use and, therefore, require constant attention (Steen, 2010, p. 326). Coping with the instability of ESV's environments and rapid growth can be facilitated through knowledge transfer with network partners and interorganisational learning (Hagedoorn, 2002; Hagedoorn and Cloodt, 2003). Benefits of such interorganisational exchange can help ESVs to innovate their business model and product, or with international expansion (Laursen and Salter, 2004; Inkpen and Tsang, 2005; Han, 2006; Masango and Marinova, 2014). Coordinating and maintaining a social network is relatively costly for ESVs given the small team size among which duties can be shouldered (Witt, 2004; Huizingh, 2011). Hence, alliance management capabilities are required by firms to manage large numbers of strategic partners efficiently (Zheng et al., 2010). Consequently, the mere existence of a social network is a necessary but not a sufficient criterion and requires skilled

entrepreneurs (Cohen and Levinthal, 1990; Teece, 2007).
Superior resource situations and organisational advantages can be communicated from entrepreneurs to VCs through a process academics call "signalling" which is discussed in the following section (Freeman, 2010).

2.3.3 Signalling

Signalling theory has established a central position in management and entrepreneurship literature to frame informational exchange (Connelly et al., 2011). For this thesis, signalling is defined as the voluntary or involuntary communication of positive or negative information by one party (the emitter) to another party (the receiver) which interprets the signal (Spence, 2002; Bird and Smith, 2005; Connelly et al., 2011). Figure 2.7 illustrates this communication mechanism.

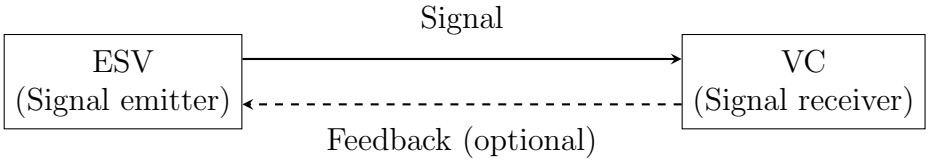


Figure 2.7: Signalling process, own illustration.

Entrepreneurship and finance literature understands signalling as a process of communication with the purpose of reducing information asymmetry between market participants (Spence, 2002). Such information asymmetry occurs between entrepreneurs who reveal information and VCs who receive and interpret signals, altogether fundamental aspects of pre-investment evaluation processes (Plummer et al., 2016; Kim and Wagman, 2016; Ko and McKelvie, 2018). In their review of signalling literature Connelly et al. (2011, p. 43) found that most studies are concerned with the communication of "quality as the distinguishing characteristic, [whereby] the notion of quality can be interpreted in a wide range of relevant ways [and] quality refers to the underlying, unobservable ability of the signaller to fulfil the needs or demands of an outsider observing the signal." Translated into the thesis context, entrepreneurs are insiders who possess information, VCs are outsiders who wish to obtain information about an entrepreneur and their business (Connelly et al., 2011; Ko and McKelvie, 2018). Signals which ESVs send, convey firm reputation, current and future firm performance, firm value, and trustworthiness (Stuart et al., 1999; Fischer and Reuber, 2007; Pollock et al., 2010). Several researchers state that the signals sent by ESVs are one of the most valuable data points when assessing a venture (Gulati and Higgins, 2003; Busenitz et al., 2005; Plummer et al., 2016).
Effective signalling can reduce information asymmetry, which lowers the perceived uncertainty and makes VCs decision-makers more confident (Maxwell et al., 2011; Connelly et al., 2011; Özman, 2017). These signals are most important in early

stages, under conditions of information asymmetry and even more so when dealing with novel technology and unproven market (Sanders and Boivie, 2004; Plummer et al., 2016; Aldrich and Fiol, 1994). In many cases, proxies which VCs use to assess ESVs, match the signals ESVs can send to VCs[5]. Thus, effective signalling can increase ESVs' likelihood to receive funding (Busenitz et al., 2005). ESVs are well advised to constantly emit these signals as VCs ingest the information at all stages of the investment process, but particularly during screening, evaluation, and due diligence (Busenitz et al., 2005). The signalling process can further be dissected into different components, the (a) signal emitter and content as well as (b) recipients and the issues which can occur during the transmission.

(a) Signal emitter and content

The content of ESV signals can be interpersonal or informational (Zott and Huy, 2007; Chen, 2009; Kirsch et al., 2009). Interpersonal signalling conveys qualities of entrepreneurs, confidence, and authenticity (Kim and Aldrich, 2005; Lee and Jones, 2008; Gedajlovic et al., 2013; Huang and Knight, 2017), whereas information signalling conveys the venture's economical value, performance, and interorganisational relations (Shane and Cable, 2002; Maurer and Ebers, 2006; Zott and Huy, 2007; Ko and McKelvie, 2018). Definitions of these first-, and third-party signals are fluid in the literature (Connelly et al., 2011; Ko and McKelvie, 2018). Signals are often ill-defined and have multiple underlying theories, such as social capital and human capital theory (Connelly et al., 2011). As the borders of an ESVs are fluid, this could result in inconsistent signal definitions, due to a lack of clarity on who is an external stakeholder (Hoang and Antoncic, 2003; Farsi et al., 2013; Milanov and Fernhaber, 2014; Eftekhari and Bogers, 2015). To avoid such confusion, for this thesis, the company perimeter is drawn around the core entrepreneurial team, comprising of the founders, and their employees who can signal collectively as an ESV, or individually. All affiliates beyond this imaginary border count towards the ESV's social network which receives the signals.

Existing research on interpersonal signalling from the entrepreneurial perspective mentions founder's education, patents, awards, and grants as possible ESV signals (Baum and Silverman, 2004; Graham and Sichelman, 2008; Pollock et al., 2010; Hoenig and Henkel, 2015; Islam et al., 2018). The signalling literature explains how efficient signalling can help ESVs to remove bottlenecks and hurdles. An example for such a signal are teams, comprising of first-time founders which fight against a significant bias being statistically more likely to fail than repeat founders. This situation could be mitigated through interpersonal signalling (Hsu, 2007; Levie and Gimmon, 2008; Gompers et al., 2010; Gimmon and Levie, 2010).

[5] The proxies which are referred to can be revisited in Table 2.2 on page 22.

Existing research on informational signalling from the entrepreneurial perspective mentions third-party connections, strategic alliances, endorsements, and affiliations can help ESVs to overcome their liabilities of newness and smallness (Stuart et al., 1999; Elfring and Hulsink, 2003). This idea combines signalling theory with social capital theory as these interorganisational ties exist in the form of a social network around the ESV (Liang and Yuan, 2016). Plummer et al. (2016, p. 1598) highlights that "third-party signals can unlock the value of signals that might otherwise go unnoticed, [allowing external parties] to make sense of the firm's characteristics and action signals, reducing uncertainty, resolving ambiguity, and overcoming a noisy signalling environment." Islam et al. (2018) adds that some signals can overcompensate the lack of other signals, such as an ESV having received a government grant, which overcompensated a weak patent portfolio. Among those affiliations which ESVs can signal are advisers (Certo, 2003; Lehtonen and Lahti, 2009) who cannot only mentor founders but also make introductions to investors and help during negotiation. Previous research also mentions the value of signalling strategic alliances with large corporate partners (Alvarez and Barney, 2001; Alvarez et al., 2006), and existing, prestigious investors (Hsu, 2004; Pollock and Gulati, 2007; Alexy et al., 2012).

A special form of signalling occurs for university spin-outs, which can signal two additional, interpersonal and informational signals. Firstly, the founder's educational pedigree gained by the affiliation with the university. Secondly, the fact that the ESV already existed as an entity in a university department, retains a tie to the university, and technology is often based on peer-reviewed research, before it was taken out as an independent business (Ko and McKelvie, 2018; Huynh, 2016; Gubitta et al., 2016; Sousa et al., 2011).

Although most research is concerned with the signalling towards potential investors, signals can also be sent to potential hires (Davila et al., 2003; Ouimet and Zarutskie, 2014; Becker-Blease and Sohl, 2015), existing and new customers (Gupta et al., 2004; Meiseberg, 2013; Wang et al., 2014) and existing and new suppliers (Certo, 2003; Huynh, 2016). When analysing signals picked up by investors, Huang and Knight (2017) found that angel investors rely more on interpersonal signalling, as opposed to VCs who rely heavier on informational signals.

(b) Signal recipients and issues

Existing research also explains how signalling efforts must be structured to be considered credible and effective. For an external entity to appreciate a signal, the content that is signalled has to be costly or difficult to achieve (Stuart et al., 1999; Lee et al., 2001; Bird and Smith, 2005; Fischer and Reuber, 2007). An example of a difficult to achieve signal is a degree from a university with strict entry requirements

which signals a founders relative academic and intellectual ability (Connelly et al., 2011). Furthermore, signals have to be sent regularly, with high frequency, and remain consistent or improving to convincingly demonstrate value of a venture to VCs (Prasad et al., 2000; Ko and McKelvie, 2018). Signals, especially for those ESVs operating in dynamic environments, must be developed over time to show momentum, differentiation among competitors, and thus reduce information asymmetry (Janney and Folta, 2003; Jonsson, 2015). Research showed that timely signals, embedded in observable actions and people, weigh stronger than promises and "name-dropping" (Busenitz et al., 2005).

In contrast to the literature on ESV resources and dynamic capabilities which mainly focuses on positive notion of social networks, studies on signalling are ripe with mentions on possible deception and even fraud (Nitin and Eccles, 1992; Bird and Smith, 2005; Connelly et al., 2011; Barone and Coscia, 2018). As one recent example, the positive signalling through high-profile advisers and board members spectacularly proved to be a fallacy in the case of Theranos (Certo, 2003; Pollock et al., 2010; Higgins et al., 2011; Carreyrou, 2015, 2018). Theranos, a bankrupt Silicon Valley firm which was valued at $9bn before it folded, had a high calibre board, decorated former Chief Executive Officers (CEOs), former US secretaries of state, and respected medical professors, which blindfolded investors. This fraud is an example for signalling being a double-edged sword. Another example of a detrimental signalling effect can be found in the behaviour existing investors. Continued follow-on investments from existing investors send a strong, positive signal because it demonstrates trust of existing partners whos information asymmetry is considerably lower than that of prospective investors. The reverse effect occurs for existing investors who, although an investment would be within their investment focus, decide not to follow-on invest, which can seriously harm the fundraising abilities of a venture and lower the valuation (Kim and Wagman, 2016).

It is noteworthy that signals are non-linear and different stakeholders require different marginal signalling strength (Pollock et al., 2010). Furthermore, signals are unstable and their strength decays over time. Islam et al. (2018) found that the signal following a grant award lasts six months. Ko and McKelvie (2018) found that certain signals are effective for certain fundraising stages, while others found that releasing additional information can dilute existing signals and succeeding or failing to reach a milestone can overwrite existing signals (Sanders and Boivie, 2004; Zheng et al., 2010; Pahnke et al., 2015). Entrepreneurs have to be aware of the signals they emit, as well as the signals they do not emit. Janney and Folta (2003) found that failure to emit signals and unawareness about negative signals can harm ESVs funds-raising efforts.

More recently, with the emergence of social media platforms, online signalling has

come to the centre of academic attention (Fischer and Rebecca Reuber, 2014; Keating et al., 2014). Signalling online can be attractive for ESVs due to the low entry barrier, low costs, wide reach, and high engagement with communities (Kaplan and Lerner, 2010). In their study of entrepreneurs' use of social media, Fischer and Rebecca Reuber (2014) found that signals can be categorised into conveying quality, relational orientation, or differentiation. Their research also determined that firms which signal a combination of these three categories are more likely to receive venture funding. In accordance with Janney and Folta's (2003) findings about the effects of not-signalling, Fischer and Rebecca Reuber (2014) mention that unawareness about non-signalling through social media or negative mentions on blogs and news can out-weight the benefits (Aggarwal et al., 2012; Fischer and Rebecca Reuber, 2014).

In summary, ESVs who successfully reduce information asymmetry though signalling, online and offline, may receive more favourable terms by investors, achieve higher valuations (Certo et al., 2001; Shane and Cable, 2002), and increase their performance and chance of survival (Brüderl and Preisendörfer, 1998; Delmar and Shane, 2004). Hitherto, the review has mentioned the concept of social networks and value of social capital in multiple occasions, both from the entrepreneurial and investor perspective. These concepts are fundamental theoretical foundations of this thesis. The next section presents an in-depth review of these concepts with particular focus on their role for ESVs.

2.4 Social capital theory

This section reviews social capital literature at the intersect with entrepreneurship. Historically entrepreneurship and the success and performance of ESVs have predominantly focused on individual entrepreneurial abilities, human capital, and financial capital (Zhao et al., 2010; Unger et al., 2011). By contrast, the understanding of entrepreneurial performance from a social capital perspective is scarce (Stam et al., 2014).

Social capital is a disputed theory and probably one of the most ill-defined concepts used in this thesis (Adler and Kwon, 2002). Researchers count between six and two dozen different definitions and argue whether social capital is a resource itself or merely the way to access resources (Putnam, 2000; Adler and Kwon, 2002; Anderson et al., 2007). Researchers hold an ongoing debate about whether social capital is a form of capital comparable to human and financial capital (Coleman, 1988; Nahapiet and Ghoshal, 1998; Lin, 2001; Robison et al., 2002; Adler and Kwon, 2002; Kane et al., 2014; Spiegel et al., 2016). To achieve a clear definition of social capital for this thesis, it is important to draw the lines between human, and social capital which are often convoluted (Coleman, 1988; Adler and Kwon, 2002).

Human capital theory, which describes a third form of capital besides financial and social capital, was developed mainly in the 1960s (Becker, 1964; Schultz, 1961). The concept of human capital allowed to separate a form of organisational capital which is embodied in skills, knowledge, and capabilities of people (Piazza-Georgi, 2002; Mosey and Wright, 2007; Grichnik et al., 2014; Milosevic, 2018). Coleman (1988) and Robison et al. (2002) make a distinction between social and human capital differing in that social capital requires a relationship between people, whereas human capital can reside in individuals.
The majority of research agrees that social capital, like the other forms of capital, is a long-lived asset which can grow through investments (Adler and Kwon, 2002; Kwon and Adler, 2014). Furthermore, capital-like qualities of social capital are its appropriability (Coleman, 1988) and convertibility (Bourdieu, 1986) which means it can be exchanged, for instance into human capital, or can replace or support other forms of capital (Kim and Aldrich, 2005). If left unattended, social capital, as other forms of capital deteriorates (Kwon and Adler, 2014). Social capital can yield potential as well as threats, and it can therefore be considered both a utility and dis-utility (Adler and Kwon, 2002).
This thesis adopts Nahapiet and Ghoshal's (1998, p. 243) definition of social capital:

> **Definition 3:** "[S]ocial capital is the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit."

Nahapiet and Ghoshal add that "[s]ocial capital thus comprises both the network and the assets that may be mobilised through that network." (Nahapiet and Ghoshal, 1998, p. 243). Over the past decades, research demonstrated the importance of networks for ESVs. Granovetter (1985) promotes the idea of entrepreneurship as a socio-economic process which is supported by Vesper (1990) who states that no venture is built in isolation but rather as an inherently collaborative effort. To understand how social capital evolved over time and appreciate why it is becoming increasingly relevant today, it is instructive to review the history of social capital theory in literature.

2.4.1 Evolution of social capital theory

The theory of social capital has ripened for a long time with first mentions dating back to the 19th century. Early political scientist De Tocqueville (1835) introduced the idea, after observing American citizens gathering to discuss political and economical matters (Nolla, 2010). De Tocqueville discovered that the formation of relationships facilitates information and opinion exchange. Five decades later,

Von Bawerk (1884), an influential Austrian economist, coined the term *Sozialkapital*[6] in his work *'Kapital und Kapitalzins'*[7] and his understanding of social capital differs fundamentally from earlier works as he first mentions an economic interpretation.

The two different notions of De Tocqueville and Von Bawerk demonstrate how several definitions coexisted already in early days, with only a few scholars engaging in the discussion. Before the turn of the 20th century, Veblen faults: "[i]t is not too much to say that the controversy has owed much of its bitterness and sterility to inadequate definition of the terms employed, especially to a lack of accuracy in the concept of capital." (Veblen, 1892, p. 249). The disagreement continues in more recent years, since adoption in the economic community increased (Granovetter, 1985; Adler and Kwon, 2002). French sociologist Bourdieu (1980, 1986) was the first to draw the connection of social capital which resides in the form of social networks Putnam (2000). In doing so, he provided an explanation why the social network of a firm can be assigned an economic value. Putnam (2000) summarises his predecessors' contributions as follows:

> *"The core idea of social capital theory is that social networks have value. Just as a screwdriver (physical capital) or a college education (human capital) can increase productivity (both individual and collective), so too social contacts affect the productivity of individuals and groups. Whereas physical capital refers to physical objects and human capital refers to properties of individuals, social capital refers to connections among individuals."* (Putnam, 2000, p. 16)

Social capital research increasingly found entrepreneurial processes to be embedded in social networks (Granovetter, 1985). Consequently, concept social capital had a significant impact on entrepreneurship literature as it led to a re-thinking of the structure of firms, which included the stakeholders around a firm (Jarillo, 1989; Florin et al., 2003; Freeman, 2010). The emergence of graph theory and social network theory, a structures to describe social capital were found (Gulati, 1999; Hoang and Antoncic, 2003; Jansen, 2003; Huber, 2009; Khaire, 2010; Semrau and Werner, 2014). Adler and Kwon (2002, p. 19) found that economists and social network researchers started combined social capital and social network research, "bridging views, focus[ing] primarily on social capital as a resource that inheres in the social network tying a focal actor to other actors.". The recent advances in computing and feasibility to replicate large scale real world networks, such as online social networks, have opened up new avenues for research, particularly in the domain of SNA (Borgatti et al., 2009; Barabási, 2016).

[6] The German term 'Sozialkapital' translates to 'social capital'.

[7] The German title of his work 'Kapital und Kapitalzins' translates to 'capital and interest.'

2.4.2 Social network theory

"Behind each complex system, there is an intricate network that encodes the interactions between the system's components." (Barabási, 2016, p. 23)

Social network theory is based on graph theory which allows mathematical descriptions of complex networks (Newman, 2014). Leonard Euler's work in 1736 on the "seven bridges of Königsberg problem" marks the first mathematical description of a network graph. According to Wasserman and Faust (1994) and Newman (2014), it was Moreno (1934) who's pioneering work in human interaction, modelled as network graphs, marks the beginning of social network studies. Since then, social network research contributed significantly in the field of sociometry, the quantitative study of social, interpersonal relationships (Wasserman and Faust, 1994). Together with further notable works such as Granovetter's (1973) seminal paper on the strenght of weak ties, mark the beginning of modern social network research, which later became the foundation for SNA (Burt, 1982, 2005; Gulati et al., 2011; Newman, 2014; Barabási, 2016). In the second half of the 20$^{\text{th}}$ century, sociologists and economists moved away from atomistic models of individuals and organisations, towards an integrated, networked understanding (Borgatti and Foster, 2003). Among the first to research the impact of social networks on entrepreneurship were Birley (1985) and Aldrich et al. (1986) who described the process of founding a new business from a network perspective.
Although graph theory emerged in the 18$^{\text{th}}$ century, it took until the 21$^{\text{st}}$ century for the technology to be available to map these complex systems and enable modern network science (Barabási, 2016). Research in the last two decades has demonstrated that networks across domains can be described by the same fundamental mathematical principles (Borgatti and Halgin, 2011; Barabási, 2016).
The most recent increase in recognition can be explained by the technological advance of online social media, which like other forms of ESV networks can be modelled as a network graph (Shepherd, 2015; Barabási, 2016). Figure 2.8 illustrates how rapidly academics embraced the concept.

This thesis adopts Newman's (2014, pp. 36) definition of social networks:

> **Definition 4:** "Social networks are networks in which the vertices are people, or sometimes groups of people, and the edges represent some form of social interaction between them [whereby] edges might represent friendship between individuals, but they could also represent professional relationships, exchange of goods or money, communication patterns, [...] or many other types of connection."

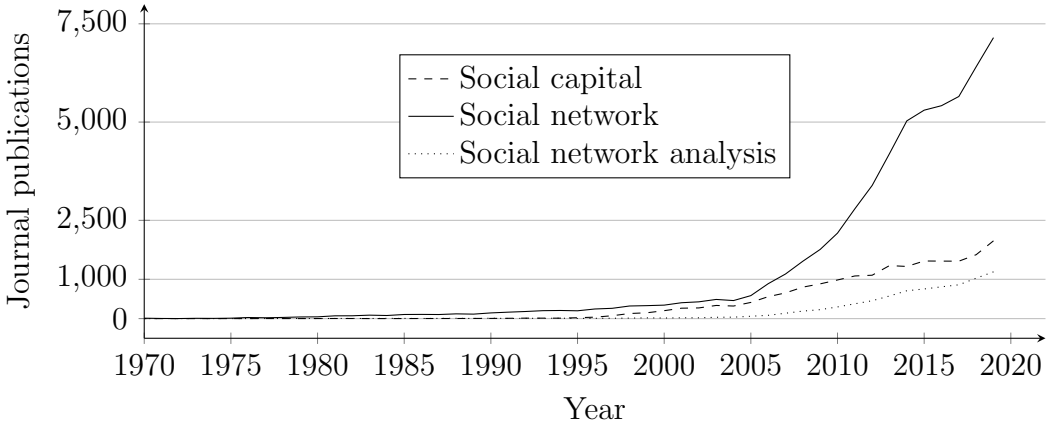


Figure 2.8: Journal publications with keywords "social capital", "social network", and "social network analysis" from 1970 to 2019, based on Scopus.

Adding to the definition, Borgatti and Foster (2003) state that vertices can be organisations of any size and be modelled as one vertex, which is important in the context of this thesis. The economic relevance of social networks is based on the assumption that relationships are important as long as they facilitate exchange of information, knowledge, and resources. The direct impact of a superior information, knowledge, and resource position on ESVs were discussed in Section 2.3.1 (Wasserman and Faust, 1994; Barabási, 2016). Another assumption is that the values of networks exceed that of the sum of the parts because of their emergent properties, i.e. features and abilities which a collective exerts but each individual lacks (Newman et al., 2006; Lin et al., 2011). These emergent properties positively influence organisational behaviour and economic outcomes (Uzzi, 1996, 1997; Jansen, 2003; Florin et al., 2003).

Research suggests that there is high awareness of the importance of social networks among market participants, but little understanding of their optimisation and economic consequences for business (Smith et al., 2017; Shepherd et al., 2019). Knowledge of concrete approaches to, and successful implementation practices of networking are not uniform among market participants. Thus, there is strong evidence that conscious networking activities conducted by ESVs yield potential and might positively influence their development and valuation (Das et al., 1998; Teece, 2010; Festel et al., 2013; Smith et al., 2017). Such potential gives rise to a "network success hypothesis" (Brüderl and Preisendörfer, 1998, p. 213).

SNA enables research into complex social networks and the mathematical description thereof (Barabási, 2016). Such complex social networks can consist of millions of vertices and structuring large networks requires a thoroughly defined array of social networks components. Table 2.3 shows a summary of those components and metrics which are later used in this thesis to describe ESV networks.

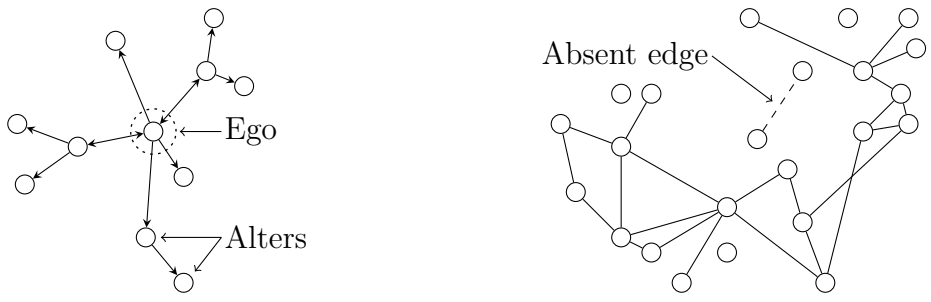
Table 2.3: Social network terminology in the social sciences merged from Newman (2014), Wasserman and Faust (1994), and Scott (2017).

Terminology	Definition
Sub-network	Sub-networks are independent networks and part of a larger network (Wasserman and Faust, 1994).
Vertex	An actor, node, or vertex is an entity in a social network which represents a person, a group of individuals, or an organisation (Borgatti and Foster, 2003; Scott, 2017; Barabási, 2016). Hereafter this network component will be referred to as a vertex.
Edge	A connection, tie, or link, in a network graph connects two vertices and represents their interaction or flow of goods, which can be material or non-material (Wasserman and Faust, 1994). Ties can further be differentiated into dichotomous states of directed and undirected, present and absent, and weighted or unweighted (Borgatti and Foster, 2003; Newman, 2014; Butts, 2009). Directed indicates a one-directional or bi-directional flow from one vertex to another, undirected analysis the latter disregards direction. Isolated vertices are not connected to the network graph. Weighted edges have quantitative strength attribute, for instance an investor who invested twice compared to a one time investor. Henceforth the element connecting vertices will be referred to as an edge.
Network constellation	A network graph, or network map is a mathematical or visual representation of the pattern in which vertices are connected by edges is called network (Barabási, 2016). For the purpose of this thesis the construct is referred to as a network constellation.
Network size	The total number of vertices in a network (Wasserman and Faust, 1994; Carpenter et al., 2012).
Degree	The number of direct edges to other vertices, also called degree centrality (Wasserman and Faust, 1994; Newman, 2014).
Centrality	Degree divided by the total number of nodes in a network. Centrality is a measure for the achieved connectedness of a vertex compared to the maximum achievable connectedness (Scott, 2017). It is therefore considered the primary measure for a vertex's importance in a network (Newman, 2014). In directed networks, where the direction (emitting or receiving a signal) is important, in-degree (incoming signal), and out-degree (outbound signal) can be differentiated (Carpenter et al., 2012; Marsden, 2015).
Eigenvector centrality	Eigenvector centrality considers second-tier connections. A vertex with high eigenvector centrality is linked to many other vertices which have a high degree centrality. (Borgatti et al., 2009; Newman, 2014).

Continued on next page

Terminology	Definition
Betweenness centrality	Betweenness centrality is a measure for a vertex's ability to bridge network gaps, also called structural holes, and facilitate and control communication across a network (Wasserman and Faust, 1994; Burt, 2005). Betweenness is defined as the number of shortest geodesic paths between any two vertices which route through the focal vertex divided by the number of shortest paths that exist (Freeman, 1979; Newman, 2014).
Density	The ratio of edges in a network compared to the maximum achievable number of edges if each vertex was connected to all vertices (Carpenter et al., 2012; Scott, 2017).
Similarity	This measure denotes the extent to which vertices are comparable regarding their attributes and is therefore a measure of heterogeneity in a network (Newman, 2014; Burt, 1995).

Essential to social network research is that the researcher determines the appropriate unit of analysis by defining boundaries of otherwise near-infinite networks (Borgatti and Foster, 2003; Creswell, 2014; Newman, 2014; Barabási, 2016). In describing ESVs' social networks, researchers can either focus on the network around a single focal vertex, a few focal vertices, or the entire network (Kilkenny and Fuller-Love, 2014; Crossley et al., 2015; Ozdemir et al., 2016). Figure 2.9 illustrates the distinction between (a) egocentric and (b) whole network analysis.



(a) Egocentric network (b) Whole network

Figure 2.9: Juxtaposition of egocentric and whole network analysis, own illustration.

The analysis of an individual vertex's network is called "ego-network" or "egocentric network" analysis. In an egocentric network one central vertex (ego) is either directly or indirectly connected to the surrounding vertexes (alter) while unconnected vertexes are removed (Borgatti and Foster, 2003; Carrington et al., 2005; Newman, 2014). A whole network analysis considers every vertex, including unconnected vertices. Therefore, it allows an analysis of every network detail, such as multiple ego-networks in the context of to the entire network. For some research settings,

only small parts of the entire network are of interest. Similarly, the analysis might focus on vertices which are unconnected, highlighting network gaps, called "structural holes" which represent potential to grow the network (Burt, 1995, 2005).
Few studies with notable exceptions such as Liang and Yuan (2016) used social network analysis for empirical studies of early-stage investment decisions. Some research has been undertaken to map investor syndication, i.e. the co-investment of several investors (Alexy et al., 2012; Gloor et al., 2013; Wang, 2016; Luo et al., 2019; Yang et al., 2018). The role of social media in ESV fundraising was empirically researched, however, without a social network perspective (Yang and Berger, 2017). As a consequence, there is a notable gap in academic literature and practitioner understanding of the intersection of social networks and ESV evaluation. This thesis addresses this gap.

2.4.3 Summary and literature gap

This chapter synthesised three literature streams and identified a gap in the literature. While theoretical and qualitative empirical knowledge about benefits of social networks are abundant in literature, there is a dearth of knowledge on network compositions and structures which maximise benefits for ESVs regarding their fundraising and growth performance (Pangarkar and Wu, 2013). Practitioners have not adopted the social network perspective. Neither do VCs include SNA in their evaluation of ESVs, nor do entrepreneurs have a methodical understanding of leveraging their networks to boost their private market position. Consequently, the effects of social networks on fundraising have received little attention (Stuart and Sorenson, 2007; Lee et al., 2010; Miloud et al., 2012; Audretsch and Link, 2012; Heuven and Groen, 2012; Festel et al., 2013; Dusatkova and Zinecker, 2016; Ko and McKelvie, 2018; Gompers et al., 2020). For entrepreneurs and investors, a lack of understanding of social networks in fledgling ESVs and their economic effects represent unrealised potential by bringing more clarity to an inherently uncertainty driven process.
Reasons for the lack of adoption are not evident in the literature especially as both groups, VCs and entrepreneurs, are very aware of the power of networks and the positive effects networks have on the financial outcome of ventures.
For VCs themselves embeddedness in networks and aptness in leveraging them plays an important role (Hsu, 2004; Hochberg et al., 2007; Cumming and Dai, 2011; Gompers et al., 2020). Some VC funds refer to their portfolio as a "keiretsu", the Japanese term for a strategically interlocking conglomerate of firms (Landström, 2007; Greve et al., 2014). Extensive social networks surrounding VC funds helps appoint better board members (Amornsiripanitch et al., 2019), increases the success of their portfolio companies to fundraise (Ter Wal et al., 2016). Studies also

suggest that social networks strengthen the ESV's visibility and brand image (Hsu, 2004), and help attract external talent (Hellmann et al., 2002). Overall VCs are often found to leverage their social network for specialist tasks they cannot fulfil themselves by working with head-hunters, patent attorneys, lawyers, or journalists (Hochberg et al., 2007).

From the entrepreneur's perspective, only a few empirical studies considering social networks were conducted. The results suggest that ESVs with strong social networks find it easier to get an introduction to a VC (Heuven and Groen, 2012), have an increased likelihood of being funded (Baron and Markman, 2003), can raise more capital (Yang and Berger, 2017), and achieve higher valuations (Zheng et al., 2010). There have been repeated calls for more research on how entrepreneurs manage an ESV by leveraging their social network (Martens et al., 2011; Zachary and Mishra, 2013; Keating et al., 2014; Islam et al., 2018). Participation of outsiders in firm-level management and the amplifying role of stakeholder voices is neglected in the literature (Fischer and Rebecca Reuber, 2014).

Researchers criticise that the entrepreneurship and investor perspective are not integrated sufficiently which disregards the dyadic dynamics between the two groups and thus call for research to bridge that gap (Huang and Knight, 2017). Furthermore, concepts such as signalling of ESVs and the technological feasibility to map large networks are not jointly explored. Additional research to uncover more types of ESV signals at the early founding stages is required (Plummer et al., 2016) with particular focus on those which can be measured quantitatively (Lee and Jones, 2008; Connelly et al., 2011; Stam et al., 2014).

The recent advance of VC funds with a data-driven investment, or crowdfunding campaigns that allow participation of unaccredited, inexperienced investors increases the demand for rigorous models (Kupor, 2019; Gompers et al., 2020). While the number of funds employing data-driven strategies is more than doubling each year, SNA as a critical element is not considered sufficiently in their models (Yang and Berger, 2017; Ko and McKelvie, 2018). Research into other industries has demonstrated that circumstances dominated by non-linearity and serendipity can be better understood when looking at them through a social network lens (Barabási, 2016; Hvistendahl, 2018).

Hitherto, studies have analysed social networks around ESVs both as the dependent and independent variable, which raises the issue of endogeneity as well as a correlation versus causation debate. The debate around repeat founders is an example of such correlation versus causation questions. In the UK, 13 of 18 unicorns[8] were founded by repeat founders (PitchBook, LinkedIn). However, it is difficult to determine how instrumental the repeat founder attribute is compared to other attributes.

[8] A "unicorn" is a company with its financial valuation exceeding $1bn.

Ramsinghani (2014) faults, "[e]ven as we live in the era of big data, nothing about venture capital investments is predictable or persistent. The correlation/causation debate continues." This research can contribute to the debate by studying whether and how social networks can serve as a proxy to infer cues about an underlying quality (Connelly et al., 2011). Existing research suggests that unrealised potential could reside in systematically evaluating ESV networks, which presents a significant research problem.

The next chapter illustrates the design of subsequent studies which aim at shedding light on the understudied ESV environment.

3. Research foundation

Contents

This chapter explains the research design process and positions of the studies in the broader philosophical context. The identification of the philosophy underlying the research is an essential procedural step and requires the researcher's awareness and reflective attitude (Van de Ven, 2007). A reflection on philosophical positions contrasts their inherent ontological and epistemological assumptions and evaluates the implications. Striving for responsible research also involves understanding how the researcher's predisposition and the problem under investigation predetermine and restrict the use of methods, which ultimately influence the results.
Thereafter follows the formulation of a theory-building strategy. The higher-level strategy for theory-building leads to an executable research methodology to conduct the studies. The research methodology includes a choice of enquiry methods, a definition of the research problem, identification of research questions and objectives, and a plan to collect suitable evidence and the analysis thereof.

3.1 Philosophical stance

The philosophy of science studies the assumptions and relationships between theory, methods, and data which has long been a controversial topic among philosophers and methodologists (Van de Ven, 2007). An example for a central question is whether researchers should begin research by selecting a theory first and subsequently collect data, or vice-versa (Robson and McCartan, 2016). Through such reflections, researchers can fulfil their obligation to correctly gauge and limit their influence on research results. Overall, this section does not engage in a philosophical discussion but instead introduces key concepts which later reflect on methods in this research and their underlying limitations. It is further worth noting that nomenclature in philosophy is non-uniform (Van de Ven, 2007). The adopted nomenclature in this thesis follows the mainstream of the social sciences and is excerpted from multiple works on research methodology (Guba and Lincoln, 1981; Van de Ven, 2007; Creswell, 2014; Easterby-Smith et al., 2015; Robson and McCartan, 2016).
Figure 3.1 shows an analogy of a tree trunk cross-section to explain the philosophy of science, the relationship between the philosophical position and the researcher's actions.

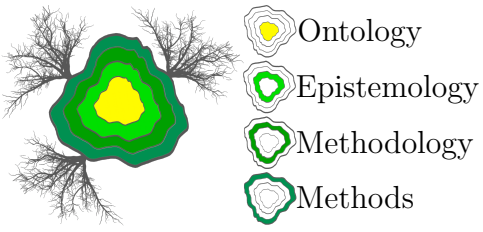


Figure 3.1: Tree trunk cross-section resembling philosophies of science, modified from Easterby-Smith et al. (2015, p. XIV).

Herein, four nested layers represent the four essential components of research designs and their relationship. Serving the same purpose as inner liners of a tree trunk, providing steadfastness, (1) *ontology* and (2) *epistemology*, underpin the research and represent the researcher's beliefs and assumptions, but remain invisible characteristics and are covered in Section 3.1.1. The more visible research characteristics illustrated by the two outer slices of the cross-section (3) *methodology* and (4) *methods*, are outlined by Sections 3.1.2 and 3.2.2.

3.1.1 Ontology and epistemology

As mentioned above, the selection of ontology and epistemology, determine the position within the philosophies of science. This thesis adopts the following definitions of ontology and epistemology.

Definition 5: Ontology summarises a researcher's assumptions about the existence of an observable reality and truth (Crotty, 1998; Van de Ven, 2007; Easterby-Smith et al., 2015).

Definition 6: Epistemology encompasses the philosophical implications of the chosen enquiry methods when understanding the nature of a phenomenon (Easterby-Smith et al., 2015; Williams, 2016).

Philosophers distinguish several positions, whereby realism and nominalism mark the ends of the spectrum (Van de Ven, 2007). Realism suggests the existence of a single, observable truth, whereas nominalism rejects the conception of an objective, observable truth and understands all facts as created by humans (Blaikie, 2007).
The guiding paradigm selected for this thesis is "engaged scholarship" (Van de Ven, 2007). Constitutive for Van de Ven's engaged scholarship paradigm is the involvement of the researcher and engagement of practitioners during every stage of the research process. This paradigm was chosen after observing a wide literature gap between established evaluation methodologies for ESVs and an alternative social network perspective. At the same time there is a wealth of knowledge to be harnessed from stakeholders, and therefore the decision was made to include them. Van de Ven (2007, p. 284) argues that "researchers can make more penetrating and insightful advances to science and practice by obtaining the perspectives of relevant stakeholders in problem formulation, theory building, research design, and problem solving than when they perform these research activities alone." With regard to this research, the engaged scholarship paradigm reflects the parallel perspectives gleaned by the entrepreneurship and VC literature review as well as those of entrepreneurs and VCs as relevant practitioner groups.
Positioning the engaged scholarship paradigm in the philosophical context, Van de

Ven (2007, p. 37) explains that "[e]ngaged scholarship adopts a critical realist perspective, [...] takes an objective ontology, [...] and a subjective epistemology." Figure 3.2 illustrates how realism and relativism bracket engaged scholarship which takes elements from both.

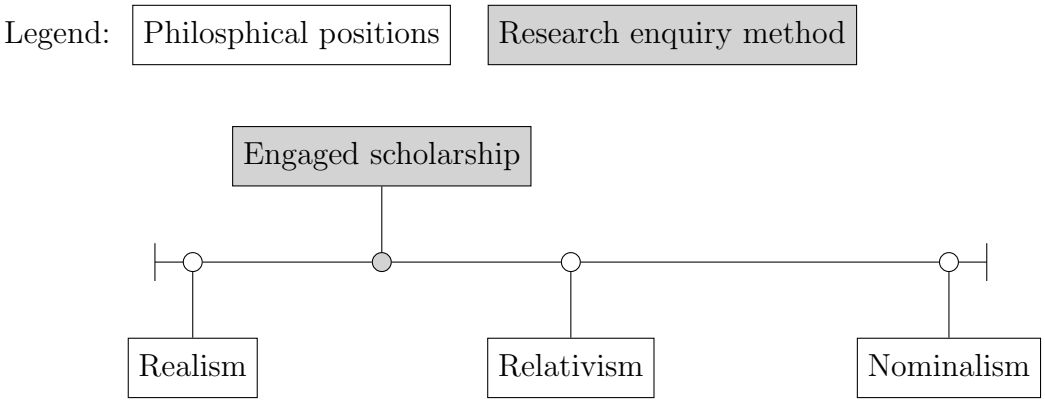


Figure 3.2: Spectrum of philosophical positions in relation to selected research method, own illustration.

The relativist perspective suggests that truth exists but only within a confined context (Baghramian and Carter, 2019). Precisely locating the engaged scholarship paradigm's philosophical position allows the researcher to understand the implications on the study that result from his beliefs.

(a) Ontological stance of this research

Table 3.1 lays the cornerstones of ontological assumptions of the realist, relativist, and nominalist positions, and illustrates the position of this research among them.

Table 3.1: Ontology of the realist and relativist position, merged from Easterby-Smith et al. (2015, pp. 47) and Van de Ven (2007, pp. 36).

	Realism	**Relativism**
Ontology	Objective, positivist. An observable, external social world exists independently of human beliefs.	Subjective, interpretivist. The social world is not exterior but construed by people, and knowledge is conceptual.
Truth	Single truth, static	Multiple truths, dynamic
Facts	Facts exist and can be revealed.	Facts depend observer's viewpoint and are too rich to be fully observed.

Van de Ven's guide reconciles the contrasting philosophical stances. He emphasises that a researcher can take the view that:

> *"there is a real world out there, but our attempts to understand it are severely limited and can only be approximated. This perspective argues*

> *that all facts, observations, and data are theory-laden and embedded in language. Moreover, most phenomena in the social world are too rich to be understood adequately by any single person or perspective. Consequently, any given theoretical model is a partial representation of a complex phenomenon that reflects the perspective of the model builder. No form of enquiry is value-free and impartial. Instead, each model and perspective is value-full."(Van de Ven, 2007, p. 14)*

Regarding ontology, the belief in and recognition of a singular truth, this research takes a critical realist position which accepts a single truth but rejects the notion that truth can be attained. Given the study's context, for the first group of study subjects, the VCs, perfect information is unattainable. Consequently, the researcher accepts that the true evaluation, is unattainable and, therefore, assumes that social networks only proxy[1] the holistic evaluation of an ESV while also recognising the *raison d'être* of alternative proxies. The literature review and pilot studies conducted before the actual studies indicated alternative approaches to conduct an evaluation, which would yield different results and consequently, truths. The analogous assumption of multiple truths similarly applies to the second practitioner group, the entrepreneurs. Among entrepreneurship researchers the feasibility to make sense of the inherently serendipitous and chaotic entrepreneurship processes is controversially discussed. Steyaert (2007) suggests that entrepreneurship can be viewed as a replicable practice of successful opportunity recognition and entrepreneurial execution, which he calls "entrepreneuring". Sarasvathy (2001) theorises in her work on principles of effectuation[2] that successful entrepreneurship creates opportunities and adapts to situations and is an open-ended process with multiple potential outcomes (Sarasvathy, 2001, 2008). This stance aligns with the researcher's presupposition, thus, a critical realist position, which allows for realist and relativist tendencies, is adopted for this thesis.

Revisiting the tree-trunk analogy, the ontology forms the primary basis for research as it begins with the researcher's beliefs and the assumptions about what truth research can find. The second layer, the epistemology, captures how primary beliefs translate into the choice of an enquiry method, which is the strategy to encounter a research problem. The choice of such methods predetermines the results, therefore, the researcher ought to be aware of the consequences for the studies results.

[1] A proxy is a "measurable variable that is used in place of a variable that cannot be measured." Upton and Cook (2014, p. 470). Thus, in this thesis the use of social network metrics (proxy variables) is examined for its applicability of inferring an ESV's value and future performance (unmeasurable variables).

[2] Sarasvathy (2001, p. 245) defines effectuation as the opposite of causation whereby causation is the "processes take a particular effect as given and focus on selecting between means to create that effect" and "Effectuation processes take a set of means as given and focus on selecting between possible effects that can be created with that set of means."

(b) Epistemology of this research

In pursuit of objectivity, Van de Ven advocates the use of several data sources and mixed-method approaches since every perspective adds towards a better understanding and is subject to different biases. The discussion about biases due to the researcher's influence does only persist in philosophy or social sciences but also in the natural sciences perspective.

The discussion might be easiest to understand by taking the natural sciences perspective, empiricism, which is the strictest form of epistemology (Bogen, 2017). Researchers who observe naturally occurring or experimentally generated phenomena take measurements and aim to minimise their influence on the results. However, even empiricists who believe in a single, perfectly attainable truth have to admit that even the most precise instruments and careful researchers will influence results, and call it the "observer effect" (Franklin and Perovic, 2019). The underlying idea is that no matter how carefully and passively a phenomenon is studied, measurements cause irreducible impact and manipulation. Understanding the observer effect as part of the engaged scholarship paradigm is important as the results are achieved through active involvement with the study subjects and are inherently exposed to the researcher's biases. To appropriately identify, understand, and mitigate the effects of the researcher's actions, the epistemological assumptions of the philosophical stance need to be revised (Van de Ven, 2007). Table 3.2 lists the epistemological cornerstones of the realist and relativist position and translates them into concrete research characteristics and strategies.

Table 3.2: Epistemology of the realist and relativist position, merged from Easterby-Smith et al. (2015, pp. 47) and Van de Ven (2007, pp. 36).

	Realism	**Relativism**
Epistemology	Objective. A social world exists which can be objectively measured and tested through inductive verification or deductive falsification. There is one appropriate way of measuring and one correct result.	Subjective. Search for meaning rather than truth. Knowledge can be derived from inductive reasoning. Predetermined methodologies do not exist. Several approaches to find truth are feasible.
Aims	Discovering, confirming theory	Converging, generating theory
Starting point	Hypotheses	Questions
Execution	Hypothesis formulation and testing, deductive reasoning	Active enquiry, "let the data speak", inductive reasoning
Sampling	Large n, randomly selected	Small n, deliberately selected
Analysis	Verification or falsification	Triangulation and comparison

Continued on next page

	Realism	**Relativism**
Observer	Subjectivist, passive, detached, and independent of the empirical world, and has no prior cognitive frameworks	Constructivist, active, engaged, part of the observation, creator of cognitive frameworks
Observer's interest	Must be concealed and should not be considered	Is the source of data and knowledge
Explanations	Demonstrate causality	Increase understanding
Unit of analysis	Reduced to minimum	Entire situation or system
Generalisation	Statistical probability	Theoretical abstraction

Since the epistemology follows the premises of the ontology, the cornerstones listed in Table 3.2 are jointly set by the ontological and epistemological positions. These assumptions are now connected to the given research context of this thesis.
As previously mentioned, the literature review identified multiple relevant perspectives, stakeholder groups, and potential approaches. Consequently the research problem is formulated to include several perspectives which require dedicated research enquiry methods. The resulting five research questions are addressed through five separate sub-studies and are described in separate chapters as illustrated in Table 3.3.

Table 3.3: Chapters and sub-studies

Chapter number	**Sub-studies**
Chapter 4	(1) ESV signalling study, (2) ESV stakeholder study
Chapter 5	(3) ESV social network function study
Chapter 6	(4) ESV evaluation experiment study
Chapter 7	(5) ESV evaluation tool study

Of the four chapters, Chapter 4 contains two sub-studies using a similar methodology, the following Chapters 5, 6, and 7 each contain a single study with dedicated methodologies. The four methodologies for the four chapters vary the research enquiry from qualitative and quantitative elements, employing inductive and deductive reasoning, intending to either discover phenomena or testing hypotheses, while using small or large samples. Table 3.4 classifies the four chapters with regard to their epistemological position across important research design and study execution elements.

Table 3.4: Epistemological position by chapter

Epistemological stance	Realism	Relativism
Aims	Chapter 6, Chapter 7	Chapter 4, Chapter 5
Starting point	Chapter 6, Chapter 7	Chapter 4, Chapter 5
Execution	Chapter 6, Chapter 7	Chapter 4, Chapter 5
Sampling	Chapter 6, Chapter 7	Chapter 4, Chapter 5
Analysis	Chapter 6, Chapter 7	Chapter 4, Chapter 5
Observer	Chapter 6, Chapter 7	Chapter 4, Chapter 5
Human interest	Chapter 6, Chapter 7	Chapter 4, Chapter 5
Explanations	Chapter 6, Chapter 7	Chapter 4, Chapter 5
Unit of analysis	Chapter 6, Chapter 7	Chapter 4, Chapter 5
Generalisation	Chapter 6, Chapter 7	Chapter 4, Chapter 5

As encouraged by the engaged scholarship paradigm, the philosophical position is slightly altered across chapters. Allocating the individual studies to the relevant philosophical position brings the section on ontology and epistemology to a conclusion. The following methodology Section 3.1.2 and subsequent methods Section 3.2 describe in detail how the chosen enquiry methods vary regarding their aims, starting points, execution, etc., and prepare for the critical evaluation of methods in Section 3.2.5.

3.1.2 Methodology

The research methodology translates the philosophical stance into a practical guide for research, and justifies the use of certain methods with the goal of building theory (Van de Ven, 2007; Robson and McCartan, 2016). A primary goal of this research project is to explain the phenomenon of growth and performance of ESVs, and their subsequent evaluation by the private market, more specifically the VCs, through a social network perspective. A secondary outcome of the study is an improved understanding of this phenomenon and expanding of theories to make them more applicable for practitioners. Van de Ven (2007, p. 19) defines a theory as "the mental image or conceptual framework that is brought to bear on the research problem." For this research, such theories are understood as applicable constructs which can be used by theorists and practitioners. Devising a plan for theory development, and thereby the contribution, is an essential step before creating a research strategy which, when executed, yields the final results. The theory development process entails crucial decisions which influence research design and questions, concepts, propositions, predictions, and results (Van de Ven, 2007). Figure 3.3 shows a schematic depiction of the model as suggested by the engaged scholarship paradigm.

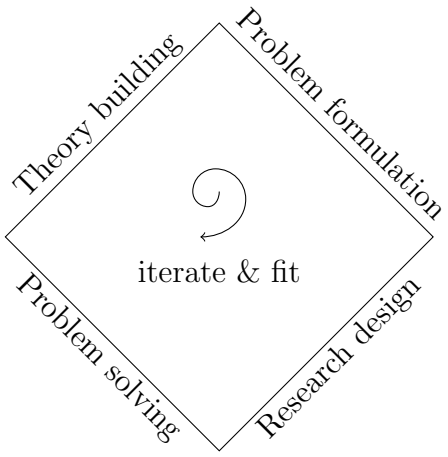


Figure 3.3: Engaged scholarship theory building model, modified from Van de Ven (2007, p. 10).

During each step in the cyclical theory-building model, researchers seek engagement with stakeholders to hone the research problem formulation, research questions, and research design. For this thesis, the procedure adopted was as follows:

- Identifying a real-world problem faced by a stakeholder through communication with ESVs or VCs.
- Formulating the research problem, research questions, and sub-research questions
- Exposing the stakeholders to the research problem formulation, research questions, and sub-research questions and incorporation of their suggestions
- Deciding which method of enquiry to use
- Proposing questions, measures, and models to capture the complexity of the problem
- Piloting the study with stakeholders and making modifications allowing to calibrate and initialise the questions, measures, and models
- Gathering and analysing data
- Evaluating results, communicating to stakeholders, and refining the proposed measures allowing application in a subsequent study

As noted earlier, the nature of the research problem that this thesis seeks to address requires the use of multiple complementary methods. After the literature review, and exploratory qualitative signalling and stakeholder sub-studies in Chapter 4, the research studies branch out into parallel qualitative and quantitative approaches. Chapter 5 represents an in-depth successive study of ESVs' business functions that can be assisted by social networks and is based on Chapter 4, while Chapter 6 quantitatively tests ESV evaluation in an experimental setting by using constellations identified in Chapter 4. Chapter 7 builds onto Chapter 6 and gathers large amounts

of real-world data to develop an ESV evaluation tool and tests metrics derived in the previous chapters. Conducting the studies in succession allowed results to inform subsequent steps. Each study with its dedicated methodology was supported by the decision matrix shown in Figure 3.4 during the planning phase.

Building	Enhancing	Testing	...theory
Inductive	Deductive	Abductive	...reasoning
Descriptive	Predictive	Exploratory	...enquiry
Linear		Cyclical	...iteration

Figure 3.4: Theory building decisions, own illustration based on Blaikie (2009).

Theory. Scholars can contribute to theory in one of three ways, either by introducing new theories or through enhancing or testing existing ones (Blaikie, 2009). Chapter 4 with its two sub-studies aims at enhancing the theory about signalling between entrepreneurs and VCs as well as relevant stakeholders for ESVs, whereas Chapter 5 builds new theory by observing archetypical approaches of ESVs to leverage their networks for specific business functions. Chapter 6 enhances existing theory by analysing pre-defined social network metrics and their effect on ESV evaluation in an online survey, whereas Chapter 7 tests theory and a set of metrics from the previous chapter with real-world data.

Reasoning. Abduction, induction, and deduction are the three main forms of reasoning identified by philosophers (Pierce, 1877; Van de Ven, 2007). Inductive reasoning is a bottom-up approach of deriving a generalisation from empirical observations (Van de Ven, 2007). By contrast, deductive reasoning is a top-down approach which begins with a generalisation and tests its applicability to individual cases (Mounce, 1997; Van de Ven, 2007). Abduction is a hypothetical inference which is tested, then altered by newly generated understanding, and exposed to further testing (Mounce, 1997). Across the four studies conducted in this thesis, the reasoning is inductive in Chapter 4 and 5, deductive in Chapter 6, and abductive in Chapter 7. The forms of reasoning were chosen to reflect the increased focus as studies proceed. The initial, inductive studies take empirical evidence from practitioners, "allows the data to speak", and aims to increase understand while building a foundation for subsequent studies. A deductive study described in Chapter 6 tests how existing theories apply to the established context. The final study follows abductive reasoning as it takes a new form of evidence while aiming to apply the previously established theories in a probabilistic description of the data.

Enquiry. Three different forms of enquiry which yield exploratory, descriptive, and explanatory results can be differentiated (Van de Ven, 2007; Buchanan and Bryman,

2011). The exploratory theory-building process starts by observing and gathering empirical data through the perspective of either a pre-defined or entirely new theory and ends with a description of the observations (Christensen, 2006; Van de Ven, 2007). The study in Chapter 4 follows an exploratory process to lay the foundation for subsequent research. By contrast, descriptive forms of theory can build onto an exploratory theory by gathering larger amounts of data and verifying it through testing of hypotheses or recognising reoccurring patterns (Easterby-Smith et al., 2015). The studies in Chapter 5 and 6 are descriptive enquiries, the former identifies patterns whereas the latter tests theory based on hypotheses. To advance descriptive theories, a construct can be abstracted to allow an explanation of a new phenomenon through a revised theory. Such an explanatory study is performed in Chapter 7. The the step-wise consolidation process along the sequence of studies in this work, increases the descriptive potential increases from exploratory, over descriptive, to explanatory research (Christensen, 2006; Blaikie, 2009).

Iteration. Additional studies can refine newly built, enhanced, or tested theory through a linear or a cyclical iteration with the aim of further generalisation (Van de Ven, 2007). A cyclical iteration makes minor controlled changes to the theory and models upon repetition of the study in the same context. The results are subsequently compared (Van de Ven, 2007). In contrast, a linear model can make controlled changes, but applies the revised theory to a different context and compares the results (Blaikie, 2009). In all studies from Chapter 4 to 7, theories are iterated linearly, changing models between studies and subjecting them to different sources of data, and involving new stakeholders.

Henceforth, after the extensive discussion of the thesis's philosophical stance and the methodology, the research design and strategy can be developed.

3.2 Methods and research design

The next section explains the higher-level considerations for the research design of the studies described in Chapters 4 to 7. Developing a research design results in "a plan for collecting and analysing evidence that will make it possible for investigators to answer whatever question he or she posed." (Ragin, 1994, p. 194).

As mentioned before, this thesis applies multiple methods in sequence. Before selecting appropriate methods, the research questions have to be defined. Onwuegbuzie and Leech (2006, p. 475) state that "research questions in mixed-methods studies are vitally important because they, in large part, dictate the type of research design used, the sampling strategy and sample size, and the type of instruments administered as well as the data analysis techniques". Of the following Sections, 3.2.1 states the research questions, Section 3.2.2 explains and justifies the mixed-methods approach, and Sections 3.2.3 and 3.2.4 differentiate between qualitative and quanti-

tative methods.

3.2.1 Research questions

The following summary shows the five research questions that are answered across the Chapters 4 to 7:

Research Question 1: How do ESVs signal to VCs and how do VCs evaluate the signal?
(Chapter 4 - signalling study)

Research Question 2: Which stakeholders are present in ESVs' social networks?
(Chapter 4 - stakeholder study)

Research Question 3: How and in support of which business functions can ESVs leverage their social networks?
(Chapter 5 - social network function study)

Research Question 4: Which social network constellations are perceived most favourably by VCs and entrepreneurs?
(Chapter 6 - ESV evaluation study)

Research Question 5: Which social network data can proxy the fundraising success and fundraising frequency of ESVs?
(Chapter 7 - ESV evaluation tool)

The development of individual research questions will be discussed in the respective chapters and follows the gradually increasing focus on social network signals in the ESV evaluation context. To answer the research questions, suitable research methods were selected allowing for multifaceted perspectives on the topic of ESV evaluation. Fittingly, a mixed-method approach reflects the process of ESV evaluation, which can comprise of a multifaceted analysis, as was identified in the literature review.

3.2.2 Methods: a mixed-methods approach

Mixed-method research deploys a combination of qualitative and quantitative methods (Robson and McCartan, 2016). Mixing methods is a relatively recent methodological advance starting in the 1980's (Creswell, 2014). To the present day, methodologists argue about the combination of methods which entails implementing contrasting ontological and epistemological positions into the research design (Tashakkori and Teddlie, 2010).
On the critics' side, researchers state that "because the two paradigms do not study the same phenomena, quantitative and qualitative methods cannot be combined"

(Sale et al., 2002, p. 43). Moreover, accepting one paradigm "precludes the other just as surely as belief in a round world precludes belief in a flat one" (Guba, 1987, p. 31). Opponents further criticise the practicability of using mixed-methods because researchers might lack the breadth of skills, face timing issues when gathering and analysing data, and fail to balance and integrate the qualitative and quantitative findings (Bryman, 2006, 2012).

Proponents of mixed-methods counter that only mixed-methods facilitate triangulation and effective capturing of multiple perspectives. Additionally, biases of the researcher, data, model, or method can cancel out if mixed methods are used (Mathison, 1988). Furthermore, advocates insist that while triangulation may not lead to converging results but instead to inconsistencies and even contradicting results, this should be seen as a strength of the approach for it better represents the real-world phenomenon (Denzin, 1978; Van de Ven, 2007). Consequently, the study of particularly complex, multidimensional phenomena warrants the introduction of additional methods (Robson and McCartan, 2016).

In the context of the thesis, the constellations of ESV networks are best represented by quantitative metrics, whereas the communicative element and signalling process between ESVs and VCs can be better captured qualitatively. Table 3.5 summarises benefits of the mixed-method approach.

Table 3.5: Benefits of mixed-method approaches, modified from Creswell (2014) and Robson and McCartan (2016)

Terminology	Benefit
Triangulation	Conducting studies based on multiple sources allow the researcher to moderate and increase the validity of results by partially or entirely confirming or disconfirming findings across studies.
Completeness	Researching a phenomenon through qualitative and quantitative perspectives more accurately capture its complexity.
Offsetting weaknesses	Each method has strengths and weaknesses which researchers can mitigate by drawing on the strengths of both methods.
Different and more refined research questions	Exercising multiple methods allows answering and honing in on a broader set of research questions. (1) How ...? → (2) How much ...?
Explaining findings	Subsequent answering of qualitative and quantitative research allows researchers to not only learn from previous research but also stress-test earlier results.

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Terminology	Benefit
Illustration of data	Qualitative and quantitative findings can augment each other and paint a more colourful picture. Bryman (2006, p. 106) refers to this mechanism as putting "meat on the bones".
Instrument development and testing	Through immersing in research, the researcher learns about the details which are most likely invisible to an outsider. Hence an exploratory qualitative study might find a measure or instrument which can inspire a future study to test the measure.
Interdisciplinarity	Often, a method gradually establishes as a gold-standard. Challenging existing perspectives, and even using methods commonly applied in other fields, can yield richer and unexpected results.

As a consequence of the benefits, methodologists have started embracing mixed-methods and defined an array of research methods which can be combined. Table 3.6 lists a sample of such methods.

Table 3.6: Overview of research methods and data sources merged from Easterby-Smith et al. (2015, pp. 47), Yin (2013, p. 9), and Van de Ven (2007, p. 30, p. 187).

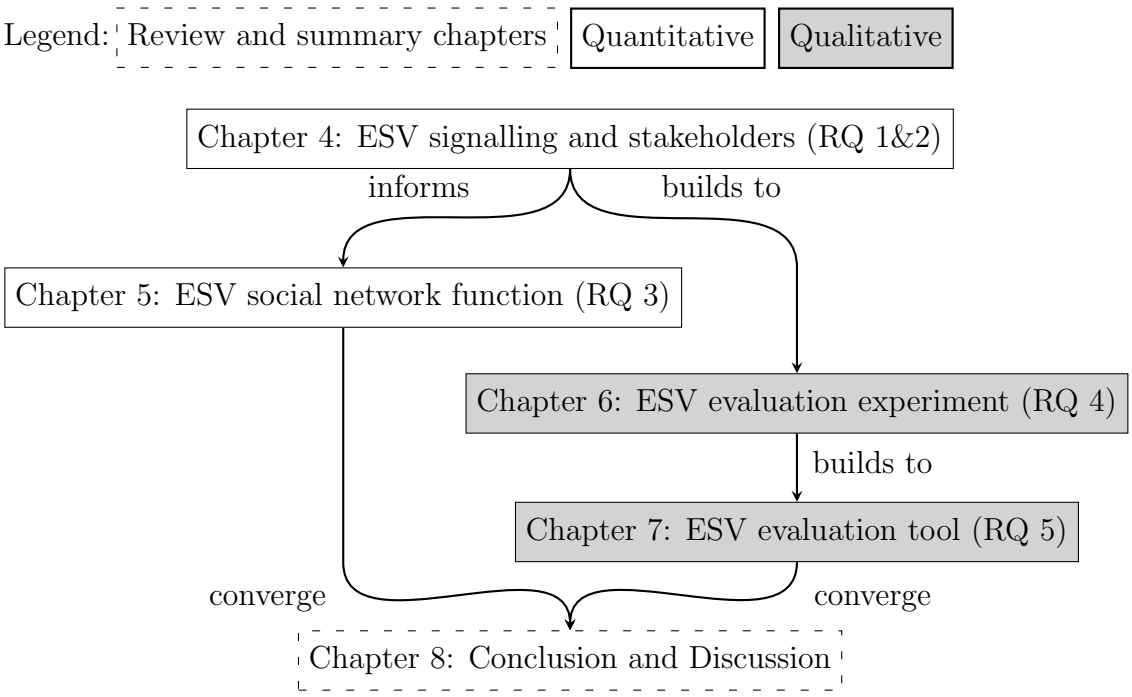
Easterby-Smith et al.	Yin	Van de Ven
• Action research	• Direct observation	• Direct observation
• Archival research	• Archival records	• Archival records
• Ethnography	• Interviews	• Interviews
• Narrative method	• Participant observation	• Questionnaires
• Case study method	• Case studies	• Web analysis
–Longitudinal	• Online survey	• Third party-records
–Comparative	• Physical artefacts	
• Grounded theory	• Documentation	

Combinations of the methods and sources mentioned in Table 3.6 have been previously used in social science contexts and literature (Bryman, 2006). This thesis leverages three methods, case studies (Chapter 4 and 5), a quasi-experiment survey (Chapter 6), and an archival, secondary data analysis (Chapter 7).
Creswell (2014) and Robson and McCartan (2016) emphasise that correct timing and sequence of studies is important for research that exercises mixed-methods, whereby Creswell differentiates between six designs as summarised in Table 3.7.

Table 3.7: Mixed-method designs, summarised from Creswell (2014).

Design	Explanation
Concurrent/ parallel	A single-phase project which conducts qualitative and quantitative studies at the same time and converges to one interpretation.
Explanatory sequential	A two-phase project which starts by collecting quantitative data and a subsequent qualitative study follows up to explain.
Exploratory sequential	A two-phase project and the opposite of an explanatory design. A qualitative study scopes a phenomenon and the subsequent quantitative study tests generalisability of initial findings.
Embedded	A single- or two-phase method which gives priority to one form, either qualitative or quantitative, and at some point gathers the other form of data which can occur concurrently (single-phase) or sequentially (two-phase).
Transformative	A two-phase design conducted in a sequence based on a predefined "transformation framework" answering of qualitative and quantitative research allows researchers to not only learn from previous research but also stress-test previous results.
Multi-phase	A multi-phase design can use a combination of concurrent and sequential data gathering phases across individual projects which can both explore and or explain previous results.

According to Creswell's terminology, this study employs a multi-phase design, as illustrated by Figure 3.5.



Note: Research question (RQ)

Figure 3.5: Mixed-method design, own illustration.

After two exploratory sub-studies in Chapter 4, the results act as the foundation for Chapter 5 (same method, sequential). Results in Chapter 5 inform Chapter 6 (different method, exploratory sequential) which in turn suggests the metrics to be used in Chapter 7 (same method, sequential) after which point the results converge with Chapter 5.

Three considerations influenced the decision to use mixed-methods for this research. Firstly, evaluating research methodology literature and weighing the benefits mentioned above against the introduced complexity warrant the use of multiple methods. Secondly, mixed-methods are thoroughly embedded and encouraged by the engaged scholarship paradigm. Lastly, the common use in existing social network studies demonstrates the feasibility of the approach (Tashakkori and Teddlie, 2010; Williams and Shepherd, 2017). Nonetheless, the criticism of mixed-method approaches was taken into consideration when choosing the specific qualitative and quantitative methods.

Hereafter, the concrete qualitative and quantitative methods are briefly outlined, and further details of the study design are mentioned at the beginning of each respective chapter to avoid confusion across studies.

3.2.3 Qualitative methods

Qualitative methods include all those enquiries which gather non-numerical data (Van de Ven, 2007). For this research, the selected enquiry method for the qualitative studies is the case study method, which is an empirical enquiry suitable for exploratory studies (Yin, 2013; Robson and McCartan, 2016). Yin (2013, p. 15) defines the case study method as an "empirical enquiry that investigates a particular contemporary phenomenon (the case) in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident." Case studies allow application in situations where there are "many more variables of interest than data points, and as one result relies on multiple sources of evidence" (Yin, 2013, p. 16). Yin's guide suggests that researchers can structure the enquiry as a single case study or multiple case studies and based on single or varying units of analysis. Figure 3.6 visualises the decision-space.

	Single-case design	Multiple-case design
Single unit of analysis	Type 1	Type 2
Multiple units of analysis	Type 3	Type 4

Figure 3.6: Design variations of case studies, modified from Yin (2013).

Both studies in Chapter 4 and 5 focus on ESV's social networks from an entrepreneurial and VC perspective whereby the former study has exploratory and

the latter explanatory tendencies.

The researcher's expectation before conducting the exploratory signalling study is that ESVs employ a broad array of different strategies, warranting a multiple-case design, which can capture differences through cross-case comparison. For the signalling study in Chapter 4, case study interviews with founders concentrate on the ESVs' signalling strategy as the unit of analysis and determine how ESVs signal to investors. VC case study interviews use the signal reception of VCs (first unit of analysis) and aim to understand how VCs receive and evaluate signals they receive from ESVs (second unit of analysis). According to Yin's case study variation matrix in Figure 3.6, the signalling study is of Type 4.

The stakeholder study is inspired by the initial results of the signalling study, which shows that social networks are an important component of the signalling process. The stakeholder study uses case study interviews with multiple founders to understand how ESVs form social networks and who inhibits positions in these networks (single unit of analysis). According to the case study matrix the study is of Type 2.

As the results of the exploratory signalling and stakeholder sub-studies confirm the preconceived notion of a variety of approaches undertaken by ESVs, the multiple-case nature is maintained for the subsequent social network function study in Chapter 5. As for the stakeholder study, the focus is solely on the ESVs' perspective, and identifies which business functions can leverage social networks (single unit of analysis). Thus, those business functions which can be augmented or performed by social networks are considered social network functions. According to Yin's case study variation matrix, the social network function is of Type 2.

(a) Interviews

The researcher gathers data for the sub-studies in Chapter 4 through interviews with entrepreneurs and VCs. The interview follows a semi-structured format, based on a pre-fabricated questionnaire. For Chapter 5, unstructured interviews are conducted in the form of a pitch to the researcher by the entrepreneur which is common practice in the VC industry (Kupor, 2019). The sampling is explained in the respective chapters and Appendix C includes a complete list of interviewed participants[3].

(b) Document content analysis

For the sub-studies in Chapter 4 founders are asked to share documentation they would usually share with VCs, such as slide decks, and other supplementary documents such as business plans, academic and white papers, industry reports, letters of intent, news and media articles, and financial forecast. Beyond that, during the interview, founders create a document, a visual representation of their social network containing the relevant stakeholders. For the study in Chapter 5 in addition

[3] Appendix C can be found on pages 241 to 247.

to the the interviews in the form of a pitch, further supplementary documents are requested from the founders, as in the studies described in Chapter 4. A detailed description of the sampling strategy, data gathering, coding, and analysis procedure follows in Section 5.3.

(c) Qualitative data analysis

One approach to reduce large volumes of textual data to a manageable level is to use a coding method. Coding classifies raw data into categories of incidents (Van de Ven, 2007). The "Gioia method" summarises raw data into first-order concepts, second-order themes, and aggregate dimensions (Gioia et al., 2013). The Gioia method is adopted for the studies in Chapter 4 and 5[4]. The first step involves sorting the obtained information to the relevant questions. This measure ensures thematic order among the answers as the semi-structured approach allows interviewees to change, revise, or reiterate answers throughout the interview. The second step summarises duplicate or similar mentions within a case study. The third step involves a cross-case comparison which identifies overarching topics that were relabelled and categorised by the researcher. The final step creates an overview of all the gathered data to allow for statistical evaluation. Since the coding procedure involves making conscious modification of the raw data the resulting codes were reviewed by the stakeholders interviewed for the studies to maintain a balance between simplification and and oversimplification

3.2.4 Quantitative methods

Quantitative methods include all methods which gather numerical data, including those that convert from qualitative into quantitative formats (Van de Ven, 2007). Methodologists differentiate non-experimental and experimental research designs (Creswell, 2014; Mertler, 2015). The ESV evaluation experiment study in Chapter 6 follows an experimental design. In Chapter 7, the ESV evaluation tool development study, has a non-experimental design. As experimental designs are more complex, this section first explains non-experimental designs and builds up to the experimental designs.

(a) Non-experimental research designs

In non-experimental designs, variables are not manipulated but instead measured as they naturally occur (Gay et al., 2012). Non-experimental designs differentiate in descriptive research, correlational research, and causal-comparative research. A misconception of such studies, especially the predictive studies, is that results imply a causation which is incorrect, *correlation* $\neq$ *causation* (Mertler, 2015). Table 3.8

[4] The exact coding procedure is schematically illustrated by Figure D.1 in Appendix D on page 247 and demonstrated for an exemplary code in Appendix D.2 on page 248.

summarises descriptive research, correlational research, and causal-comparative research designs.

Table 3.8: Non-experimental research designs

Design	Description
Descriptive research	In descriptive studies, a researcher observes a phenomenon and does not influence the study subjects, but instead observes and interprets. Two common forms of descriptive research are observational research, which count occurrences of a phenomenon, and survey research which administers a questionnaire to participants. Survey research can be conducted through face-to-face interviews, handouts, via telephone, via e-mail, or web-based (Mertler, 2015). An example in the studies context could be to count how many VCs engage with an entrepreneur during a demo day and observe the near term fundraising success of the ESV.
Causal-comparative studies	Causal-comparative studies compare differences that occur across two or more groups and aim to find causes for observable consequences based on one treatment variable (Gay et al., 2012). This design retrospectively analyses situations and is therefore referred to as "ex post facto" or "after-the-fact" design. (Mertler, 2015, p. 122). An example in the studies context could analyse ESVs with headquarters either in the UK or US and their fundraising success measured in fundraising amount.
Correlational studies	The third type of non-experimental design aims to discover relationships between one or more independent variable and a dependent variable based on existing data or own measurements obtained from a single group. The focus is on the direction and magnitude of the relationship, whereby a relationship exists if variables covary or corelate (Gay et al., 2012). The two concrete forms of correlational studies are **explanatory correlational studies** and **predictive correlational studies**. Both designs explain past events, measurements, or behaviours, and aim to predict these based on separate events, measurements, or behaviours (Mertler, 2015). An example in the studies context could be an entrepreneur's experience measured in years and fundraising success measured in fundraising amount.

According to Mertler's terminology, the study in Chapter 7 follows an explanatory correlation design. It aims to find correlations between social network characteristics (multiple independent variables) of ESVs belonging to one industry (single group) and their fundraising success measured in frequency of fundraises and fundraising amounts (two dependent variables). Understanding the evolution of ESVs' social networks requires gathering longitudinal data from a social media platform, private company databases, and websites to infer correlations. A detailed description of the

data sources, software used for data mining, cleaning, analysis, and visualisation follows in Section 7.3.5.

(b) Experimental research designs

In experimental studies, the researcher applies a treatment and studies its effect on participants or systems. Four different designs, pre-experimental, quasi-experimental, true-experimental, and single-subject, can be distinguished (Mertler, 2015). Contrary to non-experimental designs, experimental designs can reveal causation, a true cause and effect relationship. In these studies, the researcher selectively applies the independent variable, also referred to as causal, experimental, or treatment variable[5] and measures the dependent variable, also called effect or post-test variable[6]. Table 3.9 summarises the four different experimental research designs.

Table 3.9: Experimental research designs

Design	Description
Pre-experimental design	This study design does not control for extraneous variables and participant characteristics or predisposition before the treatment. Furthermore, a control group and is not required and consequently the study design is not considered as reliable (Mertler, 2015).
Single-subject design	In this form of design, one study subject is exposed to treatments while controlling for extraneous variables (Creswell, 2014).
(Quasi-) experimental design	These forms of designs control for extraneous factors and have at least one control group. Quasi-experimental and experimental designs, both sample randomly but differ in the assignment. Sampling denotes the process of choosing participants, and it is random if every member of the population has equal chances of being selected. Random sampling is a condition for both types of design. Assignment occurs after the sampling and describes the process of assigning participants to different study-groups which is classified as random if every participant has equal chances to be in any group (Mertler, 2015). In their influential work, Campbell and Stanley (1963, p. 2) define a quasi-experiment as "[a] research design involving an experimental approach but where random assignment to treatment and comparison groups has not been used". Thus, experimental designs require random assignment, whereas quasi-experimental designs do not (Mertler, 2015).

The study in Chapter 6 is quasi-experimental survey for, entrepreneurs, VC, and a control group which tasks participants to evaluate ESVs based on social network constellations (treatment variables). The details of the sampling strategy and the

[5] For this study, the independent variable is referred to as treatment variable.
[6] For this study, the dependent variable is referred to as effect variable.

data analysis are mentioned in Section 6.3.2. The final considerations on the design of quantitative studies are the types of measurement scales and the data analysis.

(c) Quantitative measurement scales

Robson and McCartan (2016) recommend researchers to chose measurement scales before gathering data as scales must reflect the nature of the available data and the required level of detail to make inferences. As scale choice directly impacts the results, a dedicated review section for each study first defines metrics and variables and second justifies the selection and discusses implied limitations. Such scales can be differentiated in nominal, ordinal, interval, and ratio scales (Stevens, 1946). Table 3.10 explains the scales in use across the studies and provides examples.

Table 3.10: Fundamental levels of quantitative measurement scales, based on Stevens (1946) and Creswell (2014).

Scale	Description	Example	Studies (Chapters)
Nominal	Named, categorical variable scale, no implicit order	Munich, London, Boston	Evaluation experiment (6) Evaluation tool (7)
Ordinal	Named, categorical variable scale, implicit order	High, medium, low	Evaluation tool (7)
Interval	Numerical, ordered scale, known distances	Likert-scale, dates	Evaluation experiment (6) Evaluation tool (7)
Ratio	Numerical, ordered scale, known distances, true zero	Rational numbers, prices	Evaluation experiment (6) Evaluation tool (7)

(d) Quantitative data analysis

The quantitative data analysed for the ESV evaluation study in Chapter 6 and ESV evaluation tool in Chapter 7 used measures of central tendency, distributions such as the normal distributions, and regression models such as ordinary least squares (OLS). Moreover, additional measures of nominal association such as "Cramér's V" (Cramér, 1946, pp. 31-42; Blaikie, 2003, pp. 101) and "Theil's U" (Theil, 1958, pp. 31-42; Bliemel, 1973) were used to analyse the binary variables across the studies. These measures of association are already introduced in Chapter 4 where they were used to quantitatively evaluate the obtained codes.
This section concludes the research development description, which hereafter is critically reviewed for its limitations.

3.2.5 Research strategy evaluation

This section evaluates the trustworthiness of the research design, the quality of the execution, and limitations of the chosen research methods. The concept of research

validity and reliability were first introduced by Campbell and Stanley (1963, p. 76) who collected "aspects of trustworthiness" of studies which were later complemented by Cook and Campbell (1976, 1979) and Guba and Lincoln (1981).
As shown in Table 3.11, Guba and Lincoln (1981) find similar criteria for the realist and relativist position but dissimilar nomenclature.

Table 3.11: Aspects of trustworthiness, modified from Guba (1981, p. 80).

Aspect	**Realist term**	**Relativist term**
Truth value	Internal validity	Credibility
Applicability	External validity, generalisability	Transferability
Consistency	Reliability	Dependability
Neutrality	Objectivity	Confirmability

For the purpose of the assessment of the research design the realist terminology is adopted.

Internal validity. The criterion measures the confidence in the plausibility of findings drawn from an enquiry. If the research enquiry follows a correct cause-and-effect relationship, it achieves credibility and internal validity (Van de Ven, 2007). The stakeholders commented on study designs before the researcher conducted the actual research to ensure the internal validity of this work. Metrics which the researcher introduced to quantify ESVs' social network characteristics have either been previously used in the same context or were borrowed from separate industries where their applicability has been tested. However, a conflict was identified, which results from a side-effect of the engaged scholarship paradigm. While contradicting stakeholder views can enrich the understanding of the phenomenon, such opposing views can be hard to reconcile. The disagreement of stakeholders and partially inconclusive results present a challenging task for the researcher. Nevertheless, Van de Ven emphasises that advantages outweigh the disadvantages, and in this thesis, areas of disagreement are highlighted and contrasting views mentioned.

External validity. This criterion evaluates the possibility to apply models or results in different contexts, such as studies with other participant groups, firms with different maturity level, geography, or industry association (Yin, 2013). A direct benefit of the mixed-method approach and sequential study design, which alters participants, methods, and geographies, is that results can inform subsequent research. The mixed method approach also highlights inconsistencies or inapplicabilities which are uncovered during the study (Van de Ven, 2007). Such multi-stage research which scrutinises previous results with each study can enhance external

validity. Nonetheless, the results may have limited applicability to other finance or entrepreneurial domains. After all, a primary motivation for this research lies in the inapplicability of evaluation methods which are not specifically designed for ESVs. Thus, it is questionable how much insight models developed in this thesis are, for instance, in later-stage firms or SMEs.

Dependability. A dependable research design features construct validity and yields reliable results. For the purpose of this research, dependability is the extent to which chosen metrics operationalise[7] ESV evaluation (Cook and Campbell, 1979; Gay et al., 2012; Robson and McCartan, 2016). This research design aims to proxy ESV evaluation. As the ESV's value and future performance cannot be measured directly, the method is vulnerable to dependability issues since, by definition, the proxy never perfectly describes reality (Van de Ven, 2007). This issue is mitigated by employing a mixed-method approach and by triangulating the phenomenon. Constant engagement with experienced stakeholders ensures the dependability of results.

Confirmability. If future research could replicate results by repeating the study, the research design is confirmable. For the studies in this thesis, specific measures were taken to enhance confirmability by documenting and standardising the research procedure. Firstly, before conducting the studies, the interview procedure for the sub-studies described in Chapters 4 and 5 were piloted. Similarly, the online survey described in Chapter 6 was tested in dry runs with a variety of candidates. As a result, alterations can be performed before, instead of during individual studies. Secondly, the qualitative surveys are conducted by following an interview protocol and questionnaire, which includes a summary of the participants' position, experience, and other information. Asking participants for such information allows to better control for factors such as their profession, industry, or demographics. Documenting the data gathering during the enquiry is important as the study participants retrospectively self-report potentially biased recollections. By relaying the gathered data back to participants and giving them the chance to clarify, misunderstandings can be avoided, however, potentially biased reporting remains an issue. Consequences could be found in common-method variance that occurs when a study subject represents the endogenous and exogenous parameter at the same time which is often the case in social network research (Posakoff et al., 2003; Aral and Walker, 2011; Hogg, 2010). The research design intends to study multiple cases and reveal inconsistencies

[7] Operationalisation is the "process of strictly defining variables into measurable factors. The process defines fuzzy concepts and allows them to be measured, empirically and quantitatively" (Shuttleworth, 2008, p. 1). To better understand the dependability of an operationalisation, an analogy can be found in the natural sciences. In natural sciences, researchers' results depend on the use of the appropriate measuring device, a thermometer to measure temperature, a ruler to measure distances, etc. Measuring with inappropriate equipment might yield results, however, the results are not dependable.

through cross-case comparison. Lastly, the programming code of the tool developed in Chapter 7, the code to mine and clean data for the tool building study, as well as all of the statistical analysis scripts, are referenced in full where used. This ensures confirmability as it allows future researchers to confirm the study in other settings.

3.3 Chapter summary

In summary, five sub-studies across four chapters have been planned according to the engaged scholarship paradigm. The resulting research designs equip a reflective researcher with the tools to execute the research. The mixed-method approach incorporates typical VC industry practices and focuses exclusively on ESVs to precisely address the identified research gap. As demonstrated by previous studies, using guidance from the engaged scholarship paradigm in conjunction with a comprehensive literature review helps bridge the theory-practice gap and yields practitioner-oriented, tangible results (Aguinis et al., 2014; Williams and Shepherd, 2017). The extensive considerations of the researcher's philosophical stance, paired with incorporating external stakeholder input mitigated biases, whilst exploring fundamental research gaps.

4. ESV signalling and stakeholders

Contents

4.1 Chapter introduction

This chapter describes the first exploratory study which is comprised of two sub-studies; firstly a signalling study and secondly a follow-on ESV stakeholder study. Figure 4.1 illustrates the position of the study in the context of this thesis.

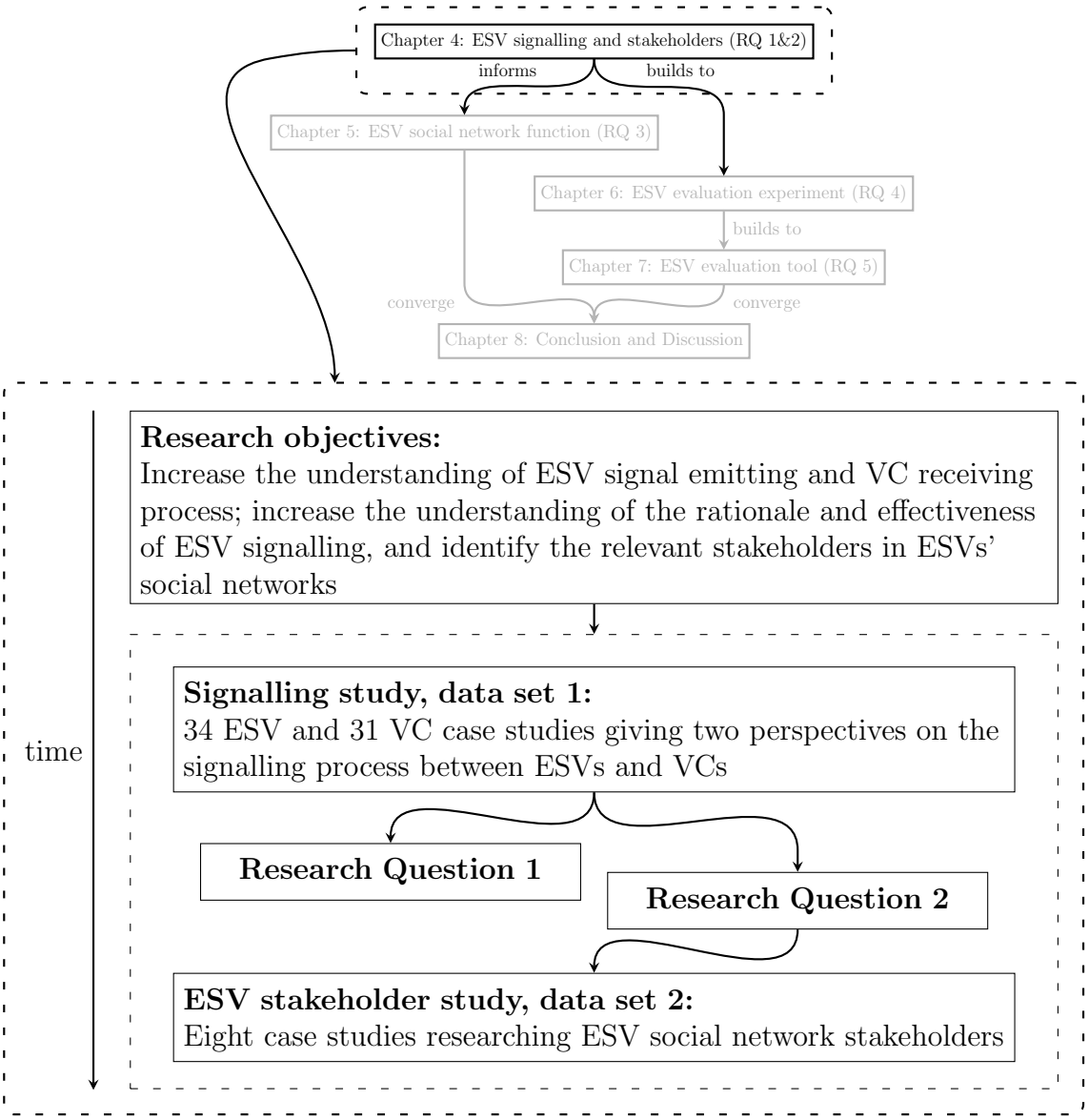


Figure 4.1: Data, research questions, and research objectives of Chapter 4, own illustration.

The following two research questions are answered as illustrated in Figure 4.1 by analysing two separately gathered data sets.

Research Question 1: How do ESVs signal to VCs and how do VCs evaluate the signal?

Research Question 2: Which stakeholders are present in ESVs' social networks?

4.2 Conceptual development and literature review

The next section provides the conceptual background of the two sub-studies and introduces the specific literature, building on the foundation provided by the broader review given in Chapter 2. The signalling literature describes the existing knowledge on signalling processes, including the signalled content, between ESVs and VCs. As the literature review will demonstrate, little empirical evidence exists upon which a study could build. Thus, an exploratory study approach was chosen. Furthermore, during this initial study of the signalling process and content, ESVs' social networks are identified as one significant component. As social network signalling is a subcategory of the entire content which ESVs can signal, the literature review hones in further on this particular signalling component.
The identification of social network signalling in the first study thus inspired a second sub-study. Moreover, the signalling literature lacks substance on social network signalling. Drawing on separate literature streams on ecosystems and strategic alliances, ESVs' social networks can be understood better, as the literature streams describe ESVs' engagement with affiliated stakeholders. ESVs, in turn, can signal these affiliations to VCs. For the second sub-study, applied methods are similar in research design and yield convergent results. Hence the literature reviews, study designs, and analyses are presented in parallel for both studies, albeit this does not reflect the precise chronological order in which the studies were conducted.

4.2.1 ESV signalling

To answer Research Question 1, this section sheds light on the existing literature, which describes the signalling process from the first contact between an entrepreneur and a VC until receiving the investment. A "warm" or "cold" introduction initiates the signalling process between the parties. A warm introduction requires a third party, a common acquaintance, and can be facilitated in-person or electronically via email, LinkedIn, or other communication platforms. In contrast, "cold" introduction does not involve a third party and can occur in-person for instance during the event, or getting acquainted serendipitously, e.g. "sitting next to each other on a plane", or via electronic outreach (Zhang et al., 2008; Wang, 2016; Miles, 2017; Kupor, 2019). Ramsinghani (2014) states that initiating contact is not only undertaken by ESVs who seek the investment, but it is similarly common for VCs to reach out to promising investment candidates. From the VCs' perspective reaching out creates outbound deal-flow, whereas entrepreneurs reaching out to a VC is known as inbound deal-flow (Ramsinghani, 2014).
As soon as contact between ESV and VC is established, the founder can signal information by sending documents for review and "pitching" to the VC. The pitch can

take place during a phone or video call, face-to-face meeting, or a presentation to a broader audience (Brooks et al., 2014)[1]. The main purpose of the initial pitch is for the entrepreneur to introduce the investment opportunity to the VC to attract interest and rebut the VC's concerns and uncertainty (Clark, 2008). To communicate their message, entrepreneurs can use verbal and non-verbal presentation elements, the latter by a slide-show or product presentation and public relations (PR) material (Brooks et al., 2014). After the pitch, and in case both parties are interested in continuing the conversation, the entrepreneur often provides supplementing documents for review, and schedules further conversations (Croce et al., 2017).

Once VCs receive the information, a due diligence process begins, which VC funds usually structure as a stage-gate process (Roberts and Barley, 2004; Baker et al., 2018). The multi-phased process begins with "light" analysis during which additional information can be gathered for instance through online-searches and further discussions with ESV's founders, employees, or collaborators. During the initial analysis by the VC, often an Associate-level employee of the VC firm will gather information and present the findings during a regular meeting with colleagues known as the "investment meeting" (BVCA, 2012; Ramsinghani, 2014; Huang, 2018). A positive response during the investment meeting means passing a stage-gate in the investment process, which leads to further, deeper due diligence. For subsequent investment-decision stages, thorough due diligence is performed which could, for instance, entail contacting existing clients of the ESV, technical analysis of the product or patents, or background checks (Campbell, 2003; Ramsinghani, 2014). Based on the due diligence, VCs decide about the investment opportunity and contractual work begins, at which point the scope of this study ends. It goes to show that throughout the pre-investment diligence active and passive signals are emitted by the prospective investment, the ESV, which are evaluated by everyone at the VC fund who is involved in the process.

The review of past empirical studies revealed that the focus of the signalling process is on the communication and sentiment in the engagement process between entrepreneur and VC (Yusuf, 2011; Spinuzzi et al., 2014; Galbraith et al., 2014). Few studies have been conducted which focus on the exchanged verbal and non-verbal content during pitches and the pre-investment due diligence phase (Clark, 2008). Notable exceptions are Douglas et al. (2014), Spinuzzi et al. (2014), and Croce et al. (2017) who found signal elements that match the investment criteria outlined in Table 2.2[2]. Some of these studies analysed the importance of the signalled content

[1] Equity and product crowdfunding campaigns might involve only "online" signalling. Moreover, investors and investee are not necessarily introduced in person. However, these small financial contributions, often made by private, unaccredited investors, have fundamentally different underlying dynamics which are beyond the study's scope (Ahlers et al., 2015).

[2] Table 2.2 on page 22 summarised qualitative and quantitative ESV investment criteria.

compared to its delivery; their results emphasised the importance of the quality of the delivery (Clark, 2008; Spinuzzi et al., 2014). During the signalling process, VCs rely primarily on experience and "gut-instinct" and use few tools (Huang, 2018; Pitchbook, 2018). Consequently, the process is unstructured, mainly supported by spreadsheet and word processing software (Huang, 2018; Gompers et al., 2020). A negative side-effect of the lack of structure paired with the uncertainty is slow decision-making, as VCs, who can become overwhelmed by the complexity, might "drag their feet" (Marks et al., 2009, p. 132). For the entrepreneur, slow decision-making implies direct risk, having to deal with multiple VCs at a time, and non value adding request of sometimes arbitrary information by VCs in search for conviction (Ramsinghani, 2014). Previous studies have investigated problems in the signalling process from a communication perspective (Galbraith et al., 2014). However, an analysis of the precise content of what entrepreneurs are signalling to VCs remains a gap in the literature (Drover et al., 2017).
As the results of the signalling study indicate a social network component that is signalled, multiple literature streams are reviewed to identify details.

4.2.2 ESV stakeholders

To answer Research Question 2, this section introduces additional literature which focuses on the stakeholders in ESV networks which make up the content to be signalled during a pitch and subsequent due diligence. As Section 2.3.1 has shown, ESVs are known to engage with their social networks to procure financial, human, and social resources. Hitherto, empirical studies focus on one or at most a few types of strategic partnerships and the respective stakeholders of ESVs. To date, there is no comprehensive study which identifies an exhaustive set of stakeholders which occur in ESV networks. Furthermore, the constellation of stakeholders around the ESVs from a social network analysis perspective is unclear. Extant literature presents reasons for ESVs to engage with stakeholders including procuring resources, attaining formal and informal advice, and growing the ESV's network through introductions to additional stakeholders (Lerner and Malmendier, 2013; Armanios et al., 2017; Chatterji et al., 2019). Through stakeholder engagement, ESVs seek to complement their business functions such as strategy, finance, marketing, human resource management, sales, and R&D (Rothaermel and Deeds, 2006; Gulati et al., 2011; Huang et al., 2012; Spender et al., 2017; Chatterji et al., 2019). As Table 4.1 shows, literature also describes a wide, although incomplete, set of the stakeholder entities.

Table 4.1: ESV social network stakeholders

Design	Reference
Accelerators & corporate accelerators	Cohen (2013); Hochberg (2016); Kohler (2016); Brown et al. (2019)
Incubators	Bruneel et al. (2012); Albort-Morant and Oghazi (2016); Bandera and Thomas (2017)
Investors	Hsu (2004, 2006); Large and Muegge (2008); Ivanov and Xie (2010); Alexy et al. (2012); Croce et al. (2018)
Mentors & advisers	Waters et al. (2002); Lehtonen and Lahti (2009)
Board members	Feld and Ramsinghani (2014); Amornsiripanitch et al. (2019)
Technology transfer offices	Siegel et al. (2003); Markman et al. (2005); Gubitta et al. (2016)
University research institutes	Wright et al. (2006); Hsu et al. (2007)
Friends & classmates	Lerner and Malmendier (2013)
Suppliers	Huang et al. (2012); Neyens et al. (2010)
Users & customers	Chorev and Anderson (2006); Baron and Shane (2007); Laage-Hellman et al. (2018); Kuester et al. (2018)

Although reasons for collaboration and engagement with stakeholders have been widely researched, the actions entrepreneurs and their stakeholders undertake as part of the engagement remain unclear. Empirical studies give insufficient advice to the involved parties on how to exchange resources and knowledge. The next section clarifies the details of the methodological approach for both sub-studies beyond the overview given in the methodology Section 3.2.3.

4.3 Method and research designs

Two studies, of which the former (signalling study) inspired the latter (stakeholder study), are devised to answer Research Questions 1 and 2. The studies first examine both perspectives of the signal emission of ESVs and the reception by VCs. Furthermore, the ESVs' affiliation with stakeholders via their social networks is analysed as a subset of the signalled content. The signalling study uses multiple cases and multiple units of analysis to reflect the dual ESV and VC perspective. The stakeholder study uses multiple cases and a single unit of analysis as only the ESV perspective on social networks is considered. Before the case studies were conducted, a questionnaire was designed (4.3.1), and case study participants were identified (4.3.2 and 4.3.3). The data was gathered during interviews with the case study representatives (4.3.4), guided by questionnaires, and subsequently analysed (4.4).

4.3.1 Questionnaire designs

Examples of the questionnaires used for both the signalling study and stakeholder study can be found in Appendix E[3]. Existing literature, as well as themes which emerged during the pilot phase, form the basis of the questionnaire. Piloting the draft questionnaires with five participants for the signalling study and three participants for the stakeholder study ascertained the interviews could be completed in the allocated time and questions were clear to the participants. The interviewer asked open-ended questions to capture the opinions of both participant groups. Applying a semi-structured interview format allowed the researcher to be both structured and produce data that is comparable across cases while remaining opportunistic and include topics which emerge during the interview. After designing the questionnaire, the sampling criteria for ESVs (4.3.2) and VCs (4.3.3) were defined for both studies.

4.3.2 ESV Samples

To be considered as a relevant case study for the signalling and stakeholder studies, the ESVs had to fulfil the following criteria:

1. ESV matches Definition 2 as shown on page 24
2. A current C-suite level co-founder is available to interview
3. The interviewee has more than one year experience in his/her current position, which implies that the ESV has been incorporated for at least one year

The first criterion ensures that the gathered data focuses on the ESV's core team opinions and do not fall victim to some existing studies' shortcomings of mixing and not sufficiently controlling for ESV maturity. The second criterion guarantees that participants have witnessed the formation of the ESV's social network since the venture's incorporation and are responsible for external perception and communication of the ESV. The rationale for the last criterion is that participants in ESV have gathered significant experience and the ESV has matured beyond the merely conceptual phase. The participants included CEOs, Chief Technology Officers (CTOs), Chief Financial Officers (CFOs), and Chief Operating Officers (COOs)
An overview of the resulting ESV samples for the signalling and stakeholder study are presented in Table 4.2[4].

[3] Appendix E can be seen on pages 255 to 261.
[4] The details of each ESV case study interviewee are shown in Tables C.1 and C.3 in Appendix C on pages 242 and 245.

Table 4.2: Signalling and stakeholder study ESV samples

Study		**Signalling (RQ1)**		**Stakeholder (RQ2)**	
Invited participants		51		12	
Recruited participants		34	(69%)	8	(75%)
Participant's position					
	CEO	31	(91%)	6	(75%)
	CTO	2	(6%)	*n/a*	
	CFO	1	(3%)	1	(13%)
	COO	*n/a*		1	(13%)
Tenure:					
	Mean yr./σ	3.4	(2.5)	8.3	(6.6)
ESV info					
Headquarter location:					
	England	25	74%	5	(63%)
	US	5	15%	3	(38%)
	Scotland	1	3%	*n/a*	
	Wales	1	3%	*n/a*	
	Israel	1	3%	*n/a*	
	Singapore	1	3%	*n/a*	
Customer segment:					
	B2B	25	74%	5	(66%)
	B2C	9	26%	3	(38%)
Investment stages					
Current:					
	Unfunded	6	18%	*n/a*	
	Angel	8	24%	3	(38%)
	Seed	12	35%	2	(25%)
	Series A	4	12%	3	(38%)
	Series B	4	12%	*n/a*	
Number fundraises:					
	Mean/σ	1.3	(1.1)	1.8	(1.2)

[1] Includes multiple mentions
Note: Due to rounding, percentages may not add up to 100%

For the signalling study, 51 ESV founders were contacted in a convenience sampling approach. Of the contacted candidates 34 were recruited to participate in the study which equals a response rate of 69%. The interviewees were comprised of a mix of the researcher's personal contacts, referrals, as well as founders in the researcher's local ecosystem, Cambridge, United Kingdom (UK), who were recruited in person or via LinkedIn to participate in the study.

For the in-depth ESV stakeholder study, 12 ESV founders were contacted in a convenience sampling strategy. Of the contacted candidates eight participated. The interviewees were asked to participate via LinkedIn. Geographically, the interviewed

ESVs are spread across six countries with a bias towards the UK and US. The majority of the ESVs in the sample sell to business customers. Such business to business (B2B) ESVs have other businesses as end-customers in contrast to business to consumer (B2C) ESVs who sell to consumers as end-customers.

4.3.3 VC Sample

To be considered a relevant case for the signalling study, the VCs who were invited to participate had to fulfil the following criteria:

- VC matches Definition 1 as shown on page 14
- VC whose responsibility includes the evaluation of investable ESV candidates
- The interviewee has more than one year experience in the current position

The first criterion ensures that the gathered data focuses on VCs who concentrate on early-stage investments which match the ESV criteria. The second criterion guarantees that participants have a responsibility as part of their position to evaluate investment opportunities. The rationale for the last criterion is that participants should have a significant amount of experience and have undergone full training. A pre-study pilot focusing on ESV stakeholders made clear that VCs are not sufficiently aware of the details of ESV networks, thus VCs were not interviewed for the stakeholder study. Table 4.3 presents the resulting VC sample for the signalling study[5].

Table 4.3: Signalling study VC sample

Study		**Signalling (RQ1)**
Invited participants		42
Recruited participants		31 (74%)
Participant's position		
	Partner	4 (13%)
	Director	6 (20%)
	Principal	1 (3%)
	Senior Associate	3 (10%)
	Associate	8 (27%)
	Tenure [years/(σ)]	5 (3.7)
Headquarter location		
	England	18 (58%)
	US	9 (29%)
	Germany	2 (6%)
	China	1 (3%)
	France	1 (3%)

Continued on next page

[5] The details of each VC case study interviewee are shown in Table C.2 in Appendix C on page 244.

Study		Signalling (RQ1)	
Investment criteria			
Investment stages[1]:			
	Angel	14	(24%)
	Seed	25	(42%)
	Series A	15	(25%)
	Series B	5	(8%)
Customer segment focus:			
	B2B	6	(19%)
	B2C	1	(3%)
	Both	24	(77%)

[1] Includes mentions of multiple investment stage foci
Note: Due to rounding, percentages may not add up to 100%

The participating VCs were recruited in person or via LinkedIn to participate in the study. The interviewed VCs were located in five countries with a bias towards the UK and US. The majority of the VCs invest at the Pre-seed or Seed-stage B2B and B2C ventures.

4.3.4 Data gathering

The data gathering took place from November 2016 until April 2018. The interviews for the signalling study were between 27 and 65 minutes long and conducted either face-to-face, via video, or conference call. The interviews for the stakeholder study were conducted face-to-face and lasted between two to three hours.
During the case study interviews, data was captured by taking notes as participants preferred to share sensitive information only when interviews were not recorded. Taking notes as opposed to recording the interviews sufficed for the study as it aimed to find topics rather than analyse details. To ensure important direct quotes were also captured, rigorous, often word-for-word notes were taken by the researcher and additions from memory completed promptly after the interview. The survey participants were promised anonymity including that names they mentioned would be omitted. All identifiable names were anonymised before being included in this thesis to comply with the promise. At the end of the interview, the notes were shown and discussed with the interviewees to avoid miscommunication.

(a) ESV cases: signalling and stakeholder study

The data gathering procedure for ESV case studies was comparable for both the signalling study and stakeholder study. Founders were asked which information and documents they could share with VCs and to make these documents available for the study. Specifically during the signalling study, interviewees were questioned about the primary challenges they face as part of their job. Furthermore, the founders explained the ESV and how they convince VCs to invest, including what they believe

is the ESV's "unfair advantage" or "unique proposition". In this context, unfair advantage or unique proposition are understood as characteristics of the ESV which cannot be easily imitated or copied by competitors. Moreover, the founders rated their familiarity with VCs' decision-making criteria and issues that occur during the engagement process with VCs.
A unique part of the stakeholder study, in addition to the interview guided by the questionnaire, was that participants created a paper drawing to visualise the ESV's social network. While completing the drawing, the interview partners discussed the relative importance of stakeholders in ESVs' social networks.

(b) VC cases: signalling study

The data gathering procedure for VC cases in the signalling study involved capturing which part of the job they perceived as most challenging, and how they overcome investment uncertainty to make decisions. Furthermore, VC participants commented on the software they used and explained the use-cases. Moreover, VCs elaborated on problems that occur in the engagement process with founders, and which information they would ideally obtain.
First, founders and VCs commented on their biggest individual challenges, and subsequently on challenges they face when engaging with each other. By asking the same questions to both groups, entrepreneurs and VCs, the questions produce a reference for potential issues of the signalling process compared to other challenges. The second question discriminates the problems of entrepreneurs and VCs with the signalling process.

4.4 Data analysis

After completing the interviews, the transcripts and notes were subjected to three post-processing steps following the Gioia et al. method[6]. To identify associations between different topics that emerged from the coded data, statistical tests were performed. These statistical tests were performed to show variation within the sample rather than to draw inferences on the population. An example of such a statistical test is the Chi-squared (χ^2) test as described in Formula 1 which identifies whether a series of observations deviate significantly from the expected observation (Blaikie, 2003).

[6] The detailed description including an example can be seen in Section 3.2.3 (c) and Figure D.1 on pages 247 to 248.

Formula 1:

$$\chi^2 = \sum_{k=1}^{n} \frac{(O_k - E_k)^2}{E_k}$$

where:

- n number of observations
- O_k is the observed frequency
- E_k is the expected frequency

The second statistical test derives from the χ^2 test and identifies associations between nominal data. For instance, an association tested as part of the analysis was whether a founder did (1) or did not (0) reveal a piece of information and subsequently faced (1) or did not face (0) miscommunication issues with a VC. Using the Cramér's V test calculates as according to Formula 2 (Blaikie, 2003)[7]

Formula 2:

$$V = \sqrt{\frac{\phi^2}{min(c-1, r-1)}}$$

with

$$\phi^2 = \frac{\chi^2}{n}$$

where:

- n is the number of observations
- c is the number of columns
- r is the number of rows

The third statistical test is the entropy coefficient, also called Theil's U test, which tests association between nominal data[8]. The threshold values for nominal association vary in literature (Cohen, 1988). Table 4.4 states the thresholds used for this thesis.

The supplementary documents which founders shared with the researcher were cross-checked for consistency with the statements made by the participants. For the stakeholder study, the drawings were analysed by listing all mentioned stakeholders, counting the total number of vertices and edges, and identifying the central vertex, i.e. the vertex with the highest degree. Lastly, the number of edges among the stakeholders were counted. After explaining in detail the methodology for both studies, the results of the studies are presented.

[7] The adapted bias-corrected version of Cramér's V was used when tables exceeded dimensions of 2x2 (Bergsma, 2013). The programming code for the bias-corrected Cramér's V is shown in Appendix D on page 249.

[8] Appendix D describes Theil's U as well as the programming code used for the association test and is shown on pages following 251.

Table 4.4: Threshold values for nominal association, as excerpted from Blaikie (2003, p. 100)

Association	Value/range
None	0.00
Negligible	0.01 - 0.09
Weak	0.10 - 0.29
Moderate	0.30 - 0.59
Strong	0.60 - 0.74
Very strong	0.75 - 0.99
Perfect	1.00

4.5 Results: signalling study

The purpose of undertaking the signalling study was to answer Research Question 1 and thereby identify both ESV and VC perspectives on signalling. The former investigates how ESVs signal their investability both through providing tangible documentation as well as through convincing VCs by mentioning favourable features. The latter investigates the VCs' perspective on how effective the signalling process is to them. The results of the ESV case studies are presented first.

4.5.1 ESV's perspective on signalling

This section presents the results gathered by interviewing founders for their perspective on signalling. After coding, five topics were identified. Firstly, the founders commented on general challenges they face (a). Secondly, they outlined their strategy for disclosing certain information to VCs (b). Thirdly, founders laid out their strategy to convince VCs to invest (c). Fourthly, founders rated their familiarity with VCs' investment criteria (d). Finally, the founders discussed issues they perceived during the engagement with VCs (e).

(a) ESVs' challenges

Founders reported on the the challenges faced by ESVs. Table 4.5 shows the themes that emerged from the coded data.

Table 4.5: ESVs' challenges

Theme	Mentions
Financing	23 (68%)
Finding talent	9 (26%)
Affordable office space	5 (15%)
IP	4 (12%)
Managing clients/PoC	4 (12%)
Time management	2 (6%)

The results show that financing of the ESV is the biggest concern for more than two thirds of founders. Around one quarter of founders find it difficult to hire talented employees for their ventures. The remaining problems such as renting affordable office space, IP, client relationship, and time management are of a concern for less than one sixth of founders.
Across the sample there is an indication that the problems faced are contingent on the interviewee's role. The two CTOs both mentioned that identifying and hiring talent are their biggest challenges, however, the sub-sample of CTOs is too small for a reasonable statistical investigation of the role's influence.

(b) ESVs' information sharing strategy

When asked what information founders share with VCs, they answered as documented in Table 4.6.

Table 4.6: ESVs' information sharing

Theme	Mentions
Pitch deck	28 (82%)
Financial forecast	20 (59%)
Client feedback	16 (47%)
Partners/ social network	14 (41%)
Paper/ report	14 (41%)
Letter of intent	8 (24%)
Product demo	7 (21%)
Investor feedback/ FAQ[1]	4 (12%)

[1]Frequently asked questions

To analyse whether the choice to share certain information is made consciously, the χ^2 test was used.

Hypothesis 4.1: ESVs randomly share information (H_0).
ESVs consciously decide what information to share (H_1).

Under the assumption that the topics are independent and randomly chosen, i.e. follow a Bernoulli distribution ($p = 0.5$) with the two equally likely outcomes, shared (1) and not shared (0), the statistical significance can be shown by using Formula 1. The χ^2 value of the eight topics is $\chi^2 = 29.35$. The threshold for a significance level $p = 0.01$ and a degree of freedom $df = 7$ is $\chi^2_7 = 18.48$. The comparison with the threshold value $\chi^2_7 = 18.48 < 29.35 = \chi^2$ of suggests the Null-hypothesis (H_0) can be rejected, assuming the data follows a χ^2 distribution. Thus, founders make conscious decisions on which information to share.
A noteworthy point, although it occurred infrequently, is the sharing of other investors' questions and feedback. The following account of a founder illustrates how

the transparency in the conversation with investors can streamline the communication. A founder interviewed for the thesis mentioned that:

> *"We spoke with more than 50 VCs which takes up a lot of time. It's pretty much Pareto, every chat has 80% in common and even the last 20% don't differ that much after a few times. By writing the questions and our answers up, and making them available, we avoid questions that just waste everyone's time. In a short summary we're also much clearer than if you ask me right now." (SigF13)*

Another founder-team interviewed for the study shared a 20-page summary in addition to their pitch-deck which even contained points that criticised the ESV and revealed sensitive information. A VC, who had an advisory role for the signalling study, said that openly sharing commonly asked questions demonstrates founders' confidence, reflection, and openness to taking advice. This coachability can be seen as a very important character trait (AdVC1).
Questioning founders about their convincing strategy allowed deeper and more nuanced analysis of the themes rather than merely reviewing their fundraising documents.

(c) ESVs' unfair advantages and convincing VCs

To convince VCs to invest, founders mentioned several factors that give them an advantage such as the team composition, strategy, and their social network partners. Furthermore, they mentioned supporting factors such as size of existing markets, or good timing for example when their development coincides with an emerging trend. Founders also benchmark their products' performance or technology portfolio against competitors' solutions. Table 4.7 summarises the frequency of the mentions with which founders demonstrated investability to VCs.

Table 4.7: ESVs signalling investability

Theme	Mentions
Internal	
Team/pedigree	16 (47%)
Industry experience	13 (38%)
Go-to-market strategy	3 (9%)
External	
Market size	25 (74%)
Differentiated technology	19 (56%)
Social network	15 (44%)
Timing, trend, market growth	9 (26%)

Among the internal factors, it is notable that the team composition and pedigree play an important role compared to the market strategy. The third most frequent mention, concerning almost half of all interviewees, are social network signals to investors. As mentioned in the methodology in Section 4.4 the Gioia et al. method was applied to translate direct participant accounts into themes. Examples of such theme summaries were that several founders pointed out that mentioning their scientific advisers and earliest customers seemed to resonate well with VCs. The two following direct quotes illustrate founder's perspective on external advisers and "name-dropping". One founder blatantly put it as:

> *"dropping a few names and saying we're working with [two companies anonymised] and [company anonymised] is knocking on our door makes us look even stronger than we are. However, it's the same when I ask investors 'what can you do for us?'. They tell me 'I could introduce you to this person and that person and kick in doors for you' - who knows if they really could? At [company anonymised] we sometimes joke, 'fake it until we make it'." (SigF22)*

A case study founder of a life-science venture explained why they leverage the affiliation with their adviser:

> *"We're in a pretty niche [market] segment so VCs reaching out to us have often heard of Prof. [name anonymised] and only find us through him. That's why we put Prof. [name anonymised] in our deck, on the website, and asked him to update his LinkedIn with our info. [...] If we have the UK's guru as one of our advisers that means a lot. Also Prof. [name anonymised] has been part of a couple of successful exits as an adviser, which shows he's not just bright but wants to make money." (SigF24)*

Next, interviewees were asked what they believe is unique about their ventures and where the ESV has an "unfair" advantage. Table 4.8 lists the identified themes that founders mentioned in regards to the topic of the ESV's uniqueness.

Table 4.8: ESVs' signalling of unfair advantages

Theme	Mentions
Data access	9 (26%)
Industry experience	9 (26%)
Brand/reputation	8 (24%)
Collaboration with incumbent	8 (24%)
Partnership with university	7 (21%)
Channel access	6 (18%)
Following trend	5 (15%)
Education experience	4 (12%)
Member of a group	3 (9%)

On the topic of unique characteristics of the ESV, the prevalence of themes is evenly balanced. It should be noted that several themes such as the university affiliation, brand, channel, data access, collaboration and membership in a group directly or indirectly involve a social network. The frequency of these mentions first highlighted the presence of social network signals and most founders mentioned a broad array of stakeholders with whom they regularly engage. One founder stated:

> *"Our space is crowded and we have strong competitors. Their products are great and some features are better than ours. In such a situation, with like-for-like comparisons, the only aspect that can't be replicated is who's first to market and which customers decide to work with you. If you want to stay at the top, you have to work with the big guys like [company anonymised]." (SigF32)*

As the next quote illustrates as an example, several founders pointed out that other than building a product which can be accelerated through increased funding and hiring developers, it can take years to assemble such "hard-won" connections. Founders also reported that being fortunate and having a timing advantage can create a sustainable moat which sends a strong signal to VCs. For instance, a founder of a mental health software ESV mentioned that

> *"the news are featuring mega [financing-] rounds and acquisitions worth hundreds of millions of dollars. The market is clearly reaching its first peak as digital mental health applications became such a big trend - I mean look in the app store on your phone - there are dozens of apps. Because we were early, we have been lucky to ride that first wave. If you set up shop now you missed out on that advantage - you might be too late to the party." (SigF25)*

Thirteen founders highlighted that their industry experience cannot be easily repli-

cated by other entrepreneurs who establish themselves as competitors. As a consequence of this sustained advantage interviewed founders see themselves uniquely positioned. AdVC2 who advised the researcher for the study mentioned the term "founder-problem fit" for this scenario, further pointing out that it can give ESVs a strong competitive advantage if they are the "best-in-class" team who dedicates their attention to solving a problem.
Two founders emphasised that their previous careers in VC helped them at various steps along the ESV journey, particularly with the fundraising efforts, as the founders have an increased awareness of VCs' preferences of (SigF9, SigF13).
The majority of founders communicate these unfair advantages verbally instead of including it in the documentation. Some founders rationale was that these unique advantages are difficult to formalise in a pitch deck and require more context (SigF1, SigF4, SigF15), while others want to ensure better control about spreading of sometimes highly sensitive commercial, or joint development agreements (SigF7, SigF29). Hence, when comparing the results of both the information and document sharing strategies in Section (b) and the mainly verbally communicated unfair advantages covered by this section, there is a clear difference of the delivered content in verbal and non-verbal communication.

During the pilot phase of the signalling study, a founder mentioned that his previous experience from working at an accelerator program impacted his information sharing behaviour (AdF1). He explained that as VCs' investment theses and industry sector foci can differ substantially, having individually tailored pitch-decks and communication strategies is essential to increase the odds of successful fundraising. "There is no one-fits-all approach to pitching" (SigF2). As a consequence, of the wealth of potential information that could be conveyed there could be merit to being familiar with VCs' preferences. This aspect of founders' knowledge was investigated by the next interview topic.

(d) ESVs' familiarity with VCs' criteria

As part of the study, founders were asked to rate their familiarity with VC decision-making criteria for ESV investments. The interviewer presented the founders with the statement: "I am familiar with VC investment criteria and preferences". Founders then rated whether they (1) strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree, or (5) strongly agree and their answers are captured by the variable $f\_criteria\_familiar$. In summary, the 34 interviewees rated their familiarity with a $mean = 3.15$, which means that they are somewhat familiar with the criteria. The standard deviation was $\sigma = 1.33$, the $median = 3$, and $mode = 3$. Table 4.9 shows the case study founders' and their ventures characteristics which were investigated for their influence on the variable $f\_criteria\_familiar$.

Table 4.9: ESVs' characteristics and familiarity with VCs' investment criteria

Variable	**Measure (unit)**	**Interpretation**
tenure[1]	integer (years)	Founder's experience in position
no_funding_rounds	integer	ESV's completed funding rounds
unfunded	binary	ESV is unfunded
angel	binary	ESV currently Angel funded
seed	binary	ESV currently Seed funded
series_a	binary	ESV currently Series A funded
series_b	binary	ESV currently Series B funded

[1] Includes previous founding, ESV, or VC experience

The variables were used for an OLS regression, the results are shown in Table 4.10.

Table 4.10: OLS regression of founders' familiarity with VCs' investment criteria

Dependent variable: *f_criteria_familiar*		$\boldsymbol{R^2} = 0.568$
Independent variables:	**Coefficient**	**Std. deviation σ**
constant	2.589	*n/a*
tenure	0.163*	0.097
no_funding_rounds	-0.223	0.265
unfunded	-0.766**	0.380
angel	0.048	0.347
seed	0.270	0.274
series_a	1.338**	0.539
series_b	1.699***	0.596

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

With regards to the limited number of participants, the explanatory power of the statistical analysis should not be overestimated. However, the results of the regression indicate that founders have a base-line familiarity (2.589 of 5) regardless of their previous fundraising experience. The *tenure* positively correlates with the reported criteria familiarity which seems reasonable given that the criteria are nondescript and founder confidence might increase over time. Interestingly, the regression shows that the number of previous financing rounds is not statistically significant. A trend of increased familiarity can be observed with founders towards later fundraising stages (Series A and B). This finding is also to be expected as interviewees were co-founding members and gained experience over subsequent fundraising rounds which also correlated with tenure. To ensure sufficient confidence in the validity of the analysis, the results were cross-checked as shown in Table 4.11 and yielded comparable results by using Cramér's V and Theil's U which are suitable statistical tools for categorical, and in this case, binary data (Blaikie, 2003).

The Cramér's V values for the analysed binary variables and supports a moderate association for the variables *unfunded* (0.45), *max_funding_stage* (0.34),

Table 4.11: Cramér's V and Theil's U test of founders' familiarity with VCs' investment criteria

Participant/ESV	Cramér's V	Theil's U
tenure	0.24^{**}	0.31
no_funding_rounds	0.16	0.30
max_funding_stage	0.34^{***}	0.32
unfunded	0.45^{**}	0.33
angel	0.00	0.11
seed	0.13	0.13
series_a	0.42^{**}	0.41
series_b	0.37^{**}	0.39

Cramér's V p-values: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

series_a (0.42), and *series_b* (0.37) as well as weak association for *seed* (0.21) and none for *angel* (0.00).

Theil's U values support the previous findings as they identify moderate associations for *unfunded*, *series_a*, and *series_b*, weak association for *seed* and *angel*.
Founders also reported that VCs expectations can differ widely which might result in criticism of different elements of the ESVs (SigF13; SigF21). SigF13 who previously discussed the rationale for sharing the most frequently asked questions with VCs who show interest, elaborated that the strategy helps to preempt questions and quickly respond to the wealth of VC's questions and preferences.
The final question posed to founders aimed to capture issues that occur during the engagement process with VCs.

(e) ESVs' perceived issues with VC engagement process

During the study's pilot phase, the consulted stakeholders also tested the questionnaire. One VC pointed out that the engagement between founders and VCs can be accompanied by significant friction (AdVC3). Hence, the questionnaire was amended to capture this topic of engagement issues, and Table 4.12 lays out the coded themes.

Table 4.12: ESVs' issues in their engagement with VCs

Theme	Mentions
Miscommunication	18 (53%)
Lack of interest	16 (47%)
Request unnecessary information	16 (47%)
Time intensive	14 (41%)
Unstructured due diligence	14 (41%)

Every case study's ESV founder mentioned at least one issue that occurred in the engagement process with investors. Five themes were identified that were prevalent in over 40% of the case study ESVs. Most frequently reported were instances in which miscommunication occurred. Concrete examples which were derived from the Gioia et al. method are different understanding of the fundraising timeline, targeted customer segments, or growth and exit expectations. Almost half of the interviewees witnessed a lack of interest from VCs which manifested in the VCs becoming increasingly unresponsive, unwilling to commit or take next steps towards an investment. Moreover, founders criticised that VCs often seek to obtain metrics, or customer testimonials and product details prematurely. These interviewees mentioned that the information sought by the VCs is so far unknown to the founders themselves, and time and effort is wasted on speculating. Finally, founders complained about the inefficiency, intransparency and lack of structure imposed by VCs on the fundraising process. One interviewee admitted that:

> *"the [engagement] process involves strong gamesmanship. If you push [VCs] too much, you look desperate and get bad terms*[9]*, if you don't push and tell VCs the [financing-] round is coming to a close, nothing happens. We're in the comfortable situation that there's still cash in the bank and we see quite a lot of interest from investors. It allows us to stall the communication with a less prestigious VC a bit and let others catch up with their due diligence process and finally settle for the best option." (SigF1)*

Another founder pointed out how detrimental the fundraising process can be to the ongoing business.

> *"I can't figure out why they [the VCs] take so long to decide whether to invest or not. Instead of being transparent, they keep asking for information we simply don't have. It annoys me how much time I waste fundraising instead of working with customers and creating actual value." (SigF32)*

To identify whether the information shared with the VCs can be associated with a reduced perception of issues that occur, Cramér's V and Theil's U were applied to the data as summarised in Table 4.13.

[9] Terms are jargon for a term-sheet, which is the contract which outlines the contractual framework of the funding round.

Table 4.13: Association of ESV information sharing, signalling, and communicated unfair advantages with engagement issues

Theme	Issue	Cramér's V	Theil's U
Sharing			
pitch_deck	*miscommunication*	0.11	0.09
letter_of_intent	*lack_of_interest*	0.02	0.06
letter_of_intent	*request_unnecessary_info*	0.02	0.06
letter_of_intent	*miscommunication*	0.02	0.06
client_feedback	*unstructured_process*	0.18	0.07
investor_feedback	*miscommunication*	0.24^{*}	0.27
social_network	*lack_of_interest*	0.33^{**}	0.14
social_network	*request_unnecessary_info*	0.33^{**}	0.14
social_network	*miscommunication*	0.15	0.06
paper_reports	*request_unnecessary_info*	0.18	0.07
paper_reports	*unstructured_process*	0.22^{**}	0.09
paper_reports	*miscommunication*	0.15	0.06
Signalling			
traction	*unstructured_process*	0.18	0.08
differentiated_tech	*time_intensity*	0.22^{*}	0.09
differentiated_tech	*lack_of_interest*	0.24	0.09
Team/pedigree	*lack_of_interest*	0.17	0.07
Industry_experience	*lack_of_interest*	0.51^{***}	0.28
Industry_experience	*request_unnecessary_info*	0.38^{**}	0.17
Industry_experience	*unstructured_process*	0.20	0.08
trend_market_growth	*time_intensity*	0.17	0.08
market_size	*time_intensity*	0.17	0.08
social_network	*lack_of_interest*	0.52^{***}	0.29
social_network	*request_unnecessary_info*	0.65^{***}	0.43
social_network	*unstructured_process*	0.28^{*}	0.11
social_network	*miscommunication*	0.24^{*}	0.09
Unfair advantage			
university_partnership	*time_intensity*	0.11	0.08
university_partnership	*lack_of_interest*	0.20	0.12
industry_experience	*lack_of_interest*	0.41^{***}	0.24
education_experience	*lack_of_interest*	0.19	0.23
education_experience	*miscommunication*	0.24^{*}	0.27
following_trend	*time¡ntensity*	0.17	0.13

Cramér's V p-values: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

The analysis yielded moderate to weak associates for all variables. Sharing information about the ESV's social network was found to reduce the requesting of information by the VC which the founders deem unnecessary. Social network information in the hands of VCs is also associated with a decline in instances where VCs show a lack of interest and miscommunication occurs. Sharing feedback and commonly asked questions by VCs with other VCs is associated with less miscommunication.

Furthermore, founders' decision to share peer-reviewed papers or reports was associated with more structured engagement, requesting more relevant information, and better communications with VCs. Lastly, sharing client feedback and pitch-decks is moderately associated with a reduction of issues stemming from unstructured engagement.
The analysis of founders information sharing behaviour and the associated perceived issues concludes the results obtained from the ESV case studies. The next section presents the VC case study results.

4.5.2 VCs' perspective on signal reception

The findings of the VC case studies were categorised into four topics. First, VCs summarised their main challenges (a). Second, VCs' strategies to overcome investment uncertainty, build conviction, and blueprint for a more solid information basis were discussed (b). Third, interviewed VCs explained which software they use and elaborated the use-cases (c). Last, VCs explained common issues that occur in the engagement process with founders (d).

(a) VCs' challenges

The interviewed VCs reported on the challenges they faced. These accounts were coding using the Gioia et al. method and are summarised in Table 4.14.

Table 4.14: Challenges faced by VCs

Theme	Mentions
Due diligence	19 (61%)
Technology	7 (23%)
Customers	5 (16%)
Team	4 (13%)
Extent	4 (13%)
Competition	3 (10%)
Sourcing	7 (23%)
Quantity	4 (13%)
Quality	4 (13%)
Post-investment value-add	4 (13%)
Sales/hiring introductions	3 (10%)
Competitor awareness	3 (10%)
Fundraising	3 (10%)

The results show that conducting due diligence presents the biggest challenge (61%), followed by sourcing investment opportunities (23%), assisting portfolio companies post-investment (13%), and raising own funds (10%).
Within the due diligence theme, assessing an ESV's technology was reported the

most frequent, followed by the assessment of the ESV's customers, team, and competitors. A smaller fraction of the surveyed participants mentioned that the extent of the due diligence is overwhelming and overly time-consuming.
Around one quarter of participants mentioned sourcing of investment opportunities presents a challenge, whereby achieving high quality investment leads and working to maintain a high quality deal-flow were the two prominent sub-themes.
The sub-themes within the post-investment challenges were introductions of the portfolio company to potential clients as well as assisting with the hiring process of the ESV. Finally the fundraising process for the VC fund itself was discussed as a challenge.
Across the sample Cramér's V and Theil's U were tested to reveal associations between the participant's characteristics and the challenges they face. The results yield few patterns as most associations are negligible or weak. Table 4.15 summarises the notable exceptions. The Cramér's V test helped identify moderate associations be-

Table 4.15: VCs' characteristics and associations with challenges

VC characteristic	**Challenge**	**Cramér's V**	**Theil's U**
tenure	*postinvestment_valueadd*	0.57	0.13
B2B/B2C/both	*due_diligence_competition*	0.52	0.15
VC_partner	*fundraising*	0.32	0.24
tenure	*sourcing_quantity*	0.28	0.09
series_b	*due_diligence_extent*	0.23	0.11

tween the tenure of VCs and an increasingly perceived challenge to add value to portfolio companies. This result is substantiated by the fact that more experienced VCs' attention, such as Partners and Principals, is directed more at fundraising and portfolio company management, whereas Associates conduct the majority of the due diligence. This could explains why Partners found fundraising challenging, whereas Associates did not. Furthermore, a weak association was found between junior Associates and the perceived challenge of sourcing a high volume of deals. Lastly, VCs focusing on Series B investments reported the amount of due diligence to be performed as challenging. As was seen in previous examples, the strength of association Theil's U is more moderate than Cramér's V as outliers are weighted stronger.

(b) VCs' overcoming uncertainty and building conviction

The study participants discussed the uncertainty during the investment process and how to build conviction to fund an ESV. Table 4.16 lists the most frequently reported strategies.

The Gioia et al. method helped to derive several clear themes, most prominently

Table 4.16: VCs' dealing with pre-investment uncertainty

Theme	Mentions
References	14 (45%)
Competitive landscape	12 (39%)
Professional advisory services	11 (35%)
Customer's opinions	10 (32%)
Database, comparable companies	8 (26%)
Getting to know founders over time	7 (23%)
Warm introductions	7 (23%)
Serial founder ESV team	6 (19%)
ESV team's academic or industry pedigree	5 (16%)
Permanent technology or general advisers	5 (16%)
Own experience with industry and technology	4 (13%)

the overcoming of uncertainty for VCs by obtaining external references (45%) on the founding team and staff from a trustworthy external source such as former employers or academic supervisors. A VC reported that:

> *"a quick chat, [...] with a founder's former boss or supervisor adds an invaluable perspective. We tend to ask for such introductions late in the diligence process because we are mindful that founders cannot introduce every VC that comes around, but we always require references at some point. Ideally, the person who provides the reference has a relation to the startup and the founders but is not biased or invested." (SigVC8)*

Another element of the diligence process that helps to build conviction stems from a VC's broad understanding of the competitive landscape (39%) which can either be achieved through paid professional services advisers (35%), a permanent network of advisers to the fund (16%), or own experience with technology and industries (13%). Speaking to experts was widely reported to be an effective tool to de-risk investment opportunities. One VC stated that they

> *"invest in more than a dozen different industries and cannot possibly be an expert in every niche. That is why we use a network of experts, some of them through services like [name anonymised]. These advisers have their finger on the pulse of an industry and we ask them questions around the competition etc. Competition is important, one of the worst VC nightmares is to invest in a company and three months later you find out that [company anonymised] is doing the same thing. If a startup is running up against the big tech-firms it gets even more difficult." (SigVC31)*

Another means for VCs to overcome uncertainty are customer testimonials (32%). Across both B2B and B2C verticals, VCs often enquire about the ESV's first customers. VC said they sometimes see customers being actively involved in the development process (SigVC9; SigVC20). SigVC8 emphasised the importance of understanding the ESV by taking the customer's perspective:

> *"Maybe even more so than a strong team, customers telling me 'I need that' trumps everything else. The voice of the customer does not lie. They have no incentive to lie. But you need to spend a significant amount of time with customers to understand their problem and the value proposition of the startup. Only that way you find out whether they will be sustained customers. Our team refers to this as 'need to have versus nice to have' which is the difference of being cut or not should the economy turn sour." (SigVC8)*

The study participants also reported the use of private market databases (26%). SigVC30 mentioned that the fund maintains a proprietary database which merges several data sets with 30 years of historical deal-data. He added that the tool, which is used firm-level wide, reduced the due diligence time by up to two thirds.
Seven VCs reported that they aim to build a relationship with the founding team before committing to an investment. One of them explained that at some point during the due diligence, the VC fund offers the ESV teams to join their entrepreneur in residence program for up to two months. The main reason is to be able to confirm whether the ESV has the momentum they claim and see with their own eyes the team dynamics and commitment (SigVC4).
Warm introductions play an important role (23%). Introductions can originate from a variety of sources such as customers, and industrial representatives (SigVC3), the VC's existing portfolio companies (SigVC9), friends or ex-colleagues of the founders (SigVC16), the VC's LPs (SigVC20), or advisers to the ESV (SigVC31).
Around one-fifth of the interviewed VCs stated that they feel more comfortable investing in serial founders. Especially when the team remained in a similar constellation and embarked on a new ESV journey, VCs perceived a strong positive signal (SigVC7). Two VCs who prefer backing serial founders mentioned that first-time founding teams often fall apart (SigVC2; SigVC16) while another stated that some first-time founders underestimate the challenges of being a founder. The VC phrased it as "if you have been there before you know what you are getting yourself into" (SigVC14).
Lastly, the ESV team's academic pedigree or industrial experience, especially when it is directly relevant to the venture (SigVC13), can be considered a substantial moat in helping to sustain defensibility.

In addition to the identified themes that help alleviate investment uncertainty, the interviewer asked a follow-up question also regarding the topic of uncertainty, suggesting potential additions to improve the information basis. Table 4.17 shows the results for such an improved information basis for decision-making.

Table 4.17: VCs' ideal information reception

Theme	Mentions
Details on the team	13 (42%)
Existing investors opinions	10 (32%)
ESV's potential to attract talent	10 (32%)
Technology/ science details	8 (26%)
R&D/ science risk	7 (23%)
Incumbents and their actions	6 (19%)
ESV customers	5 (16%)
Market size and trends	4 (13%)

Most frequently suggested were additional details on the founding team (42%) and its ability to attract and retain high profile talent (32%). Another piece of important information which is often not available to VCs is the attitude of previous investors in the ESV. Existing investors' opinions were said to be very valuable since they contain an insider's perspective and information. Therefore, the actions of existing investors can substantially influence the behaviour of VCs who are interested to invest (SigVC2; SigVC4). Around one quarter of respondents would want more information on the ESVs' technology, underlying science (26%), and the risk of unsuccessful completion of product development (23%). The remaining suggestions were put forth by less than a fifth of the interviewees and included suggestions such as more information on the ESVs' customers, incumbents, and competitors, as well as the market size and trends.

The combined results of Table 4.16 and 4.17 show that VCs employ a wide array of measures to reduce investment uncertainty, while it also surfaces areas of improvement especially around technology and social network details.

(c) VCs' tools and their use-cases

As the VCs reported challenges across all duties of a VC, including gathering and evaluating a significant amount of evidence regarding the investment opportunities, the use of decision-aiding tools and software was discussed with the interviewees. Table 4.18 lists the tools which case study VCs reportedly used.

The analysis shows that several different software solutions are in use, however, few of them could be considered broadly adopted. Many VCs mentioned that even across VCs in the same firm the use of software is non-uniform. One VC emphasised that the venture investing process is dominated by personal preference and taste

Table 4.18: VCs' use of software

Theme	Mentions
Spreadsheet and word processing	16 (52%)
Social media	15 (48%)
Private market databases	10 (32%)
Proprietary tools/metrics	5 (16%)
Fund management software	4 (13%)
Web analytics	3 (10%)
Valuation calculator	3 (10%)
Market research tools/reports	3 (10%)
Internal communications tools	2 (6%)

which translates in the adoption of software rather individually than on a fund-level (SigVC15). According to the interviewees, over half of them used spreadsheet and word processing software, and one third used information from private market databases and social media platforms such as LinkedIn, Twitter, or Instagram. One sixth of VCs reported using self-defined metrics or proprietary tools. Around one tenth of participants used fund-management software, web analytic tools, valuation calculators, market research tools, and internal communication tools. The categorical association metrics Cramér's V and Theil's U helped to investigate associations between the use of software and the perceived challenges of VCs.

Table 4.19: VCs' software and challenges associations

Software/tool	Challenge	Cramér's V	Theil's U
private_market_databases	*fundraising*	0.31**	0.19
social_media	*due_diligence*	0.25***	0.10
market_research_tools/reports	*due_diligence*	0.22	0.16
private_market_databases	*due_diligence_team*	0.17	0.09
private_market_databases	*due_diligence*	0.14	0.07
proprietary_tools/metrics	*due_diligence_team*	0.13	0.11
social_media	*competitor_awareness*	0.10*	0.10

Cramér's V p-values: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Apart from a moderate but statistically significant association between the use of private market databases and less perceived challenges of fundraising, the remaining associations were moderate to weak. The use of social media is statistically significant and associated with a reduction of due diligence challenges and an increased awareness of competitors. Private market databases, market research tools, and market reports are associated with reduced challenges of due diligence in general and the ESV teams in particular.

In addition to listing the software, its use-cases were elaborated by interviewees as

summarised in Table 4.20.

Table 4.20: VCs' software use-cases

Theme	Mentions
Use for due diligence	27 (77%)
Use for sourcing	9 (29%)
Use for post-investment	4 (13%)
Use for exit	3 (10%)

The majority of tools in use aided the due diligence process followed by applying software to source of investment opportunities. For post-investment activities and exiting investments, software was used by only one tenth of the VC sample.
Theil's U was used to investigate associations between perceived issues and the reported use of tools for certain use-cases. Moderate associations were found between the use of tools for sourcing resulting in lower perceived challenges with sourcing (Cramér's V = 0.38, Theil's U = 0.20). A stronger association exists between use of software for sourcing and managing the extent of the sourcing activities (Cramér's V = 0.47, Theil's U = 0.31), however, no association was found for the quality of the sourced investment opportunities. Regarding the post-investment activities, VCs who reportedly used software mentioned fewer perceived challenges (Cramér's V = 0.13, Theil's U = 0.13).

(d) VCs' perceived issues with ESV engagement process

The last topic discussed with interviewees were issues that occur during the pre-investment engagement with ESVs. Table 4.21 lists the identified themes.

Table 4.21: VCs' issues in their engagement with ESVs

Theme	Mentions
Timing of fundraise	
Too early, unprepared founders	6 (19%)
Too late, rushed process	8 (26%)
Lengthy due diligence process	5 (16%)
Failure to communicate	
Stakeholder network	7 (23%)
Technology to a non expert	5 (16%)
Differentiation/defensibility	5 (16%)
Momentum, reaching milestones	5 (16%)
Commercial traction	4 (13%)
Competitive landscape	4 (13%)
Customer needs and market size	4 (13%)
Product and value proposition	2 (6%)
Trust, verifiable claims	2 (6%)

Coding the VCs' mentions revealed numerous issues which compared to the issues perceived by their ESV counterparts, were less uniform across the sample. Few of the interviewed VCs reported more than one perceived issue, whereas most ESVs had reported several issues. The issues faced by VCs followed two overarching themes. Firstly, bad fundraise timing on behalf of the founders which manifests in two ways. Either the fundraising begins too early and founders seem unprepared. In addition, the lack of pressure to close the deal could lead to a lack of interest from the investor. Or, fundraising is initiated too late which creates a hasty environment and discomfort for both founders and VCs as founders risk running out of liquidity and VCs must rush to make decisions.
Secondly, VCs's criticised founders for a lack of clarity regarding the stakeholders involved in the ESVs, the technology and its differentiation from competitors, the momentum with which milestones are currently achieved, and how this translates into commercial traction in the form of customers and revenues. Furthermore, a small number of participants reported issues of trust and discomfort with unverifiable claims made by entrepreneurs.

This concludes the results of the signalling study, the next section summarises the results of the stakeholder study.

4.6 Results: stakeholder study

The results of the signalling study highlight the importance of ESV stakeholders in multiple instances. As stakeholder importance was not identifiable this prominently in existing literature, a more in-depth study of the ESVs' social networks was inspired. The resulting stakeholder study was conducted with eight ESVs and the purpose to identify main characteristics and differences across the social networks of case study ventures. As mentioned in the Section 4.3 on research design, the setup of the signalling and stakeholder study were similar. The main difference between the studies was the sample, which only consisted of founders, and the additional task for participants to sketch a visual representation of their ESV's social network. A comparison of the social network constellations visualised in the drawings, examined the elementary building blocks of networks, i.e. vertices (stakeholders) and edges (ESV and stakeholder connections), as well as constellation patterns that can be described through social network metrics introduced in Section 2.4.2[10].

4.6.1 ESVs' stakeholders

The social network drawings from eight case study interviews were gathered and dissected. Table 4.22 lists all identified classes of stakeholders.

[10] An overview of social network metrics can be revisited in Section 2.4.2 and Table 2.3 on page 38.

Table 4.22: ESV social network stakeholders

Stakeholder	Mentions	Stakeholder	Mentions
Accelerator	5 (63%)	Supplier	1 (13%)
Adviser	5 (63%)	Journal editor	2 (25%)
Competitor	2 (25%)	Journalist	3 (38%)
Contract researcher	1 (13%)	Lawyer	4 (50%)
CRO	1 (13%)	Industry expert	3 (38%)
Customer	6 (75%)	Mentor	3 (38%)
Consultant	1 (13%)	Policy maker	1 (13%)
Corporate (buyer)	5 (63%)	PR firm	2 (25%)
Corporate (user)	4 (50%)	Media analyst	2 (25%)
Former employee	2 (25%)	Publisher	2 (25%)
Former employer	3 (38%)	Recruiter	4 (50%)
Incubator	2 (25%)	Technology expert	3 (38%)
Investor	7 (88%)	University	5 (63%)
Other ESV	3 (38%)	Uni. researcher	3 (38%)
Other SME	1 (13%)		

The results indicate, in accordance with existing literature, that certain groups such as investors, customers, accelerators, advisers, corporate partners, and universities are prevalent. Besides, other stakeholders are found, however, these are not covered sufficiently by the reviewed literature. Examples include press and media, professional services such as legal, industry and technology consulting, recruiting, or contract research organisations (CROs).

While visualising the ESV's networks, the founders of the case study ESVs were also asked to indicate whether stakeholders are directly important for the ESV or instead only mentioned to VCs to demonstrate an affiliation with stakeholders, in which case the importance would be indirect. In summary, whether founders of ESVs appreciate the direct or indirect contributions by stakeholders to the venture depends on the class of stakeholders[11].

The case studies revealed that founders appreciate but hardly communicate affiliation to professional services from lawyers, contract researchers, consultants, market and industry experts. The services are more important to ESVs than mentioning their affiliation to VCs except for industry and technology experts and recruiters. Furthermore, ties to former employers and employees, or collaboration with other ESVs, SMEs, and direct competitors are important to some ESVs but mentioned less frequently to VCs. Also, stakeholders in publishing and media such as journalists and journal editors are more directly important than indirectly.

In turn, stakeholders who advise, and mentor the ESV, including affiliations with

[11]Table F.1 in Appendix F on page 267 gives a complete overview of the founder's perceived importance of stakeholders for the ESVs and VCs.

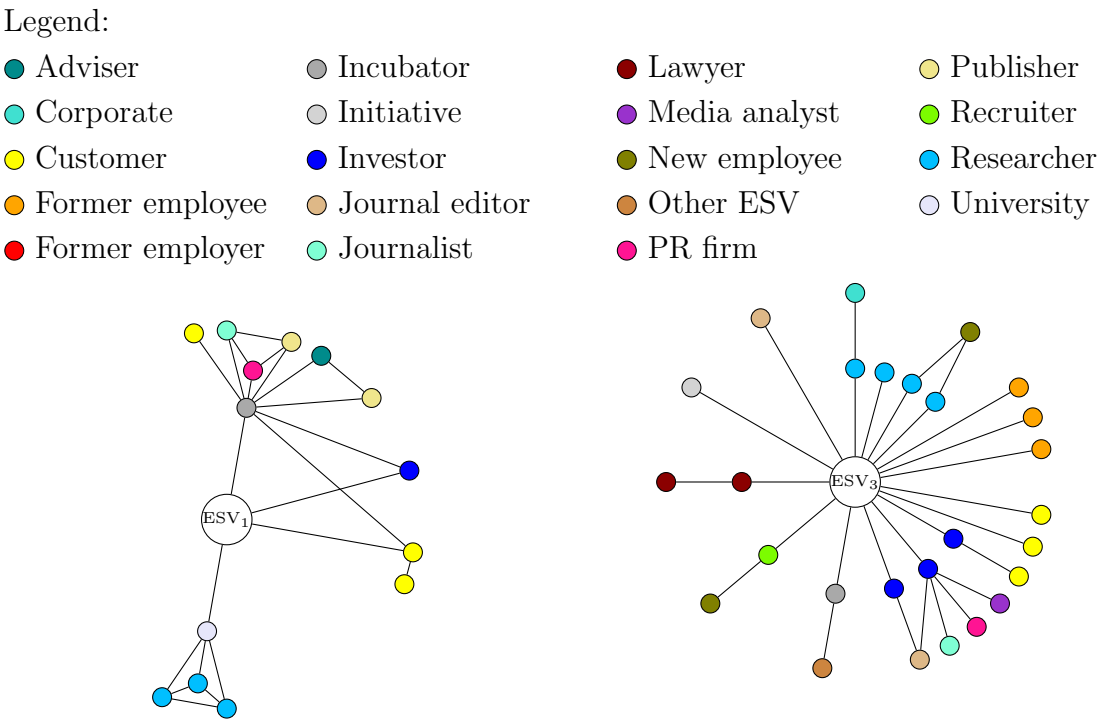
accelerators, incubators, and university programs are reported as more indirectly than directly important. Consumers and business customers are reported as important both directly and indirectly. Likewise, an affiliation with CROs or regulators and policy-makers are infrequent but both directly and indirectly important.

A surprising finding was the fact that founders reportedly established access to organisations, especially corporate stakeholders through multiple independent channels. The approach was explained as a response to the siloed nature of large firms in which buyers of technology are usually not the users and centres have individual responsibilities and budgets (StaF3). Depending on the organisation, and what ESVs seek form of engagement with the corporate different decision-makers, the organisation has to be approached differently. Founders reported of stakeholders who turned into clients, joint development partners, financiers. Such stakeholders often allowed ESVs to benefit from corporate's brand-image (StaF2, StaF4, StaF7). Another parameter of the engagement with corporate stakeholders was the choice of a top-down or bottom-up introduction, StaF7 mentioned the ESV successfully tried both strategies, first getting introduced to a large software firms Chief Information Officer (CIO) and in another case through a junior employee.
Another stakeholder group which plays an important role for ESVs are lawyers. The contractual work between founders and VCs can be complex with different stock-vesting provisions, liquidation rights, and other legal hurdles. Therefore, most founders seek professional advice. In response to that, some large legal firms have altered their approach as one specialist lawyer consulted for this study revealed (AdLaw1). Similar to early-stage VCs motivation to fund ESVs early in hopes for higher returns, legal firms scout for ESVs in a comparable manner. AdLaw1, a Partner at a London-based law firm explained that the ESVs' costs for switching legal advisers can be high, especially when lost time and the necessity to rebuild trust with a new legal representation is factored in. Thus, the lawyer advising founders on their first term sheet and fundraise, might be the same one who later helps to file for an IPO. This trend leads to a situation where even top legal firms in ecosystems battle to represent top founders. The Partner explained that legal firms reduce their hourly rates to a bare minimum or even provide free legal advice during board-meetings, and assist with international expansion of the ESV - again with the goal to be the attorney of choice for late-stage, high-fee, transactions.

As the identification of relevant stakeholder groups was complete, the social networks of the case study ESVs were further analysed regarding their structure as the drawings illustrated notably different constellations.

4.6.2 ESVs' social network constellations

Figure 4.2 shows representative social network drawings of two case study ESVs, ESV_1 in Figure 4.2(a), and ESV_3 in Figure 4.2(b).



(a) Social network ESV_1

(b) Social network ESV_3

Figure 4.2: ESV social networks drawings, own illustration, anonymised and digitised from original drawing.

The two social networks differ both in their network size (15 to 28 vertices) and the number of edges (29 to 23). The degree, i.e. the number of first-order edges varies significantly for the two ESVs (4 to 17) especially when compared to other vertices's degrees (max. 9 to max. 5). This ESVs' centrality metric indicates how connected the ESV is to all stakeholders in the network. Looking at the centrality measure, ESV_3 can be considered a "hub" as it takes a central position being the most densely connected vertex. By contrast, the "incubator" is the hub and spans ESV_1's social network, leaving ESV_1 in a peripheral position. Ten different stakeholder categories exist in ESV_1's network, the more heterogeneous network of ESV_3 comprises of a more diverse set of 15 stakeholder categories. Also, the stakeholders in the social network drawings are interconnected to a different extent. ESV_1's stakeholders are densely interconnected through 19 edges, ESV_3's stakeholders are dispersed and connected by only twelve edges. Table 4.23 shows an overview of the different network constellations measured with social network metrics.

Table 4.23: Metrics of case study ESVs' social networks

	Social network		ESV		Stakeholder	
Case study	**Vertices**	**Edges**	**Degree**	**Centrality**	**Density**	**Diversity**
ESV_1	15	23	4	28.6%	9.0%	37.9%
ESV_2	21	26	9	45.0%	4.0%	41.4%
ESV_3	28	29	17	63.0%	1.6%	69.0%
ESV_4	18	14	7	41.2%	2.3%	34.5%
ESV_5	31	16	10	33.3%	0.6%	17.2%
ESV_6	37	30	15	41.7%	1.1%	48.3%
ESV_7	26	25	14	56.0%	1.7%	13.8%
ESV_8	51	19	10	20.0%	0.4%	34.5%
mean	28	23	11	41.1%	2.6%	37.1%
σ	12	6	4	14%	2.8%	17.4%
max_delta	36	16	13	43%	8.7%	55.2%

During the analysis of the ESV' social networks, notable differences were found between the ESVs' degree. As mentioned before, the degree defines the position within the network as a central hub or peripheral vertex. The analysed networks also differ in the diversity of stakeholders, and their connectedness among each other. The stakeholder connectedness, i.e. density of edges between stakeholders varies more than 50% across the case studies. The ESVs' centrality was calculated by dividing the ESV's degree by the maximum number of possible connections if it was connected directly to all stakeholders (Marsden, 2015). The stakeholder density was derived by removing ESV from the network and dividing the number of interconnections among remaining stakeholders with the total possible number of connections. The maximum total number of connections of n vertices, thereby calculates according to Formula 3.

Formula 3:

$$max\_no\_edges = n * (n - 1)$$

where:

- n is the sum of a network's vertices

The final metric to be analysed for the case study ESVs' networks is the stakeholder diversity. It was calculated by dividing the number of stakeholders represented in each network with the aggregate number of identified stakeholders categories across all case studies networks (29)[12].

[12] A commonly used alternative to the applied diversity calculation is the Herfindahl index of heterogeneity Baum et al. (2000); Zheng et al. (2010). As the sample size for this study did not permit for any statistical evaluation, a complex calculation of the network diversity was deemed not meaningful.

4.6.3 Social network support of ESVs' business functions

As the founders finished drawing the social networks, the interviewer asked under what circumstances networks could be relied on to support certain business functions. Coding the interviewees' answers yielded six themes of business functions. First and foremost, founders relied on their networks for fundraising (100%), recruiting talent (63%), and legal advice (63%). To a lesser extent, entrepreneurs depended on their social networks for PR (38%), sales (25%), and research and product development (25%). Overall, founders mentioned most social network partners can be a substitute or complement the ESV's internal business function. The analysis of business functions, which social network can fulfil, concluded the stakeholder study. The next section discusses the results together with the signalling study and outlines both limitations and opportunities for the subsequent studies of the thesis.

4.7 Discussion

Summary. The two studies analysed the signalling process between an ESV and potential VCs as well as the social networks of ESVs. Together, the studies and their results answer Research Questions 1: "how do ESVs signal to VCs and how do VCs evaluate the signal?", as well as Research Question 2: "which stakeholders occur in ESVs' social networks?"
Interviews conducted with 34 ESV founders and 31 VCs are the foundation of the signalling study, similar to the eight interviews with founders for the stakeholder study. Studying the pre-investment process holistically, including the nuanced perspectives of ESV founders as well as VC, is unique in the academic domain. This is because previous literature only studied either the VCs or entrepreneurship perspective and mostly did not discern different investment stages (Tykvová, 2018). The confocal approach highlighted the significance of the friction-laden investment process, which, according to the results, is a priority issue for both parties.
By introducing the stakeholder sub-study, it was possible to follow a research opportunity which emerged while conducting the signalling study. The topic of ESVs' stakeholders, who form the surrounding social networks, played an important role for individuals on both ends of the signalling process. As social networks play a critical role for a multitude of key business functions, VCs reported being receptive to these signals. Thus, the social network signals were identified as an effective means to de-risk investments in the eyes of the VCs.

Implications for ESVs. Important implications for the involved participant groups can be found in the increased understanding of the founders' variety of adopted signalling strategies. While it is unlikely that a single best practice exists, there is cer-

tainly advice and stimuli for alternative approaches to be obtained from the themes that were identified in this study. As an example, founders could create bespoke documents for individual investor categories or share feedback they received about their venture with other approaching VCs. These strategies might help speed-up the fundraising process. For example sharing of investor and client feedback, academic works and reports, as well as social network details, were associated with fewer challenges during investor engagement.

Implications for VCs. Looking at VCs' strategies in coping with investment uncertainties surfaced interesting approaches. Examples included a pre-investment entrepreneur in residence scheme, VCs' use of professional services and proprietary networks of advisers to give expert advice, and a proprietary database to facilitate investment decisions. It could be argued that there is more potential to be realised as VC funds codify and homogenise their investment process, including their use of tools. Such a shift would also mean following the trend of data-driven investing, which was identified in the literature review. Advances in databases, some of which are already used by the case study VCs, and analytics-enabled tools which have already been successfully implemented in other finance-related industries might alter the way VC makes investment decisions (Gompers et al., 2020). It was interesting to observe how optimistic some VCs were with regards to potentially industry-shaking advances compared to others who were reserved. The results of the study did show that software in support of pre-investment due diligence has the widest adoption so far, which means the barrier to entry could be lower than for other VC activities and support tools. Overall, the fact that none of the tools in use had a fundamental impact on the perceived issues shows that there is still a significant amount of opportunity to create bespoke software applications and improve models that could help tie up loose ends of the multifaceted due diligence approach.

Implications for theory. The study has several implications for theory. Firstly, it provides novel findings about signalled content and its significance during the pre-investment process. In addition to the question of "how to signal?" which existing literature addresses on a communication-level, there is reason to believe that the answers to the question of "what to signal?" are similarly significant. This could be considered an essential advancement, since a lot of the empirical research to date stops at a surface-level observation and does not find the richness of themes that exist. By contrast, the investigations undertaken in this study revealed the dichotomy between stakeholders that could be considered directly vital as they assist the ESV's business functions or indirectly important as their affiliation signals legitimacy and helps overcome the liabilities of newness and smallness.
Secondly, the study also opens doors to a broader theoretical discussion on whether

the VC investment strategy can be optimised to a uniform approach. Regarding this discussion, the criticism which some VCs hold against novel evaluation and due diligence approaches should be heard and taken into account. One VC mentioned that the wealth of information that is available is a blessing and curse at the same time. Compound learning over time adds patterns which influence future decisions which can lead to an "analysis-paralysis", a situation in which an ESV is over-analysed, and no decision can be reached (Ramsinghani, 2014). Some investors, therefore, suggest to consider "the top three risks associated with [...] an opportunity, [and decide whether to reach] [...] an investment decision based on addressing these risks" Ramsinghani (2014, p. 219). In response to the analysis-paralysis problem, SigVC8 explained that a due diligence process in VC differs much from that in other investment categories since they sift through 300-1000 opportunities per year for investment purposes. Thus, the art of assessing such a large pool of opportunities lies in "getting to a quick NO". Rather than trying to understand the ins and outs of an ESV and why to invest in a company, the goal is to answer why not to invest in a company. SigVC7 phrased this as finding the "red flags that would immediately disqualify [the deal]" to which AdVC1 adds that "every deal has a little hair on it" and the purpose of due diligence is finding the hair in the deal and assessing how much hair is acceptable.

Lastly, the social network perspective is further tied to the field of entrepreneurship and VC through this study. The study identified stakeholder classes which broadens the academic repertoire, and contrasted their relevance to ESVs and VCs. Additionally, established metrics were used to quantify social network characteristics, and the study has shown that this is possible with social network depictions sketched by founders.

4.8 Limitations and further research opportunities

The signalling and stakeholder studies serve as a basis onto which follow-up studies of this thesis can be built upon. Thus, the limitations have to be addressed, some of which lead to new research opportunities.

Firstly, while saturation was achieved with the analysis of higher level network constellations, the question of why and how founders use their social networks to support certain business functions was not exhaustively answered. As this exploratory study covered the entire pre-investment signalling process, a sufficient level of detail was not reached with regards to the support of business functions. The variety of answers obtained through probing founders with one dedicated question warrants further research into ESVs' strategies to leverage their social networks. Examples of

mentions included social network supporting legal activities and go-to-market strategy. Empirical studies, especially those focusing on ESVs, are scarce, leaving a lot of "white-space" for further research (Kuester et al., 2018). Such research would also respond to criticism from previous studies that stress research on resources embedded in social networks must advance from who to how as "with this objective, we shift away from a focus present in much of the social capital literature on whom an entrepreneur knows toward an understanding of how they engage in social practices of resourcing." (Keating et al., 2014). Chapter 5 is dedicated to an in-depth study of these resourcing strategies.

Secondly, social networks in their role as an evaluation parameter for VCs were only identified but not yet thoroughly understood in the study. By isolating the social network evaluation parameter and using a larger sample, the ESV social network evaluation experiment in Chapter 6 can improve theoretical and practitioner understanding of relevant metrics and patterns. Lastly, the study could not control for the impact signalling strategies had on the fundraising decision. None of the cases had two-sided information, founders and VCs commenting on the same ESV. By devising a dedicated study in Chapter 7 the relation of signals and fundraising success were studied. Thus, this thesis can respond to results from studies such as Wang (2016) which found that these signals mainly influence a VC's decision to interact and select for consideration but little impact on the investment decision.

5. ESV social network functions

Contents

5.1 Chapter introduction

This chapter presents a study which takes results from the previous stakeholder study in Section 4.2.2 as a starting point. The stakeholder study analysed ESVs' approaches to leverage affiliations to certain stakeholders in their social networks. Figure 5.1 illustrates the study's position in the context of the thesis.

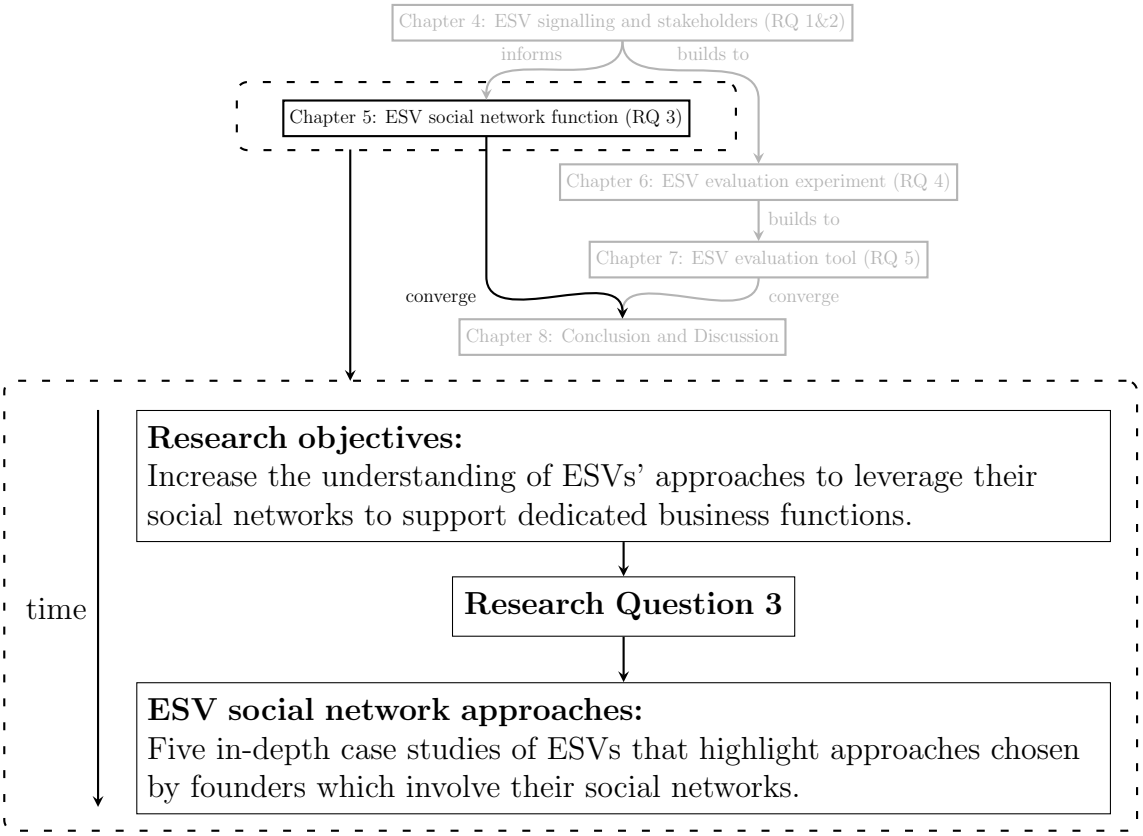


Figure 5.1: Data, research questions, and research objectives of Chapter 5, own illustration.

This study puts the spotlight on the ESVs' business functions, such as the actions of ESVs in R&D, product development, establishing access to corporate decision-makers, sales channels and market entry, or data gathering, overcoming regulatory hurdles, building a brand, and crowdsourcing tasks, or financing. Particular focus will be on social network approaches of ESVs to use stakeholders to fulfil these business functions rather than relying purely on firm internal approaches. Longitudinal qualitative data was gathered in a real-life, pre-investment setting result to answer Research Question 3.

Research Question 3: How and in support of which business functions can ESVs leverage their social networks?

The following section reviews the specific literature to understand the context of existing works which enables to build the conceptual framework for this study.

5.2 Conceptual development and literature review

Recent studies of ESVs' strategic rethinking of core business functions have been motivated by a paradigm shift called "lean startups" (Ries, 2011; Guillebau, 2012; Still, 2017; Conway and Hemphill, 2019). The paradigm's central element is a perception shift, away from understanding resource scarcity, newness, and smallness of ESVs as a stifling factor. Instead, ESVs are empowered by a leaner setup, enabling quick adaptation and iteration while using few resources and turning the resulting nimbleness into their advantage. Thus, ESVs can be more successful in developing and introducing a product than their incumbent counterparts, despite having comparatively scarce resources and sometimes relying on non-conventional means (Baker and Nelson, 2005; Huizingh, 2011; Weiblen and Chesbrough, 2015; Frederiksen and Brem, 2017). One way for ESVs to operate both dynamically and resource-efficiently is through leveraging their social network.

Extant studies discern "market" resources, such as hiring to permanently perform tasks in-house, or outsourcing, from "non-market" social network resources (Schutjens and Stam, 2003; Zhang et al., 2008; Bhalla and Terjesen, 2013; Özman, 2017; Bustamante, 2019). Researchers emphasise the importance of strategic decisions by ESVs to outsource activities that are critical to their business (Cooper, 2006; Ferrary, 2011). The frequently mentioned practices of outsourcing for the lean fulfilment of tasks can be considered as a market based approach (Bhalla and Terjesen, 2013). However, most studies researching ESV outsourcing, paint a black and white image of either complete or no outsourcing (Bustamante, 2019). This could be considered a gap in the literature as hiring talent and building capabilities in house, or paying a third party to solve a problem externally can exist in parallel and dynamically change over time (Bhalla and Terjesen, 2013; Bustamante, 2019). By contrast, this research investigates an opposite strategic approach in which ESVs build capabilities in-house to explicitly leverage third parties. A challenge is to motivate these third parties to collaborate by predominantly non-monetary incentives, as a consequence of the resource-constrained nature of ESVs. The ESV approach researched in this study will be termed the "social network approach". In her influential work, that supports the notion of entrepreneurial networkedness, Sarasvathy (2008) mentions the "crazy-quilt" factor as one of five traits that make out exceptional entrepreneurs and explains that

> *"effectuation emphasises alliances and pre-commitments from stakeholders as a way to reduce and/or eliminate uncertainty and erect entry barriers. In fact effectuators do not choose stakeholders on the basis of pre-selected ventures or venture goals; instead, they allow stakeholders who make actual commitments to participate actively in shaping the*

> *enterprise. The crazy-quilt principle emphasises that inputs from stakeholders who actually make commitments to the venture should be taken into account without regard to opportunity costs as to possible stakeholders who may or may not come on board later." (Sarasvathy, 2008, p. 88)*

Previous studies emphasised the idea of relying on social network partners during all stages of ESV maturity, from incorporation to IPO (Blank, 2013). Positive impacts resulting from stakeholders' support stem from elevated levels of creativity and idea generation (Ohly et al., 2010), prototype and product testing with (lead) users (Coviello and Joseph, 2012), iterating and innovating (Cheng and Huizingh, 2014), financing (Zhang et al., 2008), hiring (Wassermann, 2017), suppliers (La Rocca et al., 2019), marketing through social media (Ghezzi et al., 2016).

As the literature review in Chapter 2 has shown, the majority of empirical research in the overlapping areas of social networks and entrepreneurship focuses on social network resources. Besides garnering resources, other ways to leverage resources, such as those mentioned above have been studied. However, the majority of studies focus on the stakeholders and place little emphasis on the actual implementation of the engagement practice from an entrepreneurial perspective.

Table 5.1 shows an overview of previous studies which provide meta-level overviews of ESVs using the social network instead of market approaches.

Table 5.1: Meta-level studies researching ESV stakeholders

Business function as unit of analysis	**Study**
R&D partnerships impacting number of new product introductions	Rothaermel and Deeds (2006)
Investor network and fundraising success	Zhang et al. (2008)
R&D partnership impacting ESV valuation	Aggarwal and Hsu (2009)
Innovation partnerships with suppliers, customers, competitors, universities, research institutes	Neyens et al. (2010)
Interaction and collaboration with suppliers, customers, and competitors ESV success	Huang et al. (2012)
Friends, colleagues, advisers, supervisors and ESV success	Gloor et al. (2013)
Customers interaction and retention	Meiseberg (2015)
Number of stakeholders influence on on fundraising success and innovativeness	Semrau and Hopp (2016)
Entrepreneurial collaboration in hiring talent	Chatterji et al. (2019)

By nature, these meta-level overviews are either theoretical or aim to generalise the higher-level social network approach success factors. Moreover, these studies were

mostly to provide results optimising for breadth by capturing stakeholders and social network approaches which impact several of an ESV's business units or involve different stakeholder types. This trade-off of breadth over depth is a shortcoming of previous studies and they scratch the surface when analysing ESVs' social network approach strategies.

By contrast, this research addresses the gap by studying in-depth ESVs interacting with social network stakeholders to fulfilling business functions through social network instead of market based approaches. The analysis includes the "who?", "how?", and "why?" of leveraging stakeholders with strong emphasis on the latter two aspects. Taking a depth over breadth approach, this study responds to recent empirical research and reviews that have suggested researchers should "focus away from whom entrepreneurs know toward how they engage with their venture's social contexts" (Keating et al., 2014, p. 1027). Likewise, Usman and Vanhaverbeke (2017, p. 173) fault that although it has been extensively demonstrated that "start-ups rely more on external partners [...], there is still no explanation on which mechanisms start-ups are using to organise and manage collaborations successfully with external partners". Despite a deep focus, the study nonetheless finds patterns through a cross-case analysis which categorises the ESVs' social network approaches using a business model innovation (BMI) framework.

The next section outlines the study's enquiry method and research design, including the sampling strategy, and resulting samples.

5.3 Method and research design

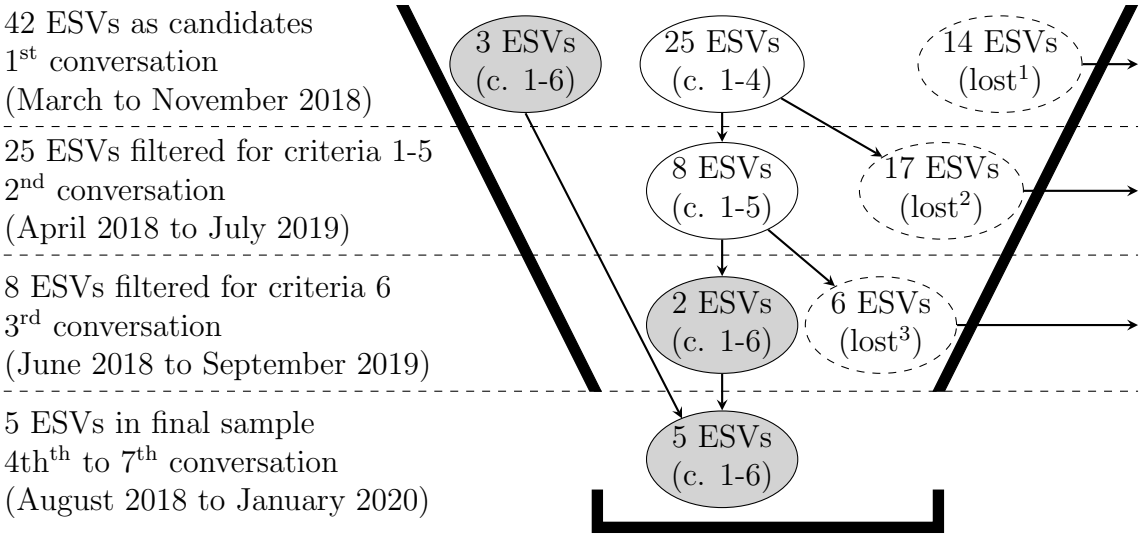
The research method chosen for this study follows the case study method outlined in Section 3.2.3. The case study firms were identified and studied in a capacity as a researcher for a VC fund which invests in Seed to Series A funding-rounds in ESVs with a focus on B2B and commercialisation of science. The dual role of the researcher as part of the VC fund allowed real-life, pre-investment conversations to be studied. Holding these conversations gave the researcher the opportunity to observe whether the ESVs ideated and implemented strategic decisions to leverage their social networks. The ESVs considered for the study matched the VC fund's investment criteria. Apart from the inclusion in these criteria, conversations with case study firms occurred independently of the investment decision of the VC fund. In full disclosure, none of the mentioned ESVs have been, are, or will be portfolio companies of the VC fund.

5.3.1 Sampling strategy

To be considered as an ESV case study it had to met the following inclusion criteria:

1. The ESV matches Definition 2 as shown on page 24
2. A current C-suite level co-founder is available to interview
3. The interviewee has more than one year experience in his/her current position, which entails that the ESV has been incorporated for at least one year
4. The interviewee or a co-founder is available for at least three separate conversations over at least six months
5. The ESV leveraged its social network for at least one critical function of its business
6. Leveraging their social network has to lead to a governance change decision by the ESV[1]

Figure 5.2 illustrates the sampling process.



[1] 14 ESVs filtered out for failing to meet criterion 4
[2] 15 ESVs filtered out for not meeting criteria 1-5, 2 for failing to meet criterion 4
[3] 6 ESVs filtered out for not meeting criterion 6

Figure 5.2: Sampling procedure, own illustration.

Sampling started with 42 ESVs which were identified as investment candidates and met the investment criteria of the VC fund. The researcher conducted an in-depth

[1] Corporate governance can be defined as "the procedures and processes according to which an organisation is directed, and controlled. [...] [This includes] the distribution of rights and responsibilities among the different participants in the organisation – such as the board, managers, shareholders and other stakeholders." (European Central Bank, 2004). While it could be argued that formal corporate governance structures are unlikely to be found in ESVs, for the purpose of this thesis it is understood as the firm-internally communicated and permanently implemented strategic decisions which involve handling of relationships and involvement of external stakeholders.

analysis of 42 ESVs from March 2018 until November 2018. During this time, a first conversation took place, which confirmed whether ESVs matched the sampling criteria.

Of the 42 ESVs, three were included in the sample as they met all inclusion criteria. These three firms were available for at least two more follow-up conversations and remained part of the sample. Of the remaining 39 firms, 14 were not available for a follow-up conversation. The second meetings took place with the remaining 25 ESVs, ten of which were subsequently identified as having met criteria 1 to 5. Two of those ESVs left the sample because a further third meeting was not possible. Of the eight ESVs that initially met criteria 1 to 5, five never met criterion 6. The final resulting study sample comprises of five ESVs that met all criteria at some point during the study.

Table 5.2 describes the resulting sample, to ensure anonymity of the founders, geographies and industry descriptions are kept deliberately high-level.

Table 5.2: Case studies ESVs in social network approach study

Case studies ESV characteristics		
Sample size		5
Case study interviews[1]		**Count**
ESV A		6
	CEO	4
	CTO	4
ESV B		7
	CEO	7
	CTO	1
ESV C		6
	CEO	6
ESV D		4
	CEO	4
ESV E		4
	CEO	4
Headquarter geography		
	Europe	5
Investment stages		
	Unfunded	3
	Seed	1
	Grant	1
ESV info		
	B2B	4
	B2B & B2C	1

[1]Some case study interviews were conducted with multiple members of the ESV 's team.

5.3.2 Data gathering and analysis

The data was gathered during face-to-face discussions with ESV founders. Leading into every conversation, the researcher emphasised his dual role as an academic researcher and representative of the VC fund. Furthermore, all ESV founders were guaranteed anonymity including names they would mention during the interaction. During the discussions the researcher took notes both in the capacity as a fund representative and a researcher. Conversations with the founders followed the structure of a real-life pre-investment discussion, which can be considered an unstructured interview procedure. During the conversations, the interviewer refrained from steering the founders towards the topic of social networks or the ESV's stakeholders. Only in those cases, where founders mentioned a social network related topic, the interviewer asked further probing questions to extract more detailed accounts. As it is challenging to lead the conversation while figuratively "wearing two hats" and taking notes, the conversation notes were promptly fully completed after the discussions. Retrospective edits to the notes included anonymisation of names and additions based on recollections. All the information mentioned in case study descriptions comprises of verbal accounts, supplementary documents provided by founders not marked as confidential, and publicly available sources such as the ESV's website or news articles. Sensitive information from ESVs' confidential documents is not included.
As the ESVs are fast-paced, following their development and activities over an extended period becomes necessary (Schutjens and Stam, 2003; Hartmann et al., 2016). Thus at least three, and in one case seven, conversations were held in total. This approach provides multiple snap-shot views and documents changes as well as their persistence. It should be noted that as a consequence of criterion 6, which requires ESVs to having made permanent governance changes, the study could not identify negative experiences from using social networks. Although no interviewee mentioned negative examples during the sample filtering conversations, bias could have been introduced by criterion 6 which will be discussed as a limitation of the study in Section 5.7.
The data analysis was performed after all case study interviews were completed. Following the case study descriptions, the social network approaches were summarised and compiled with previous interview data. The summarised quotes were then categorised into three dedicated business model (BM) elements and analysed from a BMI perspective as later explained in detail in Section 5.5.

5.4 Case study descriptions

The following sections subsequently describe all case study ESVs, beginning with a brief overview of the ESV, a problem description, the entrepreneurs' identified

solutions, and how solutions were translated into permanent governance changes.

5.4.1 Case study ESV A

ESV A was co-founded by a team who had previous work experience in logistics, management consulting, and in full-stack developing, both in larger organisations and ESVs. At the time of the first discussion, the ESV A had two employees. The founders decided to start ESV A after noticing first-hand how inefficiently firms across industries tracked their assets. The state-of-the-art solution was to either use a pen and paper-based system, or rely on near field communication or bar-code scanners from third parties which are highly specialised, expensive, and inflexible. Using mobile devices, ESV A developed an operating system agnostic software application which uses mobile devices' cameras to detect objects that serve as unique identifiers. The cloud-based platform would then allow users to create a template, comparable to a paper-based form which specifies additional information required to describe an asset. From that point on, the software would be able to show the user the template if it recognises the same or a similar asset again. Clients could use the product independently, regardless of the use-case or industry, as users could specify unique identifiers, build customised user interfaces, and fill legacy system databases.

(a) Problem faced by ESV A

ESV A's product entered the market as a freemium model[2]. After launching the product, user numbers climbed quickly, however, the majority of clients were using the free functionalities of the product. After a few months the revenue growth stagnated.

To expand their user base, the founders evaluated whether to raise venture funding from a VC, or attempt to keep growing the business organically. The founders were in two minds. If ESV A raised VC funding, they could take their product to trade shows, launch a marketing campaign, and hire a sales team. However, the founders were concerned that accepting venture funding before reaching significant commercial traction would force them to give up a large ownership stake of the company. By contrast, if ESV A first de-risked the investment opportunity for VC investors, they could later fundraise a larger amount while suffering from less dilution.

Another challenge ESV A faced was to manage the engaged user base which gave constructive feedback and suggested features, but the developer team struggled to keep up with the demand. Consequently, ESV A devised the plan to achieve a paid, large-scale contract with an enterprise customer. Achieving this would solve

[2] A freemium model allows the use of a software product's core functionality free of charge, however, additional premium features require a subscribe in exchange for a regular payment.

both problems, as software optimisation could focus on the demands of one paying customer, and the increased revenue stream would allow the founders to retain ownership.

(b) Solution identified by ESV A

The review of customer feedback and usage patterns revealed that small teams within the same firm began using the product. The founders also noticed that a user, who worked for a global car-rental firm, processed rental-car returns with the software. License number plates served as unique identifiers and information about the rental-car's condition and mileage were logged. Equipped with an improved version of the customer's template, the team visited a local car-rental branch. In a conversation with a representative, they discussed the paper-based incumbent solution and noticed the employee's frustration. Afterwards, the founders demonstrated their product, which the representative began using the following day. The representative became a daily user, converted one of his/her colleagues, and made frequent requests such as a feature allowing for automatic daily reporting and forwarding to supervisors. The two employees became ESV A's internal champions at the rental-car company, and not long after, the supervisor was in touch to negotiate a paid pilot. The pilot proved successful and the founders, equipped with a detailed report about usage statistics that stated over an hour of time saved per day, agreed with the supervisor to advised the rental-car company's senior management to roll out the product gradually to other branches. At the time of writing, the product is implemented across three countries.

(c) Governance changes by ESV A

Through their experience with one rental-car firm, ESV A approached other rental-car firms with the same strategy while gaining customers in separate industries such as retail, automotive, and logistics. Contrary to its direct asset tracking competitors, ESV A starts engagements with potential clients through employees who would use the tool and aims to turn these employees into corporate champions. By analysing the self-created templates of users who already joined the platform, the founders have an understanding of individual use-cases, which allows the developer team to tailor the tool accordingly.

The founders still pride themselves in their active users, who generously provide feedback and suggest continuous product improvements. A temporary decline in feature requests by users was mitigated through the introduction of a gamified customer feedback procedure. As ESV A's freemium users had been the most active contributors, ESV A started to offer tokens to unlock premium features in exchange for submitting feature requests. This measure increased requests per user by 20% without substantially increasing customer acquisition costs. ESV A broke even and

increased its revenues steadily allowing the founders to hire an on-the-ground team of "customer success managers" and expand their developer team.

5.4.2 Case study ESV B

ESV B was founded by five co-founders, a computer vision expert, a medical doctor, and three full-time senior management employees in the country's public healthcare provider in which ESV B is based. The medical doctor has previously sold a medical device company and is a strong advocate for reaching medical approval as a sustained competitive advantage. ESV B's product allows users to mark instances in an image, and a machine learning (ML) algorithm finds similar instances. According to the founders, almost every vision-based medical analytics tool relies on accurate quantification of instances, volumes, distributions, etc. Therefore, the product could reach wide adoption among hospitals and microscope or radiology equipment manufacturers. The main differentiation of ESV B's product to its competitors is that the users can specify a few instances which are to be recognised instead of matching and labelling thousands of images stored in crowd-shared or proprietary databases.

(a) Problem faced by ESV B

ESV B faced multiple issues at the time of first introduction. Coinciding with ESV B's formal incorporation, the regulatory body in their home market passed new legislation which made it significantly more difficult to receive approval for medical software. Furthermore, their competitors, in the meantime received approval for clinical use in a dedicated treatment category. As a treatment separated from the radiology assessment, hospitals could bill patients or insurers a premium. The re-categorisation as certified providers improved the improved hospitals return on investment (ROI) when using ESV B competitors' software. ESV B's founders knew they would need to have to find several short-cuts in their development road-map and nonetheless face strong competition. Even if ESV B received approval, they feared incumbents could build a long-term competitive advantage in the meantime. As a consequence, ESV B considered pivoting and changing their target market.

(b) Solution identified by ESV B

A member of the founding team who worked for the public healthcare provider, frequently interacted with CROs as part of his/her role. This contract research customer segment already purchases from established software providers, however, their technology is inferior and outdated compared to that of ESV B. An introduction of ESV B to a CRO was facilitated by the already affiliated member of the team. During a lab visit and interaction with technicians and researchers at the CRO, the founders noticed that only a few tasks were supported by analytics software. Instead, most research activities involved mundane tasks and significant

human labour. Furthermore, the mostly non-computer specialists employees at the CRO mentioned the inflexibility of the solution especially considering the breadth of research they conduct. Market research conducted by ESV B showed that only medium to large-scale CROs use high-priced, licensed software.
The newly identified use-case had the benefit that regulatory hurdles were less problematic. CROs predominantly sell services which are either unrelated to ongoing patient treatments and purely for research purpose or in few instances used to support decisions overseen by clinicians. However, the barrier to entry of selling to large CROs was that software solution providers required the reputation as an established firm or that a software product must first demonstrate its successful application in a number of peer-reviewed academic studies. This presented an issue since the ESV was far away from being established and a successful publication of studies in renowned academic publications takes a long time. Having observed how infrequently contract research uses advanced analytical tools, the founders began offering their software for symbolic contributions to top global university institutions. Universities who had no comparable solution in place were eager to adopt the technology and agreed to acknowledge the use of ESV B's product in their publications.

(c) Governance changes by ESV B

ESV B recognised that their product is better suited for the less competitive CRO market segment. Consequently, the founding team began targeting university research departments which conduct research in Biology, Chemistry, and Material Science. Two of the early adopters finished their academic studies and joined a CRO to continue their research. ESV B continued to attract researchers with free licenses and was able to convert some to paid licenses. Collaborating with more than a dozen global research institutes, both in universities and CROs, elevated the credibility of ESV B. Publishing research with results generated on ESV B's software platform remains an elementary line of business, as several universities have been turned into paid customers. These universities also provided customer testimonials and several public reviews on ESV B's website while praising the continued improvements and excellent customer support. Shifting their focus away from becoming a medical software device has led to internal tensions at ESV B, as the three co-founders who worked part-time for the public health organisation, made invaluable contributions at first, however, after the pivot towards serving CROs the roles and future involvement became unclear. The three co-founders working for public healthcare provider parted ways with ESV B.

5.4.3 Case study ESV C

ESV C was founded by two co-founders with an education in engineering. The founders have been working in the aerospace and environmental services industry.

The two founders saw advancements in drone and image processing technology as a business opportunity for aerial imaging in agriculture. The founders' initial research with a small scale farm demonstrated that productivity is lost as a cause of inefficient irrigation and use of fertilisers or pesticides, leading to sub-optimal yields for farmers. The entrepreneurs explained that farmers had to estimate their end of season yield and commit to delivering the amount to down-stream buyers and processors. This created an opportunity for ESV C as overestimation could mean the farmer fails to reach the quota, underestimation leaves the farmer with an oversupply of products which is hard to sell. An analytics solution based on aerial images could identify treatment mistakes and also help estimate the yield early during the growing season by counting blossoms and documenting the growth. With the aim of solving these two problems simultaneously and using their experience, ESV C was founded.

(a) Problem faced by ESV C

From the beginning ESV C encountered strong resistance and described their industry as highly conservative. Furthermore, while the founders understood their product and technology very well, their customer base was reportedly not technophilic and many resisted the use of technology on their farms. Facing pushback and losing much time in long and unsuccessful sales cycles, the founders concluded that they did not "speak the customers' language". To succeed, ESV C's founders would have to acquire a deeper understanding of their clients needs to suitably address farmers issues through a service product. Several interactions with farming organisations of varying scales also showed a higher propensity of large-scale operations to use advanced technology. However, these larger organisations were used to dealing with enterprise vendors and not pre-product ESVs. For over a year, the founders were not able to secure a pilot with a large-scale farm.

(b) Solution identified by ESV C

In search for ways to start a pilot with a large farm, ESV C found out about a local CRO who specialised in R&D as well as testing agricultural products. The CRO has a century-long history of fostering relationships with farmers, including the majority of target clients for ESV C. Farmers would regularly engage with representatives of the CRO which hosts events and has a quarterly circulation to its forum members. The founders were able to convince the head of the CRO to be invited for a demonstration of their aerial image analytics technology to representatives of the CRO. As part of the subsequent negotiation which would make the CRO and ESV C joint development partners, the CRO demanded one year exclusive access to the technology and licensing agreement for them to sell the solution to its clients as a service. ESV C had completed a successful pilot project in the research facilities of the CRO. Throughout, ESV C regularly flew their drones to take footage and monitor cer-

tain arable products. The CRO set aside a dedicated spokesperson who had weekly meetings with the founding team and, occasionally, the founders demonstrated their results to a wider community within the CRO. The technology is featured on the CROs website which has created a significant amount of inbound enquiries. During the pilot ESV C's technology and has been deployed at various farming sites as part of the service offering of the CRO. With the borrowed credibility of the CRO, an entity which was familiar to the agricultural businesses, ESV C could demonstrated their solution to several farmers. The founders hope to win these clients who used the service through the CRO after the exclusive licensing clause terminates.

(c) Governance changes by ESV C

Regular and close contact with industry veterans has helped ESV C to better understand the characteristics of farming organisations of depending on their scales, and peculiarities of farming of different arable products. Continued engagement with the CRO has helped fill the pipeline of clients who shows interest. By now, ESV C has signed commercial contracts with a group of large-scale farming operations will soon be deployed on their sites. Equipped with these contracts and several letters of intent[3], ESV C has begun their venture fundraising process.
Another CRO which would act predominantly as a channel partner similar to the first partner has seen a demonstration of the technology. To a minor extent, the second CRO could act as a further development partner who focuses on different crops. If ESV C can demonstrate the application successfully with other types of crops, they could broaden their proposition.

5.4.4 Case study ESV D

ESV D was founded by a single founder, based on doctoral research in Biology and Nanotechnology. During doctoral research, the founder tinkered with the early prototypes of a novel substrate. With the substrate, a surface can be modified to achieve unprecedented tactile sensitivity and for instance allow robots to gain dexterous skills exceeding human capabilities. According to the founder, the high value products in the robotics market have changed in the last decade. Most of the realised commercial value does not stem from the robot itself but instead the end-effectors, the part of the robot coming into contact with the handled goods. The founder explained that while handling robots in manufacturing, logistics, and retail can be considered a commodity, the end-of-arm robotic components to handle of fresh food, groceries, and unpacked goods are comparatively underdeveloped. A market survey conducted by the founder identified online grocery stores as a

[3] A letter of intent can be defined as "a letter that formally states what someone plans to do although this is not a legal promise or official contract" (Cambridge Dictionary, 2020).

beachhead market[4]. ESV D previously negotiated a paid pilot with a leading online grocery retailer.

(a) Problem faced by ESV D

To manage the pilot, the founder hired four employees. Not being able to fund a capital intensive, ground-up development, ESV D attempted to recombine using off-the-shelf components and adding their sensors. However, early during the pilot phase it became clear the results would not fulfil the customer's expectations. Nonetheless, the pilot partner was committed to the further development and offered to pause the pilot for ESV D to improve their product and continue the testing at a later stage. The founder traced the cause of the performance issues back to insufficiently developed algorithms which led to products being handled correctly. The robotic end-effector was supposed to closely mimic human interaction with sensitive products, for instance strawberries. The founder explained while human operators instinctively know how to grip and release different items, the robot had to be taught how to fulfil these tasks. ESV D's founder suggested to the pilot partner that employees could use a make shift glove equipped with the sensors for a limited period to gather data which would help ESV D improve their algorithms. Suggesting this move, however, created internal tensions at the online shop, as employees feared being part of a technology development which could ultimately make their jobs redundant. By making a select group of employees minority shareholders, the founder convinced both management and operators to begin using the sensor gloves.
At the same time, ESV D was at risk of liquidity issues which threatened the existence of the firm, and two employees chose to leave.

(b) Solution identified by ESV D

ESV D's founder won a best-of-show award, which included a small grant, at a prestigious conference. His/her previous PhD supervisor mentioned the achievement to the technology transfer officer (TTO) of the university. Consequently, the TTO asked for an introduction to the founder. The university, which is the founder's alma mater, was in a geographically disadvantaged location. It was the TTO's responsibility to raise the university's profile as an entrepreneurship hot-spot in the country. The TTO suggested a joint application for European grant which would allow the university to build and retrofit laboratory facilities. A successful application allowed ESV D to became the first research lab tenant, free of charge for five years, and office space which could accommodate a large team.
Piloting the improved end-effectors at the online shop's facilities had started again.

[4] A beachhead market is defined as one which is easily accessible, ready for adoption of a technology and customers buy similar products. Furthermore, sales cycles are similar across customers who are in turn tightly knit through strong word-of-mouth communication (Aulet, 2013).

Rewritten algorithms with fed with data the employees had gathered in the meantime, improved the handling performance and now exceeded the customer's benchmarks. The full roll-out in one logistics facility has been completed.

(c) Governance changes by ESV D

In agreement with the online shop, ESV D was allowed to publicly mention the online retailer as their customer. This external validation has helped to negotiate another contract with a retail firm.
Furthermore, the engagement with the universities' TTO continues, and the founder mentored another ESV towards a successful grant application. After several prestigious conference keynotes, the founder assumed a thought leader role in the field of robotics. Being considered a thought leader has allowed him/her to regularly speak in public, generating invaluable publicity. This publicity has helped to raise five additional non-dilutive grants. The founder admitted that during the course of the commercial trial, he/she learned to appreciate the value of a proprietary dataset to teach and improve algorithms. Only the failed trial made him/her recognise that besides the hardware the software component of the product might yield more long time value. Thus he/she used the strong position at the online retailer to renegotiate the full ownership of the data. By now, ESV D is likely to own the largest amount of data on gripping and releasing of delicate and complex to handle goods.

5.4.5 Case study ESV E

ESV E was co-founded by two graduate engineering students based on their Master's research. ESV E develops a wearable device to monitor body functions. The device can measure several biological features current devices cannot yet detect. The founders knew early on, that their product would only be able to reach adoption if it is marketed well. However, the wearable device market is saturated with dominant players with million-dollar marketing budgets and out-competing these would be impossible for an ESV. Furthermore, devices feature little differentiation, hence competing even if one has a superior product would be hard for new entrants.

(a) Problem faced by ESV E

ESV E assembled a team and launched a crowdfunding campaign. The campaign failed to achieve the fundraising target which left the founders without funding. Raising VC funding at favourable terms became impossible following the failed crowdfunding attempt. A direct route to becoming a B2C wearable device manufacturer seemed out of reach.
Through existing research-collaborations of their university department and one of the founders past career as a professional athlete, ESV E was introduced to Physiologists and Sporting Directors in world-renowned teams. The clubs were interested

in the wearable device as it allowed measuring an unprecedented number of biological features. As a consequence, the clubs offered a commercial partnership to ESV E which included financial support and an opportunity to test their prototypes with athletes. However, the funding offered by the two clubs was insufficient to finance the product development and neither Angel, nor VC investors were willing to participate in the unconventional partnership agreement. The founders suggested to expand the partnership agreement, but initially the two clubs were hesitant to include other clubs fearing to lose proprietary access and gaining an edge over their sporting competitors.

(b) Solution identified by ESV E

ESV E successfully convinced another sports team from a different discipline to join the partnership. As this third sports team was not a direct competitor, the two already partnering clubs agreed. The funds provided by the three sports clubs would suffice to develop the product. However, supplying only professional sports teams would limit serviceable market significantly, and the founders held on to their vision to ultimately sell their product to the public. Through their website, ESV E made their wearable device available for pre-order and could thereby track private customers continued interest. By claiming to deliberately limit access for private users and stating to only supply to professional athletes, ESV E believed that customers would get increasingly excited. As the device was developed in collaboration with professional athletes ESV E had turned a last resort effort into a competitive moat since none of their much larger and established competitors could make this claim. ESV E had negotiated with the three clubs permission to publicly disclose that their product was used by the professional athletes of the clubs, in hopes of bolstering marketing efforts.

One of the founders began dedicating one day per week to improve ESV E's social media presence. As part of this effort, he/she began contributing to HARO[5]. A befriended ESV founder had recommended using the platform after being publicly mentioned as a contributer multiple times, thereby getting free, high-quality coverage.

(c) Governance changes by ESV E

Over time, the founders added five professional sports clubs to pilot their product. These paid pilots have allowed the founders to bootstrap their venture and not take on any equity funding. The athletes are dispersed across geographies and disciplines which helps ESV E to make bold marketing claims. A commercial director of one of the clubs suggested that once the second device generation, which will be sold to

[5] HARO the acronym for Help A Reporter Out and is an online network which connects around 50,000 journalists over 800,000 with industrial expert sources.

end-customers, reaches the market, it could be sold as a branded version through the clubs merchandise shop. Being able to publicly mention their affiliation with world-class sports teams has helped ESV E to strengthen their brand perception. The founders hired a part-time employee to take over the role as ESV E's Chief Marketing Officer (CMO). The website pre-sales conversion rates indicated that the increased social media efforts were the primary contributor to pre-orders that exceeded 10,000 units.
ESV E seeks demand from additional sports teams to test their products. As ESV E's product is the first to detect certain biological signals, the founders see increasing value in the data they can generate through their devices. As soon as ESV E would launch the second version of their product, their plan is to make it mandatory for professional teams to share the data that will be generated. The founders' vision is to expand their product line by adding analytics services and selling data access to researchers and other device manufacturers.

5.5 Cross-case analysis

The purpose of the cross-case analysis is to compare and contrast the social network approaches used by the case study ESVs. To provide a structure for the analysis, ESVs' social network approaches were categorised into elementary BMI changes. A working definition of a BM is adopted from Afuah and Tucci (2001, p. 3) who state that a BM is "the method by which a firm builds and uses its resources to offer its customer better value and to make money in doing so". A BMI occurs when firms alter the fundamental building blocks their BM, namely, the value creation, value capture, or value network (Teece, 2010).
The BMI categorisation was chosen as it allows to focus on the "how?" and "why?" rationale of ESVs' strategic decisions in contrast to the "who?" perspective a pure stakeholder analysis would give. Furthermore, previous studies have found the BM perspective particularly relevant for ESVs who are often operating in "uncertain, complex, and fast-moving environments [...] [Thus,] new firms increasingly benefit from a combination of novel insights, rapid experimentation, and evolutionary learning and need to be more adaptive and responsive to organisational and contextual changes [...] for gaining sustainable competitive advantages." (Al-Debei and Avison, 2010; Andries et al., 2013; Wrigley and Straker, 2016; Cosenz and Noto, 2018, p.129).

Varying definitions of the first element of a BM, "value creation", are abundant in literature[6]. Adapted for the context of this study, value creation is understood as

[6] Lepak et al. (2007, p. 182) defined that "value creation depends on the relative amount of value that is subjectively realised by a target user [...] and that this subjective value realisation must at least translate into the user's willingness to exchange a monetary amount for the value received.

the process of building a product or service which is of use to the ESVs' customers[7]. Customers, in turn, are willing to compensate the ESV[8].
The second element, "value capture" is linked to the value creation and can be understood as the mechanisms that enable firms, in the given context ESVs, to retain a proportion of the value that was created for the customer (Zott and Amit, 2010; Zott et al., 2011).
The third and last BM element, which will be used to categorise findings from the case studies is the "value network". Christensen and Rosenbloom (1995) and Chesbrough (2002) describe the value network as the structure which links a firm to its surrounding ecosystems.
The three mentioned BM elements have to be viewed in a systemic way, as such Zott et al. (2011, p.1029) who see them interconnected as follows: "value creation and value capture occur in a value network, which can include suppliers, partners, distribution channels, and coalitions that extend the company's resources." The value network element is especially relevant for new ventures and market entrants since successful businesses are not built in a vacuum, and therefore an effective and proprietary value network can present one of the strongest and enduring differentiators (Teece, 2010; Al-Debei and Avison, 2010; Zott et al., 2011; Fjeldstad and Snow, 2018).

It is important to note that this cross-case analysis does not look at the general value creation, proposition, capture, or strategies of the ESVs but specifically the changes that were introduced, which involved a social network approach. To recap, Table 5.3 shows a summary of the ESV case studies.

Table 5.3: Cross-case comparison ESV overview

Case study	Product
ESV A	Asset tracking
ESV B	Image analytics
ESV C	Aerial imaging
ESV D	End-effector for robots
ESV E	Wearable device

5.5.1 Value creation effect through social network approach

ESV A established connections to lead users and turned them into integral contributors to their product development processes. Close contact with its users compli-

The closely related BM element of "value proposition", which captures reasons why an offering is "compelling to customers, achiev[ing] advantageous cost and risk structures" (Teece, 2010, p. 174), is included in the analysis of the value creation as the "use value" (cf. Bowman and Ambrosini (2000)).

[7] Bowman and Ambrosini (2000) defined this value as the "use value".

[8] Bowman and Ambrosini (2000) defined this value as the "exchange value".

mented the founders' broad industry experience with industry-specific knowledge, feature demand, and state of the art use-cases. As a result, its users served as ESV A's use-case radar and helped identify potential enterprise customers. Seeing first-hand the use-cases of lead users allowed the development team to tailor products better to their clients' requirements than their direct competitors. Moreover, clients appreciated the bespoke feel of the solution. While direct competitors sold inflexible, expensive, off-the-shelf bundles of hard-and software ESV A found an inexpensive way to include clients in the role of product development and testing without hardware requirements. Alongside selling a tool-kit, founders began focusing their development efforts on individual use-cases, and ESV A sold an enterprise-grade, bespoke service.

While ESV B's product worked with small amounts of labelled data, the accuracy of their product increased when large data sets were used to train the algorithm. Thus, ESV B was incentivised to disseminate its product widely and gather training data. Collaboration with prestigious research institutions for product development purposes, gave ESV B a credibility-edge over new market entrants. External validation of the software directly improved the customer value proposition, as their target clients, the CROs, sell high-quality contract research. Being able to mention that the analytics software was in use at the best universities in the world enhanced the perception of trust in the CRO's work. By comparison, software products the CROs previously used were rarely found in academic research due to its high price. Besides offering an analytics solution, the founders expected that the wealth of data which clients share could become ESV B's biggest asset. The founders mentioned that it is common for their competitors to outsource data-labelling to low-income countries, whereas ESV B's clients essentially act as their proprietary army of well-trained researchers that ESV a did not directly compensate.

The founders of ESV C lacked industry expertise and were initially not able to launch their product in the traditionalist agricultural industry. In an attempt to establish indirect access, ESV C had to sell to research organisations instead of farmers. The customer value proposition shifted from covering large arable land-areas and a limited number of crop categories at a low cost, to delivering small-scale, crop-agnostic, precision measurements. Following the push by their pilot partner, ESV C successfully adapted their technology to also work in indoor settings. As a result of working with the CRO, ESV C significantly expanded its technology portfolio.

ESV D developed robotic components which, according to the founder, is usually a capital intensive undertaking. By using off-the-shelf components and fine-tuning

these with a pilot partner, ESV D ensured fast development while using inexpensive components. To gather data despite their end-effectors not being deployable yet, ESV D fitted their sensors to gloves in a makeshift manner. The team thereby noticed that they could not only build new end-effectors but also retrofit existing components, thus allowing customers to keep their existing equipment. The founder emphasised that cross-platform compatibility could become the "holy grail" of robotic workflow automation, and ESV D competitors capabilities to work across platforms are limited. Most of ESV D's competitors are international robot manufacturers who have the incentive to avoid compatibility and lock customers into one platform.
In their partnership with the online retailer, ESV D has assumed a role on equal footing. Before engaging with ESV D, the online retailer had contracted multiple incumbent robotics manufacturers to build suitable robotic-endeffectors who failed at achieving satisfactory results. ESV D's solution was the first to meet all standards and has since helped its client reduce the operating costs by a seven-figure amount per year in a single warehouse. Furthermore, as the online retailer's flagship example of its digitisation strategy, ESV D has become an invaluable strategic partner.

After the crowd-funding failed, ESV E switched from a pure B2C to a pure B2B device manufacturer. Before the shift, the focus was on three factors, design, user-friendliness, and low cost. To sustainably compete in a crowded wearable device market, ESV E would have had to focus on optimising these three factors and missing out on the opportunity to build a truly differentiated product. After the shift, they found white space in the competitive landscape. Serving the closely related B2B, professional equipment market allowed ESV E to gather valuable experience which might help future efforts out-compete other manufacturers. ESV E's customers were keen to start a development partnership as they hoped to use proprietary wearable technology and gain an advantage over sports rivals in their respective leagues. The sports teams used their bargaining power to preclude competing sports teams from getting access.
ESV E used an aggressive social media tactic to create hype and make the product artificially scarce, which increased excitement among future private customers. This cost-effective marketing, primarily enabled by tagging onto sport teams brands, has helped ESV E to be on par much larger organisations when comparing online social media followership and engagement metrics.

5.5.2 Value capture effect through social network approach

ESV A altered their product development strategy to be user-centric. This approach was successful and possible by retaining and motivating their most engaged users through rewards programs which translated into higher engagement and industry-

leading user-experience and satisfaction. According to the founders, while most contributors started as freemium users, an over-proportional amount of contributors were ultimately turned into paying customers. While the founders initially emphasised that their product could be of use to everyone, their new approach was to target client segments and serve them with a mass-customised applications capable of solving niche tasks. Because ESV A's product is versatile, the development team can create a minimum viable product within less than one day, making their offering testable. By contrast, competitors would require large upfront capital expenses before any testing or customisation could be offered. As users were involved in the product development, they were familiar with the application. ESV A has seen users make improvements to their templates which has helped reduce ESV A's customer-service expenditure.

ESV B was able to swiftly adapt its tool to an array of use-cases. Enabled by the inputs from users in university organisations, the shift away from the pure medical application was possible in a few months. A focus on one application would have also drawn all the team's attention to one problem. Instead, working closely with university researchers who tinkered with the analytics software in non-medical applications pointed the founding team towards other research areas to explore. Demonstrating applicability in fields such as Biology or Material Science, and publishing peer-reviewed articles, broadened the number of addressable customers as ESV B can serve a spectrum of CROs.
As opposed to their initial customer segment consisting of hospitals and incumbent device manufacturers who have significantly more bargaining power, selling to CROs was a more level playing field for ESV B. Not only did the CROs' management see value in ESV B's product and were willing to compensate the founders for the pilot, but the CROs also expedited purchasing decisions, accepted a shorter pilot phase, and thus allowed ESV B to turn pilots faster into paid contracts. Compared to the initial use-case tied to medical equipment, the CROs saw a clearer ROI, and ESV B was able to increase their margin.

Competitors of ESV C sell specialist solutions for a single and sometimes a few crop categories. The seasonality of crops planting and harvesting creates cycles of high demand and no demand across the year. While ESV C's competitors resorted to starting operations in the northern and southern hemisphere, ESV C could remain in one hemisphere. By being able to spread farmers' demand over three quarters of the year, providing analytics during seeding, growth, and harvesting for multiple crops, customer demand is relatively constant. Indoor operations capability allows the ESV to work with CROs over the winter period. Synergistic effects from building an analytics platform that creates value for CROs and farmers, ESV C was able to

translate learnings from farm operations into the high-margin CRO business.

ESV D's makeshift sensor-gloves inspired a new line of business which would allow retrofitting existing end-effectors with ESV D's technology. In a market where incumbents use the lack of standards to lock-in customers, ESV D almost by accident learned how to work platform agnostic. Competitors miss significant portions of the addressable market, by only focusing on new sales which are compatible with only a few robotics manufacturers. By contrast, ESV D capitalised on already installed robotic end-effectors through retrofittable solutions and being compatible with all established device manufacturers.
Most clients comparable to the online retailer would expect to purchase a plug-and-play solution. ESV D's development partner agreed to jointly develop an innovative, albeit not fully functioning solution. Securing a partnership with such a cooperative partner is a remarkable achievement and presents a significant market entry barrier for new entrants. As ESV D found a partner who is strategically involved, the ESV performed the usually capital intensive development cost effectively.

ESV E can offer insights to sports teams which span disciplines, creating network effects even as a small scale operation. Similar to ESV D's founders, the founders of ESV E increasingly saw data as a durable, competitive advantage, as it would allow the device manufacturer to capitalise not only on device sales but also on strategic data-sharing agreements. ESV E has a unique opportunity to become one of the first wearable manufacturers to be applied in professional environments, and has since expanded their areas of application to divers, fighter-plane pilots, and astronaut training. ESV E's approach enabled them to fund developments and establish a high-margin business with a wealth of differentiating product features which positions to also compete in a potentially loss-leading or lower-margin B2C business.

5.5.3 Value network effect through social network approach

To promote enterprise sales, ESV A incentivised lead users, and employees of target enterprise clients. By giving users a sense of ownership of the product implementation project, while solving their the user's self-identified pain points, successful user retention was achieved. Providing their corporate champions with supporting operational metrics and sales material, ESV A ensured internal success of their product. The quantification of benefits paired with the enthusiasm of the corporate champions has proven successful to convince higher management. As a consequence, minimal capital investments in hiring customer success managers were sufficient to engage with the entire pipeline of prospective enterprise clients.

ESV B created an unconventional partnership model which is rare in the software in-

dustry. By using academic researchers from prestigious universities as development contributors ESV B could develop and sell high-margin software to the CRO industry. Similar to the regulatory market entry barrier the founders initially sought, research publication thresholds have also proven to create a barrier. By crowdsourcing the paper-publication process, ESV B has created a strong moat. Furthermore, through relationships with non-computer scientists users who shared their user experience, ESV B was able to develop an easy to use solution without sacrificing advanced functionalities. The co-development with academic and industrial research partners, who are themselves in a dense network that grows by migration of skilled talent, helped ESV B scale their sales. Users who have been using ESV B's application are unlikely to revert to mundane manual calculations. As CROs frequently hire graduates from universities and ESV B has continued to equip graduates with their software, they established a corporate champion model similar to ESV A. When comparing the two, the main challenge ESV B faces is the smaller staff count of most locally operating CROs, compared to an enterprise-scale network of, for instance, rental-car branches.

ESV C identified CROs as a secondary target customer segment, which is, in turn tightly knit to their primary customer segment, the farming operations. Long-time relationships between individuals in their two customer segments have helped break up traditional, siloed operations and win customer trust. Several of ESV C's competitors failed because they could not establish access. In this particular industry example, products are "sticky" as customers are notoriously unwilling to change their vendors, which means that ESV C can reap the benefits of the customer lock-in and loyalty. This lock-in also applies to ESV C's clients as they have become indispensable partners without which the CRO would have to cut their service offerings. Being dependable on the ESV to upkeep their service portfolio and significantly reduce its ongoing operating costs, the CRO and ESV have an intertwined strategic relationship. Besides the technological differentiation ESV C was able to build through the partnership, the founders also learned to navigate the high-inertia traditional farming industry, which in itself could be a substantial moat.

ESV D has established a partnership with two main stakeholders, the online retailer and the TTO at the founder's alma mater. As mentioned before, the close R&D involvement of the retailer is invaluable. The founder mentioned that the strategic relationship with a retailer that was willing to sacrifice being able to pick a product from a brochure but instead help to develop an innovative product has saved the ESV from failing prematurely. The founder has leveraged his domain expertise to get involved in European initiatives who in turn funded the venture on founder-friendly terms. Furthermore, several of the grant-givers are strategically valuable

partners and supply invaluable advice and ties to industry. Some of ESV D's pipeline clients are large-scale buyers of robotics technology. The robotics manufacturers have noticed the new market entrant and have been approached as a potential acquisition target and to use their commercial traction to engage partnerships with manufacturers. ESV D managed a critical moment of the pilot, winning over a highly sceptical group of employees who would be essential to the development of ESV D's algorithms. The founder's thought leadership role at conferences inspired him/her to start an initiative which investigates the trickle-down effects of installing robotics on working-class talent. This new ethics platform could help ESV D to overcome a barrier towards increased adoption of their technology as they learn to navigate sensitive workplace situations.

ESV E established a strong brand through their affiliation with prestigious sports teams. Compared to the professional athletes accompanied by a support staff of trainers, physiologists, and nutritionists, engaging with private customers would have unlikely been as involved and helpful for the wearable device development. The founders hope to continue as a strong contender in the B2B market. The high fluctuation of sports directors and trainers, leaving one team to join another one, could help ESV E to scale as coaches move on to their successor clubs. ESV E has not yet started to leverage individual athletes but sees this, as well as selling as merchandise, as a future opportunity to increase brand awareness.

5.6 Discussion

Summary. This chapter presented five case studies conducted to answer Research Question 3: "how and in support of which business functions can ESVs leverage their social networks?" The case study descriptions and cross-case analysis, which followed a categorisation into critical elements of BMIs illustrate nuanced exposées of ESVs' strategies to leverage social network stakeholders. A common theme found across the case studies was that ESVs found pilot partners who either directly contributed to the product development or indirectly through product testing. Furthermore, stakeholder involvement also traverses topics such as crowdsourced tasks, gathering of data sets, and establishing sales channel access. While stakeholders infrequently supported financing activities directly, it still shows that no business component in ESVs is immune to scrutiny to potential improvements through stakeholder involvement. The empirical study described in this chapter is among the first to analyse ESVs longitudinally while explicitly investigating strategic approaches that involve social network stakeholders.

Theoretical contribution. First and foremost, the study responds to criticism that the majority of research conducted on stakeholder relationships with ESVs fo-

cuses on the stakeholder perspective, such as corporate entities or suppliers, instead of analysing the ESV perspective (Huang et al., 2012; Weiblen and Chesbrough, 2015).
Secondly, the research study responds to calls that stakeholder involvement in social network and entrepreneurship should aim to understand the motivations (why?) and execution (how?). It contributes to the knowledge of social network approaches to fulfil critical business functions.
Thirdly, the study adds to the nascent research on ESVs' outsourcing activities (Bhalla and Terjesen, 2013; Bustamante, 2019). Focused studies on outsourcing have highlighted that ESV adaptation to increasingly fast-paced environments can be fulfilled through partial outsourcing as opposed to building firm internal capabilities through hiring. Given the accounts shared by the ESV founders it becomes clear that there is a spectrum of outsourcing which addresses the research gap and previous findings can be supported. A point worth noting is that across all case studies, ESV founders retained significant control of the business function within the perimeter of the firm and used scaleable, often redundant partners to execute functions externally while avoiding over-dependence. Fourthly, changes incorporated by the founding teams demonstrated structured, replicable examples of entrepreneurial aptness. Studies in the BMI domain have found that such successful stakeholder relationship management can often help to cope with sudden disruptions to the business and prevent bankruptcy (Al-Debei and Avison, 2010; Andries et al., 2013). Therefore, the study's results add to previous research which suggested that founders should continuously ask: "Who should perform each of the activities that are part of the business model? Should it be the company? A partner? The customer? What novel governance arrangements could enable this structure?" and permanently binding their closest stakeholders by ensuring that "value [is] created through the novel business model for each of the participants" (Amit and Zott, 2012, p. 42).
Lastly, the case study examples showcased how ESVs can achieve a critical component of stakeholder relationships, namely reciprocity. Through the proposition of saving capital and time, the case study founders incentivised and retained core stakeholders. The consistency of mutually beneficial relationships has been identified as a significant determinant on the "return on investment" of social networking relationships (Pollack et al., 2016).

Implications for practice. The study has several implications for the main interest groups of this thesis, entrepreneurs and VCs.
Founders can study the outlined approaches which were successfully implemented by ESVs and see these blueprints as inspiration to leverage their social networks more

expediently. Both high-level findings and detail-level accounts could translate into founders specific problem-settings. The analysis drawn from the case studies allows entrepreneurs to position their approaches or plans in the competitive landscape. Founders for which this study raised awareness should feel encouraged to scrutinise their strategic choices and seek for optimisation by integrating stakeholders more closely, even into the vital business functions. As for the case studies, the founders demonstrated that building a social network was within their control and the result of calculated activities.

For VCs, the case studies demonstrate which seemingly unconventional approaches founders can take to build ESVs that could eventually create more and enduring differentiators. Compared to the traditional approaches of raising venture funding first, the majority of founders featured in this study elected to focus on stakeholder engagement to cost-effectively build and sell their products. As there was no control group, it is not possible to compare the results of the case study ventures with that of a "fundraise first" strategy. Consequently, this study does not claim to favour one approach over the other but highlight the existence of several potential pathways. Studying the ESVs' approaches, VCs could reduce investment uncertainty by understanding how founders build moats and market entry barriers different from typical examples such as military or government contracts, regulation, and patents (Delmar and Shane, 2004; Sherman, 2011). Furthermore, it can be stated with confidence that VCs should be attuned to consider the upside and downside presented by a ramified stakeholder network that could be responsible for critical business functions. Thus, besides scrutinising the focal ESV, VCs conducting due diligence should "zoom-out" to capture a complete unit of analysis, one that includes the ESVs' social networks.

5.7 Limitations and research opportunities

The research study has limitations which are common in interview-based case study research designs such as small sample size, reporting biases, and interviewer influence.

Firstly, both the initial sample size of 42 as well as the final sample size of five case studies does not allow any generalisations across the ESV population. It is likely that a larger sample size could have yielded other modes of stakeholder engagement which have not been uncovered by this study. Readers should view the cases as spotlight findings which span a small vector space of strategic alternatives. The sample size resulted partly from the research design, which only allowed ESVs that made governance changes into the sample and cut those that were merely using social network approaches occasionally. Another reason for the small sample size was that it proved challenging to motivate founders to contribute to the research

project. An inherent consequence of the longitudinal study design was that at least one, often two in-depth discussions had to take place before identifying ESVs as a potential candidate. In itself, the sampling process, of funnelling from 42 to five ESVs indicates how sparsely social network are articulated among ESVs[9].
Secondly, survivors-bias plays a significant role in studies of ESV, which have notoriously high failure rates (Hellmann et al., 2002; Shermer, 2014; Smith, 2015).
Thirdly, it is likely that a positive reporting bias is present, i.e. founders were inclined to report successful experimentation and implementations but not mention the negative examples. Previous research has identified such distorting behaviour Van Gelderen et al. (2000); Hyytinen et al. (2015).
The interviewer influence might have further contributed to a positive reporting bias. The last limitation originates from the dual role of the interviewer, as a researcher and representative of a VC fund, which could have caused founders to over-emphasise positive aspects of their ventures. However, the dual role also created a more realistic investment-seeking environment and interviewer-interviewee relationship. These inherent traits of the study design can be considered a unique feature and methodological contribution.

This study indicates several promising opportunities for future research. A dedicated case study series conducted with a VC sample could identify a more nuanced understanding of how VCs respond and evaluate social network approaches of founders. Another research opportunity could lie in observing how different founders implement solutions after receiving identical advice. A possible research setting would be an industry focused accelerator program. At the beginning of the program, founders start their venture journey at comparable stages. During their acceleration time, the ESVs' target industries can be controlled for. A comparison of the founders chosen social network approaches could be drawn after the acceleration period, during which founders receive identical instructions and mentoring. Such an approach would also be likely to have less attrition in case study candidates along the survey period.
Similar to the stakeholder study in Chapter 4, this study did not analyse the social networks from a structural perspective. Furthermore, the case study based approach has the inherent reporting biases as discussed above. More anonymous settings could entice participants to mention more critical points which might complement the results of this study. The subsequent Chapter 6 and 7 take these limitations into account during the research design and are based on substantially larger samples, and in one case, third party data.

[9] Depending on how filtered ESVs are counted, across all ESVs only one fifth to one-tenth of the sample exert social network approaches.

6. ESV evaluation experiment

Contents

6.1 Chapter introduction

The previous studies in Chapters 4 and 5 demonstrated the importance of social networks for venture investing and building and that both entrepreneurs and VCs face challenges when signalling investability and evaluating ESVs. Figure 6.1 illustrates how findings drawn from the stakeholder study in Chapter 4, which identified several preferential social network constellations, serve as inputs for this study. In particular, the study examines how network size, diversity, density, and the position of ESVs in their ego-network influence the perceived investability of the ESV.

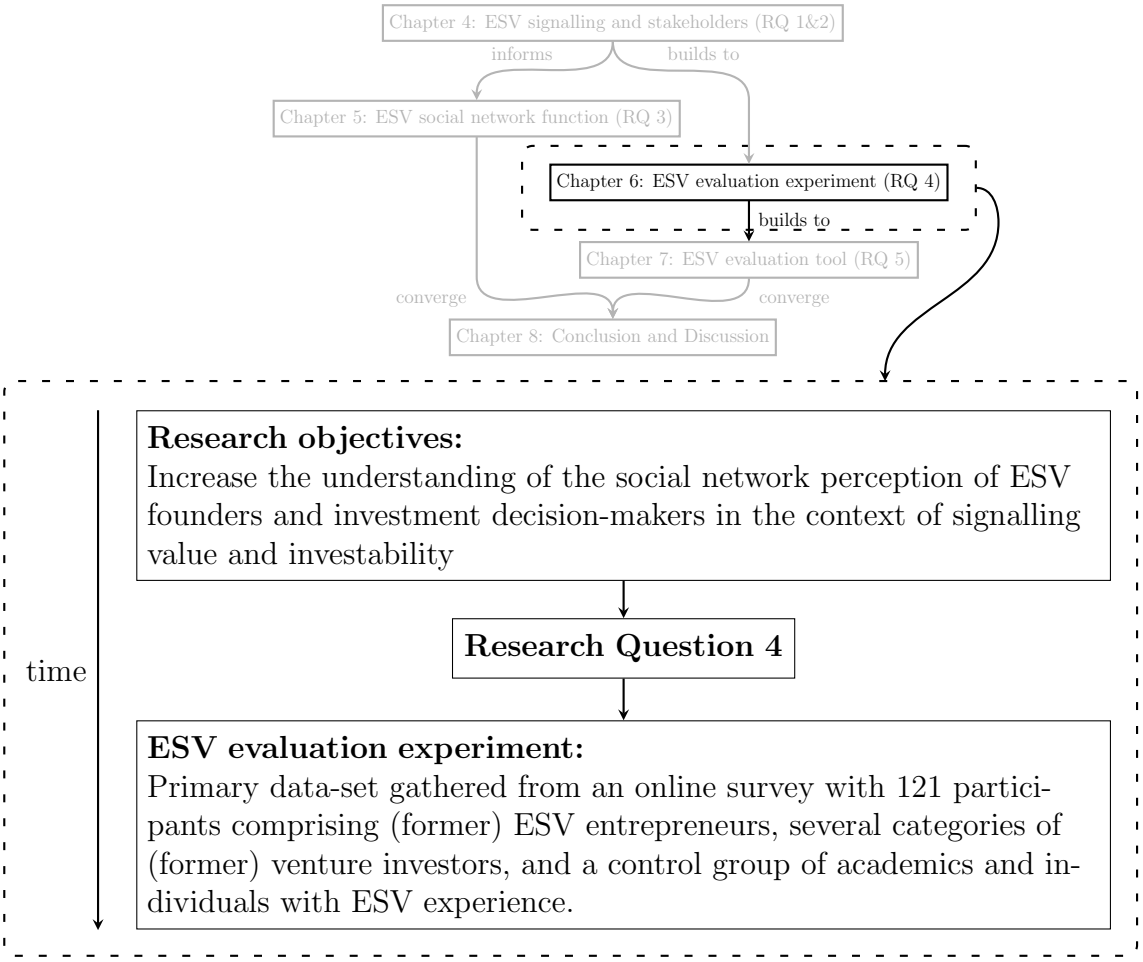


Figure 6.1: Data, research questions, and research objectives of Chapter 6, own illustration.

For this study, the specific literature on VC evaluation, business venturing, and social networks, was reviewed. The review refines the understanding of effects of ESVs' networking activities on financing and answers the following research question:

Research Question 4: Which social network constellations are perceived most favourably by VCs and entrepreneurs?

Calls to rethink evaluation techniques and advising entrepreneurs on enhancing their

chances of success are addressed through this research. A survey-based scenario experiment with experts from the entrepreneurship and venture investing domain is undertaken to examine the concept of a "social network-centric" ESV evaluation. The following sections introduce the specific literature reviewed for the study and generate the hypotheses to be tested (6.2). Furthermore, the rationale for using an online survey enquiry method (6.3), as well as its design, data gathering procedure (6.3), and results (6.4) are discussed.

6.2 Conceptual development and hypotheses

The literature review in Chapter 2 serves as a foundation for this chapter as it outlines the reasons for ESVs to form strategic partnerships and alliances with its stakeholders for resource, organisational learning and knowledge transfer, as well as signalling purposes. This section builds upon the previous reviews and focuses on characteristic determinants of ESVs' social networks. Established social network parameters are drawn from the literature and used for a quantification of critical social network characteristics. To clarify, this study also adopts Definition 4 for a social network[1].

The multifaceted and uncertain nature of the pre-investment signalling and investment decision processes, has led researchers and practitioners to call for an adaptation of evaluation approaches and development of more comprehensive models in ESV investing (Riding et al., 2007; Audretsch and Link, 2012; Sharma, 2015; Ko and McKelvie, 2018; Arroyo et al., 2019).

To date, entrepreneurial social networks, especially their structure and composition, have received little attention (Stuart and Sorenson, 2007; Lee et al., 2010; Heuven and Groen, 2012; Pangarkar and Wu, 2013; Miloud et al., 2012; Ko and McKelvie, 2018), apart from some notable exceptions (Zaheer and Bell, 2005; Zheng et al., 2010; Martinez and Aldrich, 2011; Pangarkar and Wu, 2013; Ter Wal et al., 2016). For entrepreneurs and investors, a lack of understanding about social network constellations that maximise positive signalling to investment decision-makers presents an issue. Consequently, improving the understanding of what constitutes quantifiable signals of investability, and a demonstration of a venture's value could help to bridge the financing gap for ESVs (Ko and McKelvie, 2018; Gompers et al., 2020). A review of focused literature has identified four characteristic properties of social networks which are tested in this study: network size (6.2.1), diversity (6.2.2), density (6.2.3), and position (6.2.4).

[1] Definition 4 can be revisited on page 36.

6.2.1 Network size hypothesis

Network size as defined in Chapter 2[2] is the total number of vertices in a network comprising of the stakeholders and the ESV itself. Spender et al. (2017) studied network effects on ESVs' innovation performance and found that the utility of network size follows an inverted U-shape. A benefit of larger networks is an increased chance of having many weak ties to loosely affiliated actors, allowing for the acquisition of non-redundant information (Xu, 2011). Increased network size is also a predictor of access to network resources and reaching milestones (Semrau and Werner, 2014; Semrau and Hopp, 2016). In a direct financial context, participation in more extensive social networks was found to positively impact revenue growth (Abou-Moghli and Al-kasasbeh, 2012) and the ability of ESVs to attract funding (Soetanto and Van Geenhuizen, 2015) while achieving higher valuations (Zheng et al., 2010). However, and this explains the inverted U-shape, ESVs could face difficulties in securing funding when their networks are small, as co-opting in only a few partnerships can result in an over-dependence (Hoang and Antoncic, 2003). Hoang and Antoncic (2003) also state that over-embeddedness can be a burden and thus limit firms' performance. Taking these aspects into consideration, the suggested hypothesis was:

Hypothesis 6.1: A large network comprising of many actors is perceived as more valuable than a small network with few actors.

6.2.2 Network diversity hypothesis

Several researchers who studied social network and social capital theory at the intersect with entrepreneurship argued that diverse networks allow the quickest resource location (Birley, 1985; Lin, 2001; Das and Teng, 2000). However, the benefits of similarity versus diversity in networks, in the literature also framed as redundancy and non-redundancy of stakeholders, has been the substance of academic discourse for years (Ahuja, 2000; Burt, 2004; Ter Wal et al., 2016). Baum et al. (2000) and Hoang and Antoncic (2003) stressed the importance of diversity of actors in ESVs' networks, an idea based on Granovetter's (1973) notion of weak ties. Actors outside the core group of regular interactions are especially valuable as they deliver less redundant information, a finding which is supported by empirical studies (Uzzi, 1996, 1997; Xu, 2011). From an ESV's perspective, this thought is essential because a diverse influx of ideas may help to de-risk, recombine successful ideas, and foster inter-organisational learning and knowledge transfer (Eisenhardt and Schoonhoven, 1996; Hayter, 2013; Özman, 2017). According to Nahapiet and Ghoshal (1998) and Elfring and Hulsink (2003), a decision on whether a homogeneous network of strong connections or a heterogeneous network is preferable depends on ESV characteris-

[2] The definition of network size can be revisited in Table 2.3 on page 38.

tics. They argue that in cases where the communication of complex ideas requires a deep understanding of a common language, similarity of actors is preferred, and vice versa. Lundberg (2013) found that broad networks are suited to procure resources, generate innovative ideas, and help with product introduction. Martinez and Aldrich (2011) found that cohesive, i.e. strong connections among members and diversity, as well as a spectrum of social characteristics among members positively influences ESV survival and success. Uzzi (1996) and Xu (2011) reconciled these different positions in favour of a balanced network consisting of a mix of weak and strong ties. Too much diversity may lead to an overwhelming amount of information, requiring entrepreneurs to decide which information from numerous stakeholders is essential; therefore, diluting the usefulness of multiple opinions (Ter Wal et al., 2016). Shane and Stuart (2002) demonstrated that heterogeneous connections to key individuals such as investors could further increase the likelihood to secure funding. Therefore, the hypothesis to be tested stands as:

Hypothesis 6.2: A heterogeneous network featuring multiple types of actors is perceived as more valuable than a homogeneous network.

6.2.3 Network density hypothesis

The density of a network measures the actual number of connections between actors compared to the theoretically possible number (Newman, 2014). Regarding the optimal density of networks, a long-standing discussion between influential researchers has taken place. Burt (1995), describes social capital as the lack of edges, so-called structural holes, as non-redundant ideas are more likely to occur. Instead, Coleman (1990) theorised that dense networks, which allow coordination amongst vertices in a network, yield the highest social capital. This leads to an interesting paradox for ESVs' social networks which could be an explanation why several parameters describing social networks have a U-shaped tendency, i.e. there can be too much or too little of one characteristic (Uzzi, 1997). As mentioned before, information asymmetry frequently occurs in an ESV context. The more knowledgeable party is tempted to behave opportunistically and deceive the less informed party (Williamson, 1975). Being an outsider faced with uncertainty makes it difficult for investors to acquire relevant and reliable information (Festel et al., 2013). In dense networks however, the incentive to act opportunistically is significantly reduced because misbehaviour is communicated quickly within the network and trust can be lost with multiple stakeholders at once (Coleman, 1988; Larson and Starr, 1993). As a consequence, Coleman (1988, 1990) finds that dense networks create the most value from a social capital perspective. Heuven and Groen (2012) explain that the individual performance in dense networks increases due to a higher commitment.

From an operational point of view, Soetanto and Van Geenhuizen (2015) find that an increased network density leads to a faster and more reliable exchange of information. Moreover, interconnected clusters of commonly shared partners tend to form stronger alliances (Walker et al., 1997). Reviewing the literature which discusses density of networks revealed that theories and supporting empirical evidence showed that densely populated networks are favourable. Thus, the hypothesis generation is as follows:

Hypothesis 6.3: An interconnected network of actors is is perceived as more valuable than a dispersed network.

6.2.4 Network position hypothesis

This study understands the network position as the location of a vertex within a network, in line with Burt (1976, p. 93; 2005) who states that "a position in a network [is] the specified set of relations to and from each actor in a system." As previously mentioned, in social network science, a central actor is often called "hub" and can act as a boundary spanning node in a network that benefits by taking control over information flow and direct access to a large proportion of the network (Zaheer and Bell, 2005; Barabási, 2016). Burt (1995) theorises that an optimal network requires structural holes and network actors who bridge these, control the flow and have access to non-redundant information. From a coordination cost perspective, a peripheral network position should be advantageous as the few closely connected partners handle the majority of the coordination efforts on behalf of the ESV (Rost, 2011). As a counterargument, Das and Teng (2001) and Knoben and Bakker (2019) discuss the dependence on too few partners which can present a threat for ESVs due to the comparatively low bargaining power, lack of legitimacy, and vulnerability towards misappropriation of resources. They add that the most effective mitigation is a plurality strategy to avoid overdependence at a time where the ESV is vulnerable to exploitation. Ahuja et al. (2009) mention a positive, self-reinforcing mechanism of being centrally positioned, as the ESV becomes a more attractive partner to others, enabling future relationships with a broader array of stakeholders. Moreover, they mention that ESVs in peripheral positions do not benefit from reputation gains in the same fashion as central ones. The majority of studies find evidence in favour of central positions for ESVs (Spender et al., 2017). Therefore, the hypothesis follows as:

Hypothesis 6.4: ESVs obtaining a central position are is perceived as more valuable than those in a peripheral position.

In summary, the hypotheses focus on characteristics defining social networks constel-

lations and were found to impact ESV evaluation. Thus, perceived ESV value and investability is expected to increase when size (Hypothesis 6.1), diversity (Hypothesis 6.2), and density increase (Hypothesis 6.3) or the ESV obtains a more central position (Hypothesis 6.4).

6.3 Method and research design

This study examines the investability of ESVs depending on their social network. To test the hypotheses, data was collected via an online survey. As mentioned in Chapter 2, the layered nature of ESV evaluation in practice includes many parameters, with varying degrees of importance and resulting weighting, depending on the individual venture. Thus, to allow an isolated study of the social network's influence, the parameters to be studied were limited to this single perspective. In an experimental setting, participants were asked to evaluate ESVs by assessing their visualised social network constellations. The study design incorporated the guidelines of Huber and Power (1985) and Sue and Ritter (2012). While preparing the survey pilots, 15 participants took place that allowed refinements of the survey design. During execution of the study, participants were informed about the approximate time until completion and given individual incentives to encourage participation. Furthermore, participants were reassured about confidentiality given the fact that their preferences are sensitive. The practical importance as well as the use of the data was elaborated for participants. To ensure adherence and interest of the participants in the study, the online survey was path dependent and posed specific questions depending on participants occupation, experience, and previous survey answers. Finally, participants were allowed to share the survey with suitable participants and loss of control about dissemination was managed by narrowly defining what constitutes relevant participants.
Participants of the study were provided with a detailed description and exemplary evaluation procedure as shown in detail in Appendix E[3].

6.3.1 Sample

The online survey description clearly specified the target participant groups of ESV entrepreneurs and VCs according to Definition 1 and 2, but allowed later-stage investors, academics, and other relevant practitioners to participate and serve as the control group[4]. Table 6.1 shows the online survey participants' distribution across professions and their secondary roles.

[3] The online survey description can be found in Appendix E on pages 262 to 266.
[4] Definition 1 and 2 can be revisited on pages 14 and 24.

Table 6.1: ESV evaluation experiment online survey sample

Age in years	**Responses**
< 21	2 (1.7%)
21-30	52 (43.0%)
31-40	28 (23.1%)
41-50	24 (19.8%)
51-60	14 (11.6%)
> 60	1 (0.8%)

Profession	**Responses**
Academic	10 (8.3%)
Entrepreneur	30 (24.8%)
Investor	70 (57.9%)
Other	11 (9.1%)

Investor type	**Responses**
Financial	68 (97.1%)
Strategic	20 (28.6%)

Tenure in years	**Responses**
< 1	1 (0.8%)
1	9 (7.4%)
2	15 (12.4%)
3	22 (18.2%)
4	13 (10.7%)
5	7 (5.8%)
6 to 10	8 (6.6%)
11 to 15	18 (14.9%)
> 15	28 (23.1%)

Investor role	**Responses**
Angel investor	16 (13.2%)
VC	52 (43.0%)
CVC	4 (3.3%)
Late-stage	3 (2.5%)
No investor	46 (38.0%)

Investors' stage focus	**Responses**
Pre-seed	27 (22.3%)
Seed	57 (47.1%)
Series A	50 (41.3%)
Series B	24 (19.8%)

Note: Column sums may not add up to 100% due to rounding effects or when participants were allowed to give multiple answers.

Within the group of entrepreneurs and investors, participants were sub-categorised into first-time entrepreneurs, serial entrepreneurs, former entrepreneurs, and ESV employees, while investors were categorised as angel investors, VCs, CVCs, and late-stage investors. Investors additionally specified their focus on strategic and financial returns. Participants stated their age and tenure in years, and the geographic location of respondents was identified via their IP address. The participants locations, which served as the indicator for the headquarter or residency location, were found to be in Europe (108), the US (8), and Asia (5).

6.3.2 Data gathering

Qualtrics was used to gather data through an online survey. From February to April 2018, 466 participants were invited via email, social media, and LinkedIn. The purposeful sampling strategy controls for the early-stage focus of VCs and ESVs while maximising the variety of participants regarding their experience, industries, and geographies (Shadish et al., 2002). A total of 142 participants responded (30.4%) who comprised of investors, entrepreneurs, and academics in the field of business

venturing as shown in Table 6.1. 21 answers were discarded due to missing data resulting in a final sample of 121 individuals. As the participants had to evaluate four different ESV networks per hypothesis, the four answers were treated as separate responses which explains the final sample size of $n = 484$ in the subsequent analyses and $n = 232$ when comparing two types of network constellations. Furthermore, participants were given the opportunity to justify answers in free text fields.

6.3.3 Measures

(a) Treatment (independent) variables

Table 6.2 summarises the four dichotomous, independent variables, which are hereafter called treatment variables.

Table 6.2: ESV evaluation experiment treatment variables

Network metric (*Treatment var.*)	**Treatment var. description**	**Example**
Network size *soc_net_size*	*small* or *large*, i.x. how many entities does an ESV know and engage with?	Does the ESV's social network compose of 5 or 50 entities?
Network diversity *soc_net_div*	*homogeneous* or *heterogeneous*, i.e. how diverse are the stakeholder groups in the ESV's social network?	5 VC investors or 1 VC, 1 mentor, 1 accelerator, 1 researcher, and 1 lawyer
Network density *soc_net_dens*	*interconnected* or *dispersed*, i.e. Do the entities in a ESV's network know each other?	Is it beneficial that your mentor knows the VC who is invested in the ESV?
Network position *soc_net_pos*	*central* or *peripheral*, i.e. is the ESV the most connected vertex in the network or connects primarily through intermediaries?	A VC that is invested directly versus an ESV that interacts with a lawyer via a mentor

The evaluation was presented to participants in randomised order during the experiment. Table 6.3 shows the three scenario experiment treatments.

Table 6.3: ESV evaluation experiment treatments

Treatment	**Resulting social network constellations**
A	*small/homogeneous* (A1), *large/homogeneous* (A2), *small/heterogeneous* (A3), *large/heterogeneous* (A4)
B	*small/interconnected* (B1), *large/interconnected* (B2), *small/dispersed* (B3), *large/dispersed* (B4)
C	*small/central* (C1), *large/central* (C2), *small/peripheral* (C3), *large/peripheral* (C4)

The treatments which contrasted two different treatment variables resulting in the three different treatments: *size* versus *diversity* (Treatment A), *size* versus *density* (Treatment B), and *size* versus *position* (Treatment C). Within each treatment, four social network constellations (A1-A4, B1-B4, and C1-C4) had to be evaluated which were explained to the participants as exemplary social network constellations of imaginary ESVs. Contrasting the treatment variables pair-wise against the treatment variable *soc_net_size* resulted in three treatments with four network constellations each. For instance, treatment A consists of a small homogeneous, large homogeneous, small heterogeneous, and large heterogeneous network constellation. Figures E.2, E.3, and E.4 illustrate the different visualisations of the treatments as they were presented to the participants[5].

(b) Effect (dependent) variables

The four dependent variables per treatment, hereafter called effect variables, capture the participants perceived investability and evaluation. The study description introduced the concept of network value as follows. A "high network value" has a positive influence on the ESV evaluation, while a "neutral value" means that the social network is decision-irrelevant and does not influence ESV evaluation, a "low value" represents a network which is a reason for concern and would, therefore, decrease investability. The respondents answered on a seven-point Likert-scale (1-disagree strongly, 4-neither agree nor disagree, 7-agree strongly) whereby "1" represented negative influence, "4" decision neutral, and "7" positive evaluation influence.

(c) Control variables

To control for confounding factors that affect the perceived evaluation, the study introduced several control variables that have been used in related studies (Brüderl and Preisendörfer, 1998; Witt, 2004; Zaheer and Bell, 2005; Zheng et al., 2010; Martinez and Aldrich, 2011; Pangarkar and Wu, 2013). Those control variables included the participants gender (1 = *male*), age as categorical variable (<21, 21-30, 31-40, 41-50, 51-60, <61), and tenure (<1, 1, 2, 3, 4, 5, 6-10, 11-15, >15). Furthermore, dummy variables were introduced for active investor (1-yes), multiple work experiences (MWE) (1-yes), the participants primary occupation as an investor (1-yes), entrepreneur (1-yes), or academic (1-yes). As the last control variable, investment categories of investors and stages of ESV's financing were categorised in (1-Pre-seed, 2-Seed, 3-Series A, 4-Series B, and 5-Series C).

6.3.4 Analysis

To analyse the data, an OLS regression was applied first, as the dependent variables were approximately linear. Subsequent tests with an ordered Probit and Tobit

[5] Figures E.2, E.3, and E.4 can be viewed on pages 264 to 266.

model yielded similar results. Consequently, the final analysis settled on OLS due to easier interpretation and being the best linear unbiased estimator (Kutner et al., 1996; Wooldridge, 2002). To compare the difference between each of the treatment variables, network constellations were contrasted against each other as described in 6.3.3 (a).

6.4 Results

The following section presents the descriptive results and the OLS regression results of the study, which were generated using the STATA statistics software package[6].

6.4.1 Descriptive results

Table 6.4 presents the descriptive statistics in the form of a pair-wise correlation matrix of the main effect variable *ESV_eval* and control variables (2-9) as well as their means and standard deviations.

Table 6.4: Descriptive statistics of ESV evaluation experiment

Variable	$\overline{var}$	σ	**min**	**max**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1 *ESV_eval*	4.74	1.32	1	7	1								
2 *age*	2.99	1.11	1	6	0.08	1							
3 *gender*	1.19	0.39	1	2	-0.01	-0.11	1						
4 *tenure*	4.99	2.63	0	9	-0.05	0.72*	-0.08	1					
5 *active_inv*	0.62	0.49	0	1	0.00	0.30*	0.16*	0.34*	1				
6 *MWE*[1]	0.18	0.39	0	1	0.02	0.14*	-0.12*	0.15*	0.15*	1			
7 *investor*	0.65	0.48	0	1	-0.02	0.35*	0.13*	0.33*	0.93*	0.21*	1		
8 *founder*	0.29	0.45	0	1	0.02	-0.04	-0.08	-0.10	-0.25*	0.55*	-0.26*	1	
9 *academic*	0.15	0.36	0	1	0.02	-0.1	-0.20*	0.04	-0.30*	0.29*	-0.28*	-0.01	1

Note: n=484, $^*p < 0.1$, [1] MWE = multiple work experiences

6.4.2 Regression results

(a) Network size Hypothesis (6.1)

The first hypothesis suggested that ESVs with larger networks are more favourably evaluated than ESVs with smaller networks. Table F.2[7] shows the results from the OLS regression models 1 (*soc_net_div*), 2 (*soc_net_dens*), and 3 (*soc_net_pos*) which yield the estimates of the test for this hypothesis. As expected, due to the scenario experiment, none of the introduced control variables significantly influences the evaluation of the ESV. The regression coefficient of large social networks (A2&A4, B2&B4, C2&C4) was positive and statistically significant at the 1% level in all three models. Table 6.5 shows the summarised results.

[6] The STATA script can be retrieved from https://github.com/Marcfelske/STATA-online-survey-analysis.

[7] Table F.2 can be viewed on page 268.

Table 6.5: *soc_net_size* treatment summary

Constellation vs. constellation	LikertΔ	Significance level	Model
A2&A4 vs. A1&A3	0.599	p<0.01	1
B2&B4 vs. B1&B3	0.909	p<0.01	2
C2&C4 vs. C1&C3	0.574	p<0.01	3

Larger networks were perceived more favourably by the survey participants regardless of whether constellations were generated by overlaying *soc_net_size* with *soc_net_div*, *soc_net_dens*, or *soc_net_pos*. The results indicate support for Hypothesis 6.1, larger networks are perceived as more valuable and thus improve an ESVs' evaluation.

(b) Network heterogeneity Hypothesis (6.2)

The second hypothesis to be tested supposed that the evaluation of ESVs with heterogeneous networks would be superior to those with homogeneous networks. The results are depicted for OLS regression models 5 to 8 in Table F.3[8]. Table 6.6 shows the summarised results.

Table 6.6: *soc_net_div* treatment summary

Constellation vs. constellation	LikertΔ	Significance level	Model
A1 vs. A3	1.198	p<0.01	5
A1 vs. A4	0.686	p<0.01	6
A2 vs. A3	1.884	p<0.01	7
A2 vs. A4	1.372	p<0.01	8

The regression coefficients for the more diverse networks (A1 and A2) compare positively and statistically significant to the less diverse networks (A3 and A4) at 1% level. The results support Hypothesis 6.2.

(c) Network density Hypothesis (6.3)

The third hypothesis followed the assumption that a network of interconnected stakeholders (B1 and B2) lead to a better ESV evaluation than dispersed networks (B3 and B4). As Models 11 to 14 in Table F.4[9] demonstrate, Hypothesis 6.3 is confirmed at the 1% level.

Participants ranked ESVs' social networks with heterogeneous stakeholders higher than homogeneous ones. The participants perceived a small network (B1) and a dispersed network (B4) only marginally different. Thus, participants perceived an equivalent trade-off between increasing size and reducing network density.

[8] Table F.3 can be viewed on page 269.
[9] Table F.4 can be viewed on page 270

Table 6.7: *soc_net_dens* treatment summary

Constellation vs. constellation	LikertΔ	Significance level	Model
B1 vs. B3	1.074	p<0.01	11
B1 vs. B4	0.017	p>0.1	12
B2 vs. B3	1.835	p<0.01	13
B2 vs. B4	0.777	p<0.01	14

(d) Network centrality Hypothesis (6.4)

Finally the fourth hypothesis predicted that ESVs which obtain a central position in their social network are evaluated more favourably than ESVs in peripheral positions. The detailed OLS regression results of Models 16 to 19 are presented in Table F.5[10]. Table 6.8 summarises the regression coefficients.

Table 6.8: *soc_net_pos* treatment summary

Constellation vs. constellation	LikertΔ	Significance level	Model
C1 vs. C3	2.041	p<0.01	16
C1 vs. C4	1.479	p>0.1	17
C2 vs. C3	2.628	p<0.01	18
C2 vs. C4	2.066	p<0.01	19

The results show survey participants favour ESVs obtaining more central positions (C1 and C2), over the peripheral positions (C3 and C4). The regression coefficients are the largest compared coefficients in other models. Consequently, the results strongly support Hypothesis 6.4.

To ensure the robustness of the regressions and thereby findings, variance inflation factors (VIFs) were calculated to test for confounding effects of the treatments. The VIF for all variables was calculated to be less than < 2.3 and therefore well below the recommended threshold of (Kutner et al., 1996; O'Brien, 2007; Prinzler, 2012) of 5-10, suggesting few problems of multicollinearity[11].

The summary of the regression results concludes the analysis of the online survey. The next section discusses and evaluates the survey experiment in the context of existing literature and practitioner understanding.

[10] Table F.5 can be viewed on page 271.

[11] Multicollinearity occurs if explaining variables of a model are correlated with each other. This can have negative effects on the interpretability of the individual contributions of model variables and thus the results, while also impeding the model's robustness (Aiken and Wea, 1996).

6.5 Discussion

Summary. The beginning of the study presented the theoretical underpinnings of various factors which determine social network constellations, including the formulation of hypotheses. Afterwards, the results were linked to the existing literature, and critical points supplemented with additional qualitative findings that were obtained through the survey and individual follow-up interviews.
Studying preferences of relevant stakeholder groups such as entrepreneurs and investors was enabled through an online survey scenario experiment which tests the impact of social networks on ESVs' evaluation. The OLS regressions showed broad support of the hypotheses, which suggests that the perceived evaluation and investability increases for ESVs whose social networks are large and have heterogeneous roles among their stakeholder groups. Furthermore, the perceived value increases for interconnected social networks of ESVs in which the ESV obtains a central position.

Theoretical contribution. All hypotheses were formulated based on existing literature making the findings consistent with the described theories. Thus, the study contributes to a generalisation of theoretical concepts, and the expansion of theories to the field of ESV at the intersect with signalling and network theory. Studying the effects on the perceived evaluation of ESVs based on their networks revealed that social networks are a decision-relevant metric which is positively correlated with a favourable evaluation and a signal of investability. The relevance of social networks for ESV evaluation is a significant finding as it suggests that the value created for entrepreneurs outweighs the costs of coordinating the social network. More specifically, the findings suggest that founders can influence the investability perception of their venture by aiming to position themselves in a social network which maximises constellations according to the chosen metrics. Overall, ESVs centrally embedded (Hypothesis 6.4) in a large (Hypothesis 6.1), diverse (Hypothesis 6.2), and densely interconnected (Hypothesis 6.3) network are preferred by the participants.
Hypothesis 6.1 was confirmed as the results demonstrated an influence of increasing social network size resulting in better ESV evaluation. The survey participants emphasised additional benefits resulting from reduced dependence on a single tie, as well as increased information flow as a positive feature of diverse networks. One participant stressed that ESVs tackling complex problems require multidisciplinary input which makes an extensive network a necessity. ESVs' ability to handle an extensive network can be seen as a positive signal, particularly when a problem-specific selection of partners is assembled. However, some participants reported that large networks would be too difficult to handle for some ESVs. Reasons mentioned were the increased "noise" and having to resolve conflicting views that lead to a situation where inputs could become overwhelmingly frequent, which was previously shown

by other studies (Ter Wal et al., 2016). Mitigating large information exchange is a challenge that can be assigned to the absorptive capacity concept (Zheng et al., 2010). Consequently, participants added that during the early stages, a focused network with aligned stakeholders might be beneficial to avoid losing sight of core targets. The findings, therefore, reflect the notion of a U-shaped tendency also found in the literature (Uzzi, 1997; Spender et al., 2017).

The predominantly positive effect of network diversity (Hypothesis 6.2) was confirmed as the results found a significant increase in perceived ESV evaluation with increasing heterogeneity of network stakeholders. Participants reported that "a broad stakeholder base helps to scale easier" and prepares the venture for later stages as stakeholders can give access to their proprietary social networks. Even few weak ties to high reputation individuals were reported to increase visibility and confer legitimacy, both ideas which are known from signalling theory. By contrast, other participants claimed that social networks comprising of multiple experts in "few domain areas are most suitable for ESVs", whereas "broad domain expertise [is preferred] in later stages" during which the firm grows geographically and potentially serves multiple industries. Supporting Hypothesis 6.3, an interconnected network being superior to a dispersed network, participants emphasised that high density reinforces trust and increases transparency. As mentioned earlier, the lack of transparency is a concern for investors taking an outsider view, who thus wish for a reduction of information asymmetry. From an entrepreneurial perspective, additionally gathered qualitative survey data suggested that interconnected networks "would become a nightmare to handle as networks grow". The resource-constrained nature of ESVs could be problematic, and networks would be "harder to manage and [one] can neglect some relationships". Controversially, various participants indicate that a less dense network might have upsides too. The most frequently mentioned example was the ability to remain in control of information flow. For instance, a seed-stage founder shared an experience: "[...] when you have a tech problem, and there are many in early stages, the last thing you need at that moment is a concerned investor on the phone. Much rather would you tell him a week later in person how you fixed it." Such a situation could occur when stakeholders communicate directly rather than through the ESV. From an external stakeholder's perspective, a sizeable unconnected network might yield the most significant extension to his/her network because it is unlikely to know all stakeholders already. The benefits of a position in a sizeable network of loosely connected individuals also reflect in the data, as the large dispersed networks were almost equivalently valued to small interconnected networks. The findings drawn from the analysis are well founded on literature which states that a network comprising of many weak ties ensures little redundancy of information and ESVs that span the boundaries between stakehold-

ers remain in control (Granovetter, 1973).
Finally, Hypothesis 6.4 predicted a positive influence on perceived valuation when ESVs obtain a central position. The participants' responses and the analysis thereof support this prediction. The effect on participants perception was most substantial for the network position treatment compared to all other treatments. In their qualitative remarks, investors were critical of peripheral ESV positions as ESVs relying on few partners, a situation that could create strong dependencies on stakeholders. Investors stated that they prefer to see "vested interest" of other stakeholders and the ability to compensate eventual losses of stakeholders from the ESV network with stakeholders from the VC's own network. One participant reported a self-reinforcing mechanism in which a central actor may quickly expand their network as opposed to a peripheral ESV. Some respondents reported that the ability to handle a few connections is interpreted as a weakness of the ESV's management team. Positive aspects of peripheral positions were reported as well. The main reason given in favour of decentralised positions is the minimal effort required to concentrate on a few key partners and still have indirect network access to a broad stakeholder base. Additional data and qualitative remarks mirror the positions in the literature which emphasise coordination and cost-advantages of peripheral positions (Rost, 2011) whereas opponents warn of the resulting dependency (Miles et al., 1999; Knoben and Bakker, 2019). Monitoring dependencies is critical for ESVs which procure critical resources through their networks (Sullivan and Ford, 2014) as overdependence can constrain further access to resources or partners (Ahuja et al., 2009) and increase the risk of failure or poor economic performance (Uzzi, 1996, 1997).
In addition to contributions to research on network theory, resource-based view, absorptive capacity, and signalling theory, the study provides new evidence of dynamism along the ESV life-cycle and the role of the assessor on ESV evaluation. Regarding dynamism, Martinez and Aldrich (2011) state changes in requirements of ESVs concerning their social networks occur over time. Tidd (2013) describe that networks are critical during the launching phase of a venture during which search and identification activities dominate. In a few qualitative remarks, ESV maturity was mentioned as a condition. However, the quantitative data does not indicate significant changes towards later stages. Similarly, characteristics of the evaluating person, such as their prior experience, were mentioned. Three young investors reported placing a high value on ESV networks as their own networks have not yet developed to the extent of senior investors. The qualitative evaluations, however, did not reflect this influence.

Implications for practice. The study contributes to the practitioner understanding of ESV and social networks in four important ways.

First, the study introduces a new perspective on evaluating ESVs by highlighting the importance of their social networks. Results drawn from this study strengthen the case for networks being an essential element of an ESVs investability signals to VCs which has mainly been neglected in the literature to date.
Second, the magnitude of the preferences found in several models suggests that a network perspective should supplement existing evaluation approaches. As different constellations had both strong positive or strong negative and statistically significant influence on the perceived valuation, establishing a formalised methodology which thoroughly examines social networks of an ESV seems reasonable. The metrics utilised to test the hypotheses could be adopted by practitioners to develop actionable evaluation tools.
Third, the results provide advice on how ESVs should orchestrate their networking activities to optimise the perceived positive signals which could lead to more favourable evaluations of the venture. These notions align with evidences in previous studies which found that purposely building social networks is possible and advisable for entrepreneurs (Hallen, 2009; Hallen and Eisenhardt, 2012).
Fourth, prior research focused on later-stage companies and traditional valuation or qualitative assessments of ESV founding teams. Existing studies provided little guidance for practitioners on how to analyse social networks. By contrast, this study sought to reveal which social network constellation of ESVs increases the perceived investability in the eyes potential investment decision-makers and several control groups.

6.6 Limitations and research opportunities

Despite its contribution to theory and practice, this study has limitations in five separate areas. First, the sample is limited to a small portion of the entire VC and entrepreneur population.Furthermore, the selection of candidates and whether they chose to participate introduces a bias which is challenging to control for. The response rate of 30.4% is comparable to other publications in the entrepreneurship field. Future surveys could aim for increased coverage by focusing on fewer stakeholder groups or technology verticals and thereby investigate a more specific sample.
Second, the study focuses on the higher-level network character and disregards the characteristics of individual ties. Studies such as Stuart et al. (1999) demonstrated that the individual characteristics of network actors have a significant influence on network value. Future research could assess the characteristics of ties with a higher level of detail.
Third, several participants and scholars such as Hoang and Antoncic (2003) point out the importance of monitoring network changes over time. The research design excluded the time-dimension from the models to reduce complexity. Future studies

focusing on the element of time could respond to this notion. Two questions could be worth investigating: (1) how long does a weak network tie remain valuable before necessarily creating redundancy over time by becoming a strong tie? (2) how can networks of ESVs be captured when the staff count grows rapidly? It could be argued that the external ties of an ESV are a mesh of multiple networks around its founders and employees. Thus, the assumption of a single ESV network rather than seeing the network as a conglomerate of sub-networks presents an oversimplification. However, during the research design the decision was made that the additional complexity of fragmenting the ESV into its team members and their respective social sub-networks would not justify the additional insight.
Fourth, the research aimed to determine the factors which maximise ESV perceived value and investability. In a discussion leading to this study, and interviewed practitioner mentioned that spotting a weakness in a social network might be of higher importance than identifying a strength. Future research could investigate if weaknesses can be revealed by reversing the treatment variables or whether other metrics have to be introduced.
Finally, reducing ESV evaluation to one parameter, i.e. social networks of the ESVs, was a necessary simplification to to extract the influence of social networks around ESVs. It should be assumed that commonly assessed factors such as the product, team, technical defensibility, or the market would have possibly confounded the evaluation experiment. Moreover, in real world applications, detailed social network information might not be available to VCs when making an investment decision. The last two limitations present an opportunity for future research to incorporate findings from this study in a broader context, repeat evaluation experiments under consideration of additional decision-making factors, and with publicly available data.

The study in Chapter 7 addresses several of the limitations of this study and incorporates those into the research design. Examples for such aspects are a longitudinal observation of social networks, the use of third party data, and tying the results to the observable financial performance of ESVs.

7. ESV evaluation tool

Contents

7.1 Chapter introduction

The study in this chapter investigates whether an ESV's investability can be analysed by looking at its social network. The previous Chapter 6, and particularly the social network metrics described in it, serve as a conceptual foundation for this study. Conclusions drawn from the previous studies inspired a comprehensive industry analysis into third-party data sources that could be used to proxy ESV success. Figure 7.1 illustrates the position of the final study conducted for this thesis in the context of previous studies.

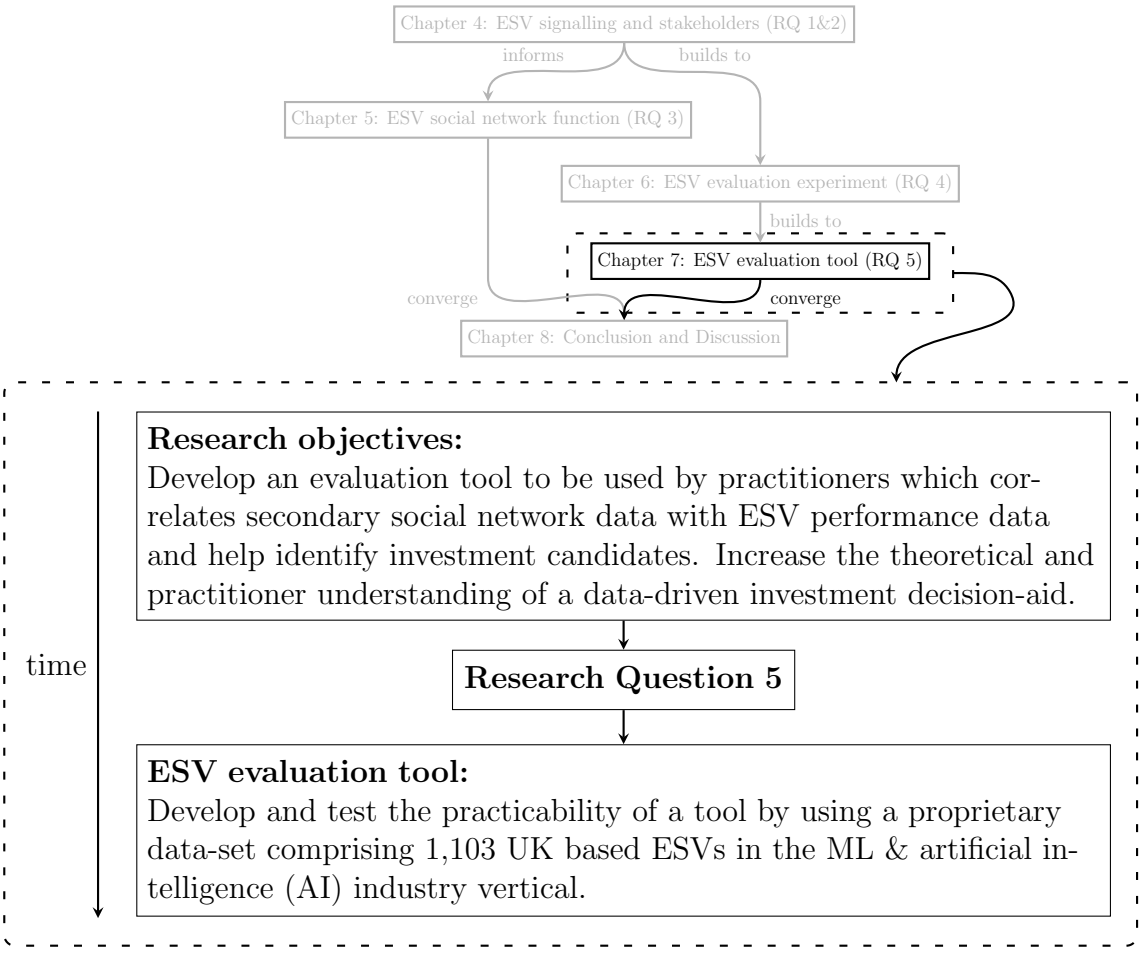


Figure 7.1: Data, research questions, and research objectives of Chapter 7, own illustration.

For this study, ESV success is measured as financial fundraising success and the fundraise frequency. Gathering longitudinal data from private market databases, social media, and ESV websites creates a unique, proprietary data set which is used to answer Research Question 5.

Research Question 5: Which social network data can proxy the fundraising success and fundraising frequency of ESVs?

The next section develops the conceptual background of the study.

7.2 Conceptual development

The following section first reviews the existing and specific literature that describes how ESV success can be quantified (7.2.1), and second formulates hypotheses (7.2.2) which are tested to answer Research Question 5.

7.2.1 Literature review

In the literature on VCs' approaches to evaluate ESVs, a common denominator can be identified. Studies predominantly aim to predict future success based on historical data and thereby understand the risk-return profile of the investment opportunity (Ramsinghani, 2014). A critical parameter for the risk-return profile is the resulting ROI for the investor, as well as the gains of the entrepreneur, which both are fundamentally dependent on the venture's financial success. This financial assessment of VCs' investments depends on the entry-price they initially pay for their equity stake, potential additions to the investment over multiple investment rounds, and the exit price that is achieved when the investment is liquidated (Gompers and Lerner, 1999; Ramsinghani, 2014). However, this success of a venture is not only difficult to predict, as a consequence of the serendipity of the ventures' development, but also obfuscated by investment uncertainties and asymmetric information as thematised in Chapter 2. To estimate the ROI of an ESV pre-investment, multiple proxies, obtainable from secondary data, have been theoretically suggested and empirically tested by previous research. Murphy et al. (1996), Spinelli et al. (2012), and Staniewski (2016) provide overviews of such success factors. The results of a review going beyond those existing works are listed in Table 7.1.

Table 7.1: ESV success factors

Success factor	Reference
Firm survival	Agarwal and Audretsch (2001); Van Gelderen et al. (2006); Raz and Gloor (2007); Andries and Debackere (2007); Fried and Tauer (2015)
Jobs created, employee growth	Watson et al. (1998); Brüderl and Preisendörfer (1998); Laitinen (2002); Davila et al. (2003); McCartan-Quinn and Carson (2003); March-Chorda (2004); Caliendo and Kritikos (2008); Khaire (2010); Fried and Tauer (2015)
Achieve milestones	Roure and Keeley (1990); Steier and Greenwood (1995); Zheng et al. (2010); Vu et al. (2012)
Achieve IPO/M&A	Robinson (1999); Plummer et al. (2016); Croce et al. (2018)
Receive VC	Hsu (2007); Colombo and Grilli (2010); Zheng et al. (2010)

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Success factor	Reference
Market share	McCartan-Quinn and Carson (2003); Van Gelderen et al. (2006)
Unit sales, revenue, ROI, profit	Roure and Keeley (1990); Cooper (1993); Kakati (2003); Baron and Markman (2003); Sebora et al. (2009); Hormiga et al. (2011)

In recent years, research into success factors has shifted from predominantly qualitative survey data, towards a quantitative "data-driven" assessment of secondary data. Quantitative research has been enabled through both by the advent of private market databases and increased computational performance, which made large structured data readily available and analysable (Martens et al., 2011; Arroyo et al., 2019; AdF3; AdVC4).

The review of previous studies surfaced three critical limitations of research on ESVs' success.

Firstly, as the literature review in Chapter 2 described, firms exert fundamentally different characteristics as they mature. Many studies fail to consider "success" during fledgling stages from perspectives other than M&A and IPO, therefore oversimplifying the problem.

Secondly, ESVs have a non-linear, almost cyclical growth pattern which is initiated by discrete events (e.g. achieve a milestone, set new milestone goals, fundraise, execute or make adjustments, and repeat), which few studies consider (Vohora et al., 2004; Zheng et al., 2010; Martens et al., 2011).

Finally, the most successful firms, ultimately those investors aim to identify, are extreme outliers (Feld and Mendelson, 2011; Ramsinghani, 2014; Liang and Yuan, 2016), which are conversely often excluded from statistical analysis (Yang and Berger, 2017). As a consequence, traditional, linear statistical models have not been successfully applied on neither qualitative nor quantitative analyses (Stuart and Abetti, 1987; Nahata, 2008). Thus, academic studies in the venture investing context applied non-linear models such as Logit and Probit models which are more suitable to describe discrete data (Nahata, 2008; Allison, 2010).

In the past five years, ML based, neural network approaches were adopted by researchers and practitioners for modelling purposes (Martens et al., 2011; Arroyo et al., 2019). Those approaches benefit from being able to model patterns and non-linear relationships while being more robust towards issues arising of multicollinearity and occurrence of outliers (Bishop, 2006; Garg and Tai, 2013). Such approaches have several characteristics which allow for more complex models, through inclusion of a greater number of parameters, which can positively influence their descriptive

power and accuracy (Goodfellow et al., 2016)[1].

In parallel to the advancements in ML algorithms, SNA algorithms allowed researchers to handle large sets of "networked-data" which opened up new research opportunities in several areas, among them financing (Kalampokis et al., 2013). The importance of "online" relative to "offline" social networks is subject to an intensive academic debate (Wu, 2007; Tan and Tan, 2012; Song, 2015). Nonetheless, this newly emerged area of research has attracted interest from the finance-oriented academic and practitioner community. The combination of state-of-the-art modelling combined with private market data and a social network perspective opens new methodological avenues to assess and predict ESVs' success and characteristics.

This growing body of literature is limited to a small number of peer-reviewed publications. Therefore, conference publications, working papers, and research from tangential domains were also included in the review. Table 7.2 summarises the results of the concentrated literature review.

[1] Higher descriptive potential involves a trade off, as results are often difficult to interpret due to a greater number of variables and decreased transparency of causation. Such models can be metaphorical "black-boxes" (Muhlbacher et al., 2014; Goodfellow et al., 2016; Doerr et al., 2015).

Table 7.2: Advanced models based on SNA in the VC and ESV domain

Reference/ unit of analysis	**Analysis/method/detail**
Alexy et al. (2012) predicted second-round fundraising amounts from previous investors portfolio diversity, and network degree/syndication.	3,668 US firms and 3,173 VC investments in the areas of advertising, e-commerce, enterprise software and services, games and video, hardware, mobile, network hosting, search, security, software, and web. Their analysis was performed using linear regression to correlate with the logarithm of the funding amount. The research found that ESVs funded by investors with higher degrees (connections to other VCs) are more likely to fundraise a second round, while those rounds are also larger. The finding is noteworthy since it contradicts an established finding that better connected, highly reputable VCs invest at a "discount" (Hsu, 2004).
Gloor et al. (2013) compared social networking behaviour with ESV success.	Comparing the social networks of the sample participants form a real world networking event and measuring social network metrics using LinkedIn, Facebook, Xing, and e-mail, the authors mapped networks of 62 entrepreneurs and 77 academics with a total network of 15,913 LinkedIn and 6,928 Facebook actors as well as 28,152 email headers. Their analysis showed that more central actors and entrepreneurs who are connected to key individuals (Directors, VCs, and Advisers) were more successful. The success metrics used in the study were venture survival, entrepreneur seniority in the ESV and prize money wins in competitions. The results showed that the professional LinkedIn network is the best predictor followed by Xing, e-mail and the more informal Facebook. Furthermore, the study also indicated that combining networks increased the predictive power.
Spiegel et al. (2016) predicting second round fundraise success of ESVs.	Snapshot SNA of 70 US internet ESVs and their 145 founders. Based on previous first-round investments and SNA of founders' LinkedIn networks, fundraising events drawn from AngelList, Crunchbase, and SEC data were used to predict whether ESVs could raise second-round funding retrospectively. The study used a t-test and Fisher's exact test. The considered factors included the founders' network centrality, average number of (co-)founders, previous VC, consultant, or founding experience, average years of education and experience. The study found that shorter paths, i.e. closeness between VCs and ESVs, makes receiving second-round investments more likely and encouraged further ESV specific research.

WP = working paper, C = conference paper

Continued on next page

Reference/ unit of analysis	**Analysis/method/detail**
Ter Wal et al. (2016) researched the influence of network closure of investor syndicates on the ESVs' ability to raise second-round funding.	Snapshot of 10,266 US ESVs that received funding over 37,146 funding rounds from 5,032 investors, reduced to 2,371 syndicated first-round investments involving 1,646 unique investors. Furthermore, US patent and trademark data was included in the Logit regression analysis. The study identified that ESVs receiving investments form syndicating investors with either open-specialised or closed-diverse networks have the highest chance of receiving second-round funding.
Liang and Yuan (2016) predicted investor behaviour in a four-degree separation network around Facebook Inc.	Snapshot of 11,916 primarily US companies, 12,127 people, 1,122 investors, and 5,341 funding investment activities. Analysis of closeness calculated for all firms using shortest paths and similarity using the Jaccard coefficient in combination with investor and company information such as age and industries. ML approaches such as Decision Trees, Support Vector Machines, and Naïve Bayes were used to predict investments drawn from Crunchbase data. The study found that edge prediction can be facilitated through a ML based link prediction model and called for a replication of the study in the VC domain. Furthermore, (Liang and Yuan, 2016) suggests research into finding "super-stars" in networks.
Glupker et al. (2019) predicted fundraising success from investor community affiliation.	14,000 ESVs and over 5,300 investors, for a total of nearly 60,000 investment rounds. SNA was used to detect investor communities and correlated community membership with a binary variable of measuring whether an exit has occurred. Using traditional statistic approaches such as logistic regression, as well as ML approaches of Random Forests and K-nearest neighbour, the study identified that unsuccessful investors are easier to identify than successful investors.
Banerji and Reimer (2019) analysed founders' LinkedIn followership influence on fundraise amount.	The study analysed the LinkedIn followership numbers of founders of 129 US ESVs in the information and technology industry. Using linear correlation, Banerji and Reimer analysed the variance in followership numbers correlated with reported fundraise events drawn from Crunchbase. They found that founders with higher followership numbers fundraise larger amounts 69% of the time.
Arroyo et al. (2019) analysed firm success based on founders, company, and fundraising information.	A retrospective, longitudinal analysis of 120,507 companies with 34,180 fundraise rounds was analysed through various ML approaches such as Decision Trees, Random Forests and Support Vector Machines. The decision support tool defined success as being acquired (M&A), to achieve a fundraise, or an IPO. Analysed metrics included: firm age, binary variables for companies' phone, web, Twitter, Facebook, LinkedIn presence, number of rounds, fundraised amounts, valuation and investor counts, as well as the time since last fundraise.

WP = working paper, C = conference paper *Continued on next page*

Reference/ unit of analysis	Analysis/method/detail
Yang and Berger (2017)^{WP} predicted fundraising amounts through social media metrics.	Snapshot of 37,875 US companies selected, 119 analysed for Twitter and Facebook followership and engagement measured by posts and Tweets. The data was analysed using a multi-variate OLS and Logistic regression. The study found that Twitter follower count, as well as Facebook fan activity, correlate with total logarithmic fundraising amount. Furthermore, it found that Twitter follower tweet counts and ESVs' tweet count were not significant.
Nann et al. (2011)^{WP} predicted ESV success and economic value creations.	Snapshot of 14,854 alumni from 12 German universities were identified on the professional network Xing. 80 randomly drawn alumni/entrepreneurs of each university were analysed for their companies' job creation numbers. Betweenness and degree centrality of entrepreneurs was analysed for linear correlation with the success metrics "survival" and economic impact. The economic impact was defined as the number of employees multiplied with average income based on a survey. The study found a significant correlation between founders' economic impact and alumni group betweenness centrality. Further research into the strength and relevance of social ties was encouraged.
Xiang et al. (2012)^{C} applied topic modelling on TechCrunch articles to predict M&A activity.	Textual information from web- and social media sites, was analysed using ML approaches such as Bayesian Network, Support Vector Machines, and Logistic regression. ML outperformed the traditional statistical approach and found M&A with above 60% true positive and below 8% false-negative rate. Metrics included employee number, company age, location, offices, product, providers, milestones articulated in and revisions of the companies' Crunchbase profiles, TechCrunch articles per company, competitors, and acquired competitors.
Yu and Perotti (2015)^{C} analysed fundraising capability based on Twitter metrics.	644 ESV firms across industries and stages were analysed for their Twitter follower and friendship metrics as well as the firm's betweenness centrality in the Twitter network. The total fundraised amount was used as a proxy of success for each firm and analysed with a linear regression model. The preliminary results show that the betweenness centrality could be an indicator for firms fundraising capability.
Jin et al. (2017)^{C} researched the influence of social media presence on fundraising rounds.	Snapshot of 2880 US ESVs across industries was drawn from Crunchbase and analysed whether ESVs raised second-round funding. Using OLS, 2SLS, Logit regression models company and founder information were analysed for correlation. The study found that ESVs with a social media presence raise funding rounds with more investors and found that Tweets page-rank is not relevant. Analysed metrics included: age, employee count, and number of different lines of business, funding received before first-round funding, total funding, and executive-level management experience, ESV industry, years until second-round fundraise, number of Tweets and number of followers.

WP = working paper, C = conference paper

Continued on next page

Reference/ unit of analysis	**Analysis/method/detail**
Zhang et al. (2017)^{C} analysed crowd-funding success based on social media engagement.	271 ESVs on AngelList with a Twitter and Facebook account operating in a variety of industries were tracked over seven months for their AngelList followership, Facebook likes and posts, and Twitter followers and Tweets. An analysis with Decision Trees, Support Vector Machines, and K-nearest neighbour predicted crowd-funding success with 84% accuracy. In detail, ESVs that use social media are more likely to successfully crowd-fund. Furthermore, among successful companies, 47.8% are on Facebook and 69.6% are on Twitter. In contrast, among unsuccessful companies, only 9.5% and 38% are on Facebook and Twitter respectively. Across all variables, the AngelList followers, Facebook posts and crowd-funding campaign description length were found to predict success, Twitter followers and Tweets were found to be irrelevant.
Sharchilev et al. (2018)^{C} predicted second-round investment based on web mentions.	37075 firms on Crunchbase were analysed for their inbound websites' content. Findings from an analysis using a ML Decision Tree suggest that the web presence and unstructured data have to be taken into account as they improved the model's explanatory power compared to models based solely on information from a structured database.

WP = working, paper C = conference paper

The comprehensive literature review of studies at the intersect of online social media, with ESV success description and prediction helped position this study among existing works, identify a research gap, and clarify to which previous calls for research it could respond. Five issues were isolated from the literature.
Firstly, comprehensive success measuring for ESVs is not sufficiently understood (Zachary and Mishra, 2013), especially when compared to later-stage investments where more quantitative metrics are available to build comprehensive models (Miloud et al., 2012). Secondly, the studies mentioned above outline several avenues for subsequent research, for instance, into non-linear approaches, network-structured, or relational data (Ter Wal et al., 2016; Banerji and Reimer, 2019). Thirdly, researchers called for longitudinal data analysis which reflects the fundraising cycles commonly found in ESVs and simultaneously analysing content and relationship qualities rather than counting events or followership numbers (Zheng et al., 2010; Yang and Berger, 2017). Fourthly, the studies encourage breaking away from self-reported, ego-network data towards larger secondary data sets. Even beyond structured data, several researchers call for studies that harness contextual, web-scraped data (Xiang et al., 2012; Martinez and Aldrich, 2011; Alexy et al., 2012; Banerji and Reimer, 2019). Lastly, existing studies predominantly focus on US based companies. Such focus can be seen as no longer timely, especially considering that the European investment volumes are growing faster than their US counterparts and fundraising volumes have reached historic highs (PitchBook, 2020a).

Besides the already mentioned calls, this study is similarly motivated by calls for further research following qualitative studies. Researchers encourage studies of ESV success concerning entrepreneurs' aptness of using online social networks. Selected examples demonstrated that online social networks and online social media have emerged as an important entrepreneurial medium, and should be part of every entrepreneur's "digital acumen" (Fischer and Reuber, 2011; Fischer and Rebecca Reuber, 2014; Ellison et al., 2014; Smith et al., 2017). Matching the scope of the thesis, Aggarwal et al. (2012, p. 990) emphasised the importance of "electronic word-of-mouth" especially during the earliest stages of new ventures. Last but not least, practitioners within the VC industry have started embracing social media as a decision-relevant factor (Jin et al., 2017; Arnold, 2017) with some going so far as to state: "Ten years from now, social media will be the starting point of any investment" (Ted Leonsis, in Hong, 2013).

7.2.2 Hypothesis formulation

Informed by the insights gained from the previous study in Chapter 6, the social network parameters of (a) size, (b) position, (c) density, and (d) and diversity were also investigated in this study. A fifth parameter, (e) network relevance, expands

the list of four social network parameters.

(a) Network size hypothesis

Researchers of previous studies have analysed the impact of the size of entrepreneurial social networks on ESV success. Thus, to test whether this study can confirm such a mechanism, the first hypothesis is formulated as:

Hypothesis 7.1: ESVs with a larger social network raise higher amounts of funding, achieve higher valuations, and fundraise more frequently.

(b) Network position hypothesis

Researchers in previous studies empirically demonstrated the importance of a central ESV position. The hypothesis to test whether centrality positively impacts the ESV success is:

Hypothesis 7.2: ESVs obtaining a central position in the global social network, raise higher amounts of funding, achieve higher valuations, and fundraise more frequently.

(c) Network density hypothesis

Several studies in the reviewed literature found that the density and the resulting increase of shortest paths between vertices in ESV social networks are associated with increasing ESV success. The second hypothesis to be tested can, therefore, be formulated as:

Hypothesis 7.3: ESVs with a denser social network raise higher amounts of funding, achieve higher valuations, and fundraise more frequently.

(d) Network diversity hypothesis

Network diversity has previously been studied theoretically and in empirical, qualitative works. Identified effects ranged from positive to negative. As the review in Chapter 6 showed, an inverted U-shaped relationship can stem from being overly diverse or overly homophilous (Uzzi, 1997; Xu, 2011). Consistent with Chapter 6, the hypothesis is formulated as:

Hypothesis 7.4: ESVs with more diverse social network raise higher amounts of funding, achieve higher valuations, and fundraise more frequently.

(e) Network relevance hypothesis

Previous quantitative studies encouraged further research into the contextual, content specific investigation of social networks (Martens et al., 2011; Banerji and Reimer, 2019; Xiang et al., 2012). The debate of online versus offline social networks is fuelled by the idea that online relationships lack authenticity, relevance, and depth of content (Hoang and Antoncic, 2003; Kane et al., 2014; Hoang and Yi, 2015). As the extant literature emphasises the relevance of ESVs' ties to its stakeholders, similarly should the online networks be relevant. Therefore the hypothesis formulates as:

Hypothesis 7.5: ESVs with a more relevant social network stakeholders fundraise higher amounts, achieve higher valuations and fundraise more frequently.

The above literature review focused on measuring success, approaches to model ESV success, and helped formulate the Hypotheses 7.1 to 7.5. These elementary building blocks provide the foundation for the research design, and enable the researcher to conduct the study, test the hypotheses, and answer Research Question 5.

7.3 Research design

This section describes the design of a real-time, longitudinal study of ESVs and their fundraising activity. To build a tool which can serve as a decision-aid that seeks correlation of fundraising data with online social media data, two types of success metrics have to be selected. The first group of success metrics are considered dependent (7.3.1), to be explained variables, the second group are independent (7.3.2), which serve as a proxy to explain the dependent variables. After identifying suitable variables, the data sampling (7.3.4) and data gathering strategy (7.3.5) are discussed.

7.3.1 Dependent variables

Table 7.1 shows an overview of success factors and success metrics that have been used in previous studies and were considered as dependent variables for the study. A central element of this study is to build upon and expand these factors. The selection was derived through the exclusion of factors which the researcher considered unsuitable for reasons explained below.

Firstly, following the reviewed literature, operational and financial metrics such as the market share, revenue, profits, or ROI were excluded as they are not prevalent among ESVs (Ramsinghani, 2014; Sharchilev et al., 2018). Secondly, jobs created, especially for firms at the ESV stage were not considered a reliable predictor (Davila et al., 2003; Fried and Tauer, 2015). Particularly the advent of software-based, high-

technology ventures in the digital age have made staff count an unreliable predictor as teams can be small and nonetheless create large financial successes (Ramsinghani, 2014; Hoffmann and Yeh, 2018)[2]. Thirdly, firm survival is difficult to assess, and also a non-relational success metric as previous studies modelled it as a binary event. The assessment of a company's state as operational, deadpooled, or non-operational is challenging because many firms continue to appear to be active in databases although they have stopped trading. Fourthly, milestone achievements were excluded as they are difficult to define, quantify, and most likely incomparable among ESVs. A real time analysis of ESV achieving an IPO or M&A is not feasible given the time horizon of several years. Comparing exited companies with current ESVs is a procedure that has been criticised previously in this thesis as it resembles an apple and pear comparison. Finally, the last available success metric to be used were fundraising events, which have also been successfully used as described in the literature review Section 7.2.1.
Table 7.3 lists and describes the dependent variables selected for this study.

Table 7.3: Dependent variables

Dependent variable	**Description/measure**
$fund\_raise\_\bar{t}$	Mean duration between fundraises
acc_fund_raise	Accumulated fundraise amounts across funding-rounds
$max\_valuation$	Highest achieved post-money valuation

The metrics described in Table 7.3 are interpreted as positive when fundraises and valuations are high, and fundraising cycles are short. It should be noted that previous studies have shown that fundraise amounts have local optima and excessive amounts lead to high dilution of the founders equity (Feinleib, 2011; Rowley, 2017). Similarly, intense fundraising in a short period of time could indicate that entrepreneurs spend the majority of their time searching for capital. However, following suit with the approach of the reviewed studies, those direct fundraising metrics were considered the most applicable by the researcher, and the implications are discussed as part of the study's limitations.

7.3.2 Independent variables

In conjunction with the dependent variables, identification and selection of independent variables was necessary to conduct the study. The focus of the analysis in this study is on online social network characteristics of ESVs, in particular, independent

[2] Evidence from several venture-backed firms shows that employee numbers can be a bad predictor for ESV success. Relevant examples include firms such as Instagram which was 13 and WhatsApp 35 employees strong before being acquired for $1bn and $19bn respectively (Shontell, 2012; Metz, 2015).

variables such as the investor network, online social media network of Twitter, and the ESV's website analytics. Here, the two website analytics, global page-rank and number of inbound links, warrant further explanation.
The global page-rank is calculated based on the number of unique website visitors over the last three rolling months, and the inbound links are counted as those third-party websites that link onto an ESV's website (Amazon Alexa, 2020).
Figure 7.2 shows the schematic description of the ESV user relationships analysed as part of the study.

(a) Follower relationship (b) Friend relationship

(c) Mutual relationship (d) Mutual weighted relationship

Figure 7.2: Twitter follower and friendship schematic, own illustration.

Beyond focusing on follower and friendship numbers as performed in previous studies, additional information from the social media site Twitter, in combination with content from the ESVs' websites was used. This additional detail expands existing research with first-time researched elements. Informed by the insights gained from the previous study in Chapter 6, the metrics used are also categorised into size, density, and position.

Table 7.4: Dependent variables

Independent variable	**Description/measure**
Network size metrics	
$follower\_degree\_t_i$	Absolute number of followers at time during survey per ESV
$follower\_degree\_\bar{t}$	Mean of followers during survey per ESV
$follower\_degree\Delta$	Absolute change of followers per ESV over survey period
$follower\_degree\_rel\Delta$	Relative change of followers per ESV over survey period
$friends\_degree\_t_i$	Absolute number of friends at time during survey per ESV
$friends\_degree\_\bar{t}$	Mean of friends during survey per ESV
$friends\_degree\Delta$	Absolute change of friends per ESV over survey period
$friends\_degree\_rel\Delta$	Relative change of friends per ESV over survey period
Network diversity metrics	
fo_div_fr	Quotient: $follower\_degree\_t_i / friends\_degree\_t_i$ mean of snapshots
$new\_inv\_div\_f\_o\_inv$	Quotient: $investors / f\_o\_investors$ mean of fundraise events

Continued on next page

Independent variable	Description/measure
Network density metrics	
$ego\_net\_followers\_density$	Density of follower network per ESV
$ego\_net\_friends\_density$	Density of friends network per ESV
Network relevance metrics	
$followers\_match\_t_i$	Absolute number of followers at time matching ESV's website content
$followers\_match\_\bar{t}$	Mean followers at time matching ESV's website content
$followers\_match\Delta$	Absolute change of followers matching ESV's website content over survey
$followers\_match\_rel\Delta$	Relative change of followers matching ESV's website content over survey
$followers\_match\_w\_t_i$	Absolute number of matching words at time matching in ESV's website content with all followers
$followers\_match\_\overline{w}\_\bar{t}$	Mean matching words at time matching in ESV's website content with all followers
$followers\_match\_w\Delta$	Absolute change of matching words in ESV's website content with all followers
$followers\_match\_w\_rel\Delta$	Relative change of matching words in ESV's website content with all followers over survey
$followers\_match\_\overline{w}\_pf\_t_i$	Mean of matching words at time with ESV's website content per follower
$followers\_match\_\overline{w}\_pf\_\bar{t}$	Mean of matching words with ESV's website content per follower over survey
$followers\_match\_\overline{w}\_pf\Delta$	Absolute change of the mean matching words in ESV's website content per follower
$followers\_match\_\overline{w}\_pf\_rel\Delta$	Relative change of the mean matching words in ESV's website content per follower
$followers\_match\_\overline{w}\_u\_rel\Delta$	Relative change of matching words per follower over survey
$friends\_match\_t_i$	Absolute number of friends at time matching ESV's website content
$friends\_match\_\bar{t}$	Mean friends at time matching ESV's website content
$friends\_match\Delta$	Absolute change of friends matching ESV's website content over survey
$friends\_match\_rel\Delta$	Relative change of friends matching ESV's website content over survey
$friends\_match\_w\_t_i$	Absolute number of matching words at time matching in ESV's website content with all friends
$friends\_match\_overlinew\_\bar{t}$	Mean matching words at time matching in ESV's website content with all friends
$friends\_match\_w\Delta$	Absolute change of matching words in ESV's website content with all friends
$friends\_match\_w\_rel\Delta$	Relative change of matching words in ESV's website content with all friends over survey
$friends\_match\_\overline{w}\_pf\_t_i$	Mean of matching words at time with ESV's website content per friend
$friends\_match\_\overline{w}\_pf\_\bar{t}$	Mean of matching words with ESV's website content per friend over survey

Continued on next page

Independent variable	Description/measure
$friends\_match\_\overline{w}\_pf\Delta$	Absolute change of the mean matching words in ESV's website content per friend
$friends\_match\_\overline{w}\_pf\_rel\Delta$	Relative change of the mean matching words in ESV's website content per friend
$friends\_match\_\overline{w}\_u\_rel\Delta$	Relative change of matching words per friend over survey
tweet_count	Absolute number of Tweets per ESV
Tweets_per_day	Mean of Tweets per ESV per day
global_pagerank	Amazon Alexa page-rank of ESV's website, the best achievable web-rank is 1, the worst being 20 million
inbound_links	Absolute number of inbound-linked websites, the lowest link count is 1 and can be infinite
Network position metrics	
esv_inv_degree	Absolute number of investors per ESV
esv__f_o_inv_degree	Absolute number of follow-on investors per ESV
esv_inv_net_degree_cen	Degree centrality of ESV in in investor network
esv_inv_net_eigen_cen	Eigenvector centrality of ESV in investor network[1]
esv_inv_net_between_cen	Betweenness centrality of ESV in investor network[2]
$followers\_max\_X\_matches$	ESV edges to X most central followers in global network
$friends\_max\_X\_matches$	ESV edges to X most central friends in global network
Binary ESV features	
has_Twitter	ESV has a Twitter presence
has_website	ESV has a web presence
b2b	ESV is sells B2B
accelerator	ESV has been part of an accelerator program

[1] Eigenvector centrality assigns relative scores to all vertices in the network based on the premise that edges to vertices with high degree are favourable. Previous studies used this metric in an ESV context (Spiegel et al., 2016). For a definition of eigenvector centrality view Table 2.3, p. 38. Note: Variables only shown for followers and friends also exist for mutual relationship (*mutual_rel*) and weighted mutual relationship (*weigh_mutual_rel*) networks according to Figure 7.2 (c) and Figure 7.2 (d) but are not listed here.

7.3.3 Control variables

Besides the dependent and independent success metrics for ESV, control variables were introduced for the ESVs' age, customer base, headquarter location and respective ecosystem, as well as the fundraise stage. As the data about ESVs was gathered from three different private market databases, which apply varying classifications and labels for sub-industry categories, the main search category artificial intelligence (AI) & ML was the only control for industry influence besides *b2b*. Table 7.5 lists the control variables that were introduced to control for ESV characteristics.

Table 7.5: Control variables

Control variable	Description/measure
company_age	Number of days since ESV's incorporation
b2b	Binary 1 for B2B ESVs and 0 for B2C ESVs
hq_city_ecosystem	Headquarter/ecosystem location in the UK
$fund\_raise\_stage$	Highest achieved fundraise stage of the ESV

7.3.4 Sampling

As outlined above, the focus of the investigation was on the social networks, in particular the investor networks, the web presence, and the social media network Twitter. A large enough industry-vertical had to be identified to qualify as a relevant sample, which at the same time must have a sufficiently high prevalence of the key attributes. In the following, the (a) sampling criteria, (b) sample selection, and (c) sample description are elaborated.

(a) Sampling criteria

The goal was to sample ESVs according to the following "main" sampling criteria:

1. Geography
2. Industry-vertical
3. ESV age, maturity, and fundraising history

As an additional constraint to the sampling criteria, the goal was to select a sample in which the ESVs have maximum availability of attributes which were later used as proxies. Thus in a suitable sample, most ESVs meet the "necessary availability" criteria:

1. ESV has a Twitter presence
2. ESV has an active website
3. Website analytic for the ESV's website is available

Finally, two "sufficient feasibility" criteria taking the form of one upper and one lower boundary for the sample size were considered.

1. Lower boundary: sample size must be sufficient to make inferences about a population
2. Upper boundary: limited sample size results from rate limit of Twitter application programming interface (API)

The upper boundary limits the sample size as a consequence of Twitter's restrictions to data-mining[3]. As the survey period was scheduled to last six months, the maximum feasible network size is around three to four million users.
For the lower boundary the Cochran formula was used to estimate the necessary sample size n_0 as shown below:

$$n_0 = \frac{Z^2_{\alpha/2}\ \hat{p}\,(1-\hat{p})}{E^2} \tag{7.1}$$

where:

- $Z_{\alpha/2}$ is the Z-score for a two-tailed test for a given confidence level α
- $\hat{p}$ is the estimated probability that an attribute is present in the population
- E is the allowed margin of error

The aggregate of main, necessary, and sufficient sampling criteria was subsequently used to select an initial sample for the survey.

(b) Sample selection

First, those geographies with sufficiently high Twitter prevalence were determined. The private market database PitchBook[4] offered this information as summarised in Table 7.6. Regarding company maturity, the search focused on ESVs which had not yet received Series B funding.

Table 7.6: ESV Geographies, their mean Twitter usage, and standard deviation across verticals

Geography	**Mean Twitter use**	**Std. dev. σ across verticals**
Europe excl. UK	71.2%	11.6%
US	77.2%	12.6%
Asia	44.6%	15.5%
UK	84.3%	12.3%

Second, the Asian market was excluded on the basis of a low mean Twitter prevalence of 44.6%. The observation that geographies vary in their Twitter adoption rates suggested to abstain from a global analysis due to difficulties in controlling geographical bias[5]. Among the US and all European countries, the UK was the one with the highest mean Twitter adoption. Accordingly the UK was chosen as a geographic focus of the study.
Third, an industry vertical had to be selected. A summary of the verticals can be

[3] The Twitter API allows up to 180 requests per 15 minute window, depending on the type of requests. Given the rate limit of five Tweets per request and user and a total network size of, for instance, one million Twitter users, the process would require 58 days.
[4] The PitchBook database can be accessed via https://pitchbook.com.
[5] ESVs may have multiple or undisclosed office locations.

viewed in Table G.1[6]. The two verticals with the highest Twitter adoption were the AI & ML and financial technology (FinTech) vertical. The decision for the UK AI & ML ESV vertical was made based on the representativeness of the candidate samples.

Table 7.7: Twitter statistics for UK, AI&ML and FinTech ESVs

Vertical	Stage	Incorporation	Frequency (Twitter)	
AI & ML	All	All	465/654	(71.1%)
	Until Series A	All	446/390	(87.4%)
	Until Series A	From 2015	266/227	(85.3%)
FinTech	All	All	1,375/835	(60.7%)
	Until Series A	All	495/440	(88.8%)
	Until Series A	From 2015	226/190	(84.7%)

To estimate a minimum sample size for each sample, starting with AI & ML, the Cochran Formula 7.1 was applied with an assumed confidence interval of 95% for which $Z_{0.05/2}=1.96$, a conservative assumption of a 5% margin of error, and $\hat{p}=85.4\%$ as the prevalence of Twitter use in the ESV sample. Therefore:

$$n_0 = \frac{1.96^2 \cdot 0.853 \cdot 0.147}{0.05^2} \approx 192 \tag{7.2}$$

However, since the population is finite, the Cochran formula 7.1 had to be adjusted by a finite population correction factor 7.3. The total sample size of all AI & ML firms in the UK was $N=5061$, which yields a corrected minimum sample size of:

$$n_{corr} = \frac{n_0}{1 + \frac{n_0 - 1}{N}} = \frac{192}{1 + \frac{192-1}{5061}} \approx 185 \tag{7.3}$$

whereby the expected margin of error given the corrected actual sample sizes equates to:

$$Z_{\alpha/2}\sqrt{\frac{p\,(1-p)}{n}}\sqrt{1-\frac{n}{N}} = 1.96\sqrt{\frac{0.853 \cdot 0.147}{408}}\sqrt{1-\frac{227}{5061}} \approx 2.55\% \tag{7.4}$$

The result is significantly below the 5% assumed margin of error and indicates that the sample is large enough. Accordingly, the calculations for the FinTech industry yielded a minimum sample size of $n_{corr}=192$ rendering the FinTech sample insufficient in size[7].

[6] Table G.1 can be viewed in Appendix G on page 273.

[7] Corrected minimum sample size given $\hat{p}=84.7\%$, $N=5{,}073$
$n_0 = \frac{1.96^2 \cdot 0.847 \cdot 0.153}{0.05^2} \approx 199$, $n_{corr} = 199 \cdot \frac{199}{1+\frac{199-1}{5073}} \approx 192 > 190$

Last, the size of the sample was limited to companies that were less than than five years old at the time of the survey to comply with Definition 2 of an ESV. The resulting sample is described in the following section.

(c) Sample description

Before starting the survey period, the initial sample size of 266 ESVs on the PitchBook database were complemented with search results of two additional private market databases, Crunchbase[8] and Tracxn[9]. Consequently, the number of identified ESVs was significantly increased, and data consistency and validity was enhanced through cross-checking. This procedure is explained in detail in Section 7.3.5 on data gathering and reviewed as part of the studies limitations in Section 7.5.1. However, it had to be mentioned here to explain the discrepancy in sample size of 266 to 1,077 at survey start in Table 7.8, which outlines the fundraising stages along the survey.

Table 7.8: Event frequencies for AI & ML ESV sample in the UK before, during, and after the survey period

Stage	**Start of Survey**	**End of Survey**	**During Survey**
		Institutional Funding	
Series B funding	0	7	+7
Series A funding	68	86	+37
Seed funding	222	233	+74
Corporate backed	6	9	+3
		Non-institutional Funding	
Angel funding	38	38	+7
Grant funding	30	31	+8
Crowd funding	16	19	+6
Accelerator/incubator	200	176	+18
Secondary transaction	2	2	+1
Convertible debt	0	1	+1
Merged or acquired	1	5	+4
		Other	
Unfunded	520	493	*NA*
Discontinued	0	3	+3
Sum	1,077	1,103	+26

Note: The difference between ESVs before and after the study does not add up since multiple events occurred for ESVs as follows: 142 ESVs had 1 event, 20 ESVs had 2 events, 3 ESVs had 3 events.

During the survey period, 165 ESVs had a fundraising event at which they received institutional or non-institutional VC funding. Table 7.9 and 7.9 provide further in-

[8] The Crunchbase database can be accessed via https://www.crunchbase.com.
[9] The Tracxn database can be accessed via https://tracxn.com.

formation about the ESVs in the sample, including information on their headquarter location, social media and web presence, representation in one of the three private market databases, and their fundraising milestones since incorporation.

Table 7.9: Nominal descriptive statistics of sample

ESVs stages[1]	
Accelerator/incubator	34.4%
Angel funded	9.2%
Convertible debt	0.3%
Corporate funded	1.4%
Crowd funded	3.1%
Debt funded	0.1%
Grant funded	7.9%
M&A	0.6%
Secondary transaction	0.5%
Seed funded	34.2%
Series A funded	10.0%
Series B funded	1.1%
Out of business	0.4%
Sum	100%

ESVs Headquarter ecosystem[2]	
London ecosystem	69.6%
Cambridge ecosystem	3.5%
Oxford ecosystem	2.0%
Bristol ecosystem	1.0%
Other ecosystems	23.9%

ESVs binary characteristics	
Twitter presence	77.2%
Website presence	98.3%
Event during study	18.1%

Private market database source[3]		
PitchBook	Crunchbase	Tracxn
649 (58.8%)	367 (33.3%)	736 (66.6%)

[1] Stages which were achieved by ESVs in sample since their incorporation
[2] All ecosystems with 1% or higher representation in the sample
[3] 649 duplicates were identified among the private market databases, resulting in 1103 unique ESVs.

Table 7.10: Interval descriptive statistics of sample

	Mean	**Min**	**Q1**	**Q2**	**Q3**	**Max**
Days since ESV's incorporation	1,045	−189	680	1,046	1,411	1,784
Days between past fundraises	373	0	205	315	472	1,749
Days since penultimate fundraise	371	0	135	315	506	1,749
Absolute number of fundraises	1	0	0	1	1	12
Absolute number of investors	2	0	0	1	1	19

Note 1: Q1, Q2, and Q3 are the 25%, 50%, and 75% percentiles.
Note 2: Company age is measured since the date of incorporation and ESVs with a negative number of days (-N) since incorporation are to be founded in N days after the survey start.

As described above, different types of primary data were gathered. The mechanics of the data gathering process are outlined in the following section.

7.3.5 Data gathering

Before the survey start, a setup period of one month was used to assemble the starting sample of 1,077 ESVs. Subsequent data gathering took place over 202 days between November 2018 and June 2019 during which bimonthly snapshots of all data types were taken. At each snapshot, newly identified ESVs were added to the sample.

Taking multiple snapshots of the ESVs' Twitter networks was necessary as follower- and friendship ties are not time-stamped, but the study relied on longitudinal time series data.

Overall, four categories of data were required for the study: (a) private market data, (b) Twitter network data, (c) as well as website content and analytic data. Of those four, web analytic and Twitter data are used as direct independent variables, the website content is post-processed to derive network relevance information which then served as independent variables. In turn, private market information served as dependent variables.

The choice of databases can be explained as follows. Twitter was used as a social network platform over Facebook, LinkedIn, and others as it allows researchers to mine data in sufficient quantities and has a high adoption rate among ESVs. Amazon Alexa's web analytics was used because it provided the researcher with inexpensive data access. The private market databases were selected from a pool of 15 sources and selected for data quality, access costs, and high coverage of ESVs. The data was gathered using programming scripts in the Python language[10].

(a) Private market data

Historical financial data. Data drawn from private market databases provided historical financial information about the ESVs such as the amounts, valuation, and the date of institutional or non-institutional fundraising rounds. To triangulate for increased data validity and better coverage of the ESV market, the three databases PitchBook, Crunchbase, and Tracxn were used. Data from the different private market databases were merged and checked for inconsistencies[11]. Several duplicate companies were found among the three databases. If information was only available in one database, it had to be accepted. To resolve identified data inconsistencies, the original source document and Companies House records were viewed[12]. Overall, analyst curated and verified data was trusted over web-scraped data. The arithmetic mean was used for remaining unresolvable inconsistencies.

ESV-investor network data. The ESV-investor network is formed of the ESVs and their investors whereby connections represent investments. The network information was composed by the researcher on the basis of the private market database entries[13].

[10] Unless explicitly mentioned, Python-native or standard data manipulation libraries, such as Pandas (https://pypi.org/project/pandas/) and Numpy (https://pypi.org/project/numpy/) were used.

[11] View Python code on https://github.com/Marcfelske/private-market-database-merge

[12] Companies House can be accessed via https://www.gov.uk/government/organisations/companies-house.

[13] View Python code on https://github.com/Marcfelske/NetworkX, the script used the NetworkX library (https://pypi.org/project/networkx/)

(b) Twitter network data

The main data used to derive the independent variables was obtained by scraping data from Twitter. A main advantage of Twitter's platform over other social media platforms is its relative openness and the availability of an API that facilitates the download of large volumes of data for research purposes. In snapshots taken throughout the survey, all Twitter followers and friends of each ESV were logged[14]. Similar approaches to taking snapshots have been suggested and implemented in previous research (Fischer and Rebecca Reuber, 2014; Yang and Berger, 2017). Before being included to the sample, each company was analysed for signs of having ceased operating such as not functioning websites or a web-scrape search for keywords[15,16]. For each ESV, only Twitter accounts registered as a business account of the ESV were considered. Thus, in all cases where the ESV used a private account, for instance, the founder's own Twitter account, the ESV was excluded. The Python library NetworkX was used to create different versions of the ESVs' social networks including, follower-, friends-, mutual friendship-, and weighted networks[17].

(c) Website content and web analytic data

Website scraping. All identifiable ESVs websites were scraped for contextual information[18], which was complemented with the ESVs' description on Twitter and in private market databases. As mentioned before, Twitter's API was used to mine Tweets, whereby reTweets were excluded. The content between ESVs and the vertices in the respective follower-, friends-, mutual friendship-, and weighted networks was matched using Python script and Porter word stemming (1980)[19].

Website analytics. Amazon Alexa web analytics was used to extract information about inbound links and the page-rank of the ESVs websites[20].

7.3.6 Analysis

After gathering the data it was subjected to two analyses, (a) a time series analysis and (b) three ML models.

[14]View Python code on: https://github.com/Marcfelske/Twitter-data-mining, the script used the Tweepy library to mine data through Twitter's API (https://pypi.org/project/tweepy/)

[15]The keyword search string used was "ceas*" OR "out of business" OR "deadpool*" OR "bankrupt*".

[16]View Python code on: https://github.com/Marcfelske/google-search-scrape, script used the Beautifulsoup4 (https://pypi.org/project/beautifulsoup4/) and Requests library (https://pypi.org/project/requests/)

[17]View Python code on: https://github.com/Marcfelske/NetworkX, script used the NetworkX library (https://pypi.org/project/networkx/)

[18]View Python code on: https://github.com/Marcfelske/web-scraping

[19]View Python code on: https://github.com/Marcfelske/content-matching, Porter stemmer on https://pypi.org/project/nltk/

[20]View Python code on: https://github.com/Marcfelske/web-analytics, script used the Beautifulsoup4 (https://pypi.org/project/beautifulsoup4/) and Requests library (https://pypi.org/project/requests/)

(a) Analysis: time series

The analysis of the time series was conducted with guidance from Robson and McCartan (2016). Previous studies have analysed ESV metrics and their correlation with fundraising events, such as studying changes in employee count (Davila et al., 2003).

The aim of this research project was to investigate whether the occurrence of a fundraising event correlates with a change in social media metrics. As illustrated by Figure 7.3, the analysis split the time series in segments pre-event and post-event.

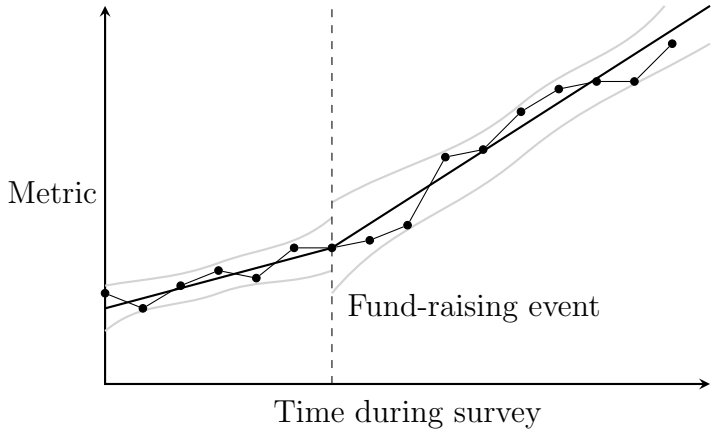


Figure 7.3: Time series schematic, own illustration

The time series was approximated with a linear regression as suggested by related methodological guides (Blaikie, 2003; Ireland et al., 2005; Carpenter et al., 2012; Dusatkova and Zinecker, 2016). When the slope of the regression changed by more than the standard error of the regression, the change was considered relevant. In line with Robson and McCartan's (2016) recommendations, data series were discarded when less than three time series elements existed before or after the event.

(b) Analysis: ML models

The goal of the analysis is to determine the applicability of SNA metrics to model ESV success metrics. Several other studies have used such evaluation of signals to measure a proxy variable they called "signal fit" (Connelly et al., 2011, p. 52).

As discussed in the literature review in Section 7.2.1, the availability of modern ML models made analysis of large data sets feasible. The social network data set comprises of over four million Twitter users, and the data set of 1103 ESVs contains a large number of extreme outliers. As suggested by Carpenter et al. (2012) and Dusatkova and Zinecker (2016), the applicability of a multi-variate regression and OLS were first tested. However, as expected, traditional statistical approaches did not yield significant effects with noteworthy effect strengths.

For further analysis, the data was post-processed into categorical values as sum-

marised in Table D.3.3[21,22]. The post-processing prepared the gathered data for the training of three ML models: a Decision tree (DT), a Gradient Boosted Tree (GBT), and a Random forest (RF)[23]. DTs are a non-parametric supervised learning method which are often used for classification and regression (Raschka, 2012; Goodfellow et al., 2016). RFs are a complified version of DT as they ensemble multiple consecutive trees (Breimann, 2001).
The performance of the models used are judged by their accuracy, F_1 score, precision, and recall compared to similar publications in the research domain (Xiang et al., 2012; Liang and Yuan, 2016; Zhang et al., 2017; Sharchilev et al., 2018; Glupker et al., 2019; Arroyo et al., 2019). The matrix in Figure 7.4 shows all potential categorisation successes and mistakes which can occur when using a ML model to classify instances, in the given case ESV success variables.

	Actual positive	Actual negative
Predicted positive	True positive (TP)	False positive (FP)
Predicted negative	False negative (FN)	True negative (TN)

Figure 7.4: Confusion matrix, modified from Davis and Goadrich (2006)

Formula 5, 6, and 7 were obtained from (Davis and Goadrich, 2006; Powers, 2011; Flach and Kull, 2015).
First, the accuracy of a model, as shown in Formula 4, measures all correctly identified instances as a fraction of the total number of instances.

Formula 4:

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN}$$

Second, an algorithm's recall is defined as the ratio of the correctly predicted instances of a class to the total of true instances of all classes.

Formula 5:

$$Recall = \frac{TP}{TP + FN}$$

Third, the precision of an algorithm is defined as the ratio of the correctly predicted instances of the total of false instances of all classes.

Formula 6:

$$Precision = \frac{TP}{TP + FP}$$

[21]Table D.3.3 can be viewed in Appendix D on page 253.
[22]View Python code on: https://github.com/Marcfelske/post-processing
[23]View Python code on: https://github.com/Marcfelske/machine-learning-models, script used the SKlearn library (https://pypi.org/project/sklearn/).

Fourth, the F_1 score aggregates the recall and precision score by taking their hyperbolic function and thereby strikes a balance to optimise recall and precision simultaneously.

Formula 7:

$$F_1 = \frac{2}{\frac{1}{Recall} + \frac{1}{Precision}}$$

The composition of the ML models can be taken further by investigating the importance of individual metrics[24], which can either measure how often a metric was used to split the trees within ML model, or the achieved information gain from using each metric (Ke et al., 2017). Outlining the analysis approach concludes the research design section. Thus far, the use of social networks to proxy ESV success within this study was explained, all variables as well as the sampling procedure were introduced, and the data gathering strategy was presented. Subsequently, the results of the study are presented.

7.4 Results

The results of the time series analysis (7.4.1) as well as the results obtained from applying the ML models to the data set (7.4.2) are presented separately.

7.4.1 Results: time series

The time series analysis overlayed the fundraising events with the developments in the ESVs social networks and found significant changes as shown in Table 7.11.

Table 7.11: Time series results of 159 events and significant social media metric changes

	Significant changes in Twitter metrics					
Variable	**Up**		**Down**		**Total**	
$followers\_t_i$	59	(38%)	52	(33%)	111	(71%)
$followers\_match\_t_i$	55	(35%)	45	(29%)	100	(64%)
$followers\_match\_w\_t_i$	58	(37%)	48	(31%)	106	(68%)
$followers\_match\_\overline{w}\_pf\_t_i$	59	(38%)	48	(31%)	107	(69%)
$friends\_t_i$	57	(37%)	49	(31%)	106	(68%)
$friends\_match\_t_i$	57	(37%)	50	(32%)	107	(69%)
$friends\_match\_w\_t_i$	57	(37%)	46	(29%)	103	(66%)
$friends\_match\_\overline{w}\_pf\_t_i$	58	(37%)	47	(30%)	105	(67%)
$mutual\_rel\_t_i$	55	(35%)	46	(29%)	101	(65%)
$mutual\_match\_t_i$	52	(33%)	52	(33%)	104	(67%)
$mutual\_match\_w\_t_i$	58	(37%)	52	(33%)	110	(71%)
$mutual\_match\_\overline{w}\_pf\_t_i$	58	(37%)	53	(34%)	111	(71%)

Continued on next page

[24] In the literature, this is termed the "feature importance" (https://lightgbm.readthedocs.io/en/latest/pythonapi/lightgbm.plot_importance.html) to maintain consistent terminology throughout the thesis, feature importance will be referred to as metric importance hereafter.

	Significant changes in Twitter metrics					
Variable	**Up**		**Down**		**Total**	
$weigh\_mutual\_rel\_t_i$	56	(36%)	46	(29%)	102	(65%)
$weigh\_mutual\_match\_t_i$	60	(38%)	52	(33%)	112	(72%)
$weigh\_mutual\_match\_w\_t_i$	61	(39%)	55	(35%)	116	(74%)
$weigh\_mutual\_match\_\overline{w}\_pf\_t_i$	62	(40%)	54	(35%)	116	(74%)

Overall, the analysis covered 165 companies and 191 fundraising events. 32 events of 14 companies had to be excluded as the events happened to early or late during the survey period with less than three snapshots pre-event or post-event. This leaves 151 companies with a Twitter and web-presence and 159 fundraising events. The results indicate a support of the network relevance Hypothesis 7.5 and show that the time around fundraises is particularly volatile for ESVs and their social media presence. In about two thirds to three-quarters of the cases, Twitter metrics varied significantly, meaning the linear regression slopes before and after a fundraising event differed by more than one standard error. Also, a tendency of increases over decreases in Twitter metrics was observed (0 to 7%). Hence, the time series analysis showed a small positive association of fundraise events and changes Twitter metrics. However, for each of the four analysed network types there were no clear tendencies identified[25]. The weighted mutual relationship networks were only slightly more prone to show effects than the other network types. As for the metrics within each network type, the average word matches per user consistently had the highest association.

Further in-depth analysis of the significant metric variation showed that the changes in Twitter metrics lagged behind the fundraising event. As shown in Figure 7.3, the data set was divided into two segments delimited by the fundraising event. The lag can be shown through a sensitivity analysis which tests whether the pre-event regression or post-event regression better describe the social media metrics around the time of the event. On average, in 71% of the cases when the metrics increased and 64% when the metrics decreased, the pre-event regression better described the first post-event metric data point. Thus, it can be said that the change in Twitter metrics lags around zero to two weeks.

The additional analysis used the control variables to segment the data sets into two separate groups either into binary categories or separating at the median value. The following two lists showcase where groups generated from splitting along control variables either exerted notably different behaviour or might have been expected to show different behaviour but failed to do so[26].

Notable differences of ESVs characteristics on social media metric changes following

[25]The four analysed network types can be revisited in Figure 7.2 on page 164.

[26]Reported are those splits where notable differences occurred for at least half of the social media metrics in excess of 10%.

a fundraising event:

1. The older half of ESVs was 26% less likely to have a significant change in metrics
2. ESVs with the upper half of followership numbers were 15% less likely to have a significant change in metrics
3. ESVs with the upper half of friendship numbers were 11% less likely to have a significant change in metrics
4. ESVs which raised funds as part of an accelerator program were 31% more likely to have a significant change in metrics
5. ESVs which had a fundraise event after longer than the mean fundraise frequency had a 22% higher chance to of a significant change in metrics
6. ESVs which had a fundraise event after longer than the mean initial fundraise time were 18% more likely to show a significant change in metrics
7. In all but one case where multiple fundraise events were registered during the survey period, the slope increased, however, the second and third event led to smaller increases than the first.
8. ESVs, which had an above-median follower to friendship ratio, were 39% more likely to show a significant change in metrics.

Notable lack of effect of ESVs characteristics on social media metric changes following a fundraising event:

1. Similar metric changes were found for first or subsequent fundraises
2. Inconsistent social media effects for fundraises of varying investment stages
3. ESVs with their headquarters in various ecosystem locations had indiscernible metric changes
4. Financing round size and valuation had no significant influence on the likelihood of experiencing significant changes in metrics

Another clear trend was found from the analysis of the content matches among ESV followers and friends. Firstly, over 90% of ESVs had a markedly, 13% higher average of word matches with their friends than their followers. ESVs with above median friend to follower content match-ratio were 17% more likely to see a change in Twitter metrics, and a 29% higher chance that the change was positive meaning an upwards trend post-event.
This concludes the time series analysis, the remaining analysis focuses on the results generated with the ML models.

7.4.2 Results: ML models

The ML models are used to determine the meaningfulness of ESV social media metrics as a proxy for ESV success. The three success metrics, (a) fundraise frequency ($fund\_raise\_\bar{t}$), (b) accumulated fundraise amounts (acc_fund_raise), and (c) maximum achieved valuation ($max\_valuation$) were analysed separately, the results of which are summarised hereafter. Finally, the results of a (d) thought experiment to predict ESV fundraises are presented.

(a) Fundraise frequency

The first success variable to be analysed was the fundraise frequency of the ESVs. Table 7.12 shows the accuracy, precision, recall, and F_1 score for the three ML algorithms (DT, GBT, and RF) which modelled the fundraise frequency.

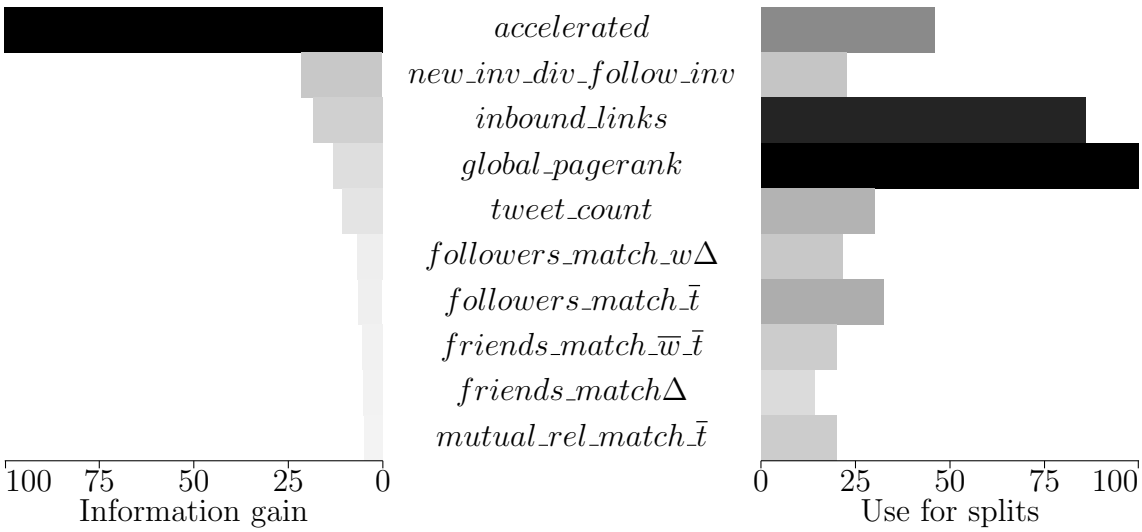
Table 7.12: Fundraise frequency ML model performance

Model	Accuracy	Precision	Recall	F_1
DT	0.54	0.51	0.54	0.52
GBT	0.57	0.52	0.57	0.53
RF	0.56	0.40	0.56	0.45

The results show that more than half of the fundraises were correctly classified into the following categories:

1. no fundraise ($NA\_fund\_raise\_\bar{t}$)
2. pre-incorporation fundraise ($pre\_inc\_fund\_raise\_\bar{t}$)
3. fast fundraise frequency ($fast\_fund\_raise\_\bar{t}$)
4. medium fundraise frequency ($medium\_fund\_raise\_\bar{t}$)
5. slow fundraise frequency ($slow\_fund\_raise\_\bar{t}$)

The most accurate results are achieved for the ESVs that have not yet fundraised (1.) and those with a slow fundraise frequency (5.).
As a next step, all individual metrics were used to classify ESVs for their fundraises. The best classification results were achieved using the GBT model for and Figure 7.5 shows the ten most relevant metrics, both in terms of highest information gain, and number of tree splits to model fundraise frequency.



Note: All metric strengths were normalised to calibrate the most important metric to "100".

Figure 7.5: Metric importance in fundraise frequency GBT model

Analysing the individual metrics shows support for multiple hypotheses as network size, diversity, and relevance based metrics were factored in the GBT model. This can be interpreted as a support of Hypothesis 7.1, 7.4, and 7.5. Overall, ESVs that participated in an accelerator program (*accelerated*) have the highest information gain in the GBT model, which implies that the metrics serve as a strong proxy to explain the fundraise frequency. Closer inspection reveals that accelerated ESVs have a mean fundraise frequency of 326 days compared to 448 days for non-accelerated ESVs. Both metrics, *accelerated* and *new_inv_div_f_o_inv* support the network size and diversity hypothesis. This support stems from the fact that affiliation with an accelerator connects an ESV to a cohort and previous cohorts of ESVs, a high number of newly investing VCs further increases the size of ESVs' social networks, hence increasing network size and diversity.

The remaining metrics support the network relevance hypothesis. Both website analytic metrics, *global_pagerank* and *inbound_links*, are the most used metrics of the GBT model measured by their number of DT splits. However, direct interpretation and therefore meaningfulness for the relevance hypothesis of the two web metrics is inconclusive upon closer inspection. As the mean fundraise time for the upper half of *inbound_links*[27] and *global_pagerank*[28] only differs by ±20 days from that of the lower half, no clear trend could be found. Another point worth noting is that the metrics which measure content matches with friends and followers were more important in the model than the plain follower or friend counts. Although the mean for higher content matches and bigger increases over the survey period only

[27] A high number of inbound links is expected to be a positive success metric.
[28] A low global page-rank is expected to be a positive success metric.

resulted in slightly shorter fundraise amounts, the results were consistent across the content-based metrics. The metric importance in the model is comparable for the content-based metrics and no clear critical metric stood out.

(b) Fundraise amount

The next set of ML models was used to classify the fundraise amounts of ESVs in seven categories:

1. unfunded ($no\_funding$)
2. $US100,000 up to $US500,000 ($five_figure$)
3. $US500,000 up to $US1m ($half_mil$)
4. $US1m up to $US5m ($six_figure$)
5. $US5m up to $US10m ($five_mil$)
6. $US10m up to $US100m ($seven_figure$)
7. more than $US100m ($eight_figure_plus$)

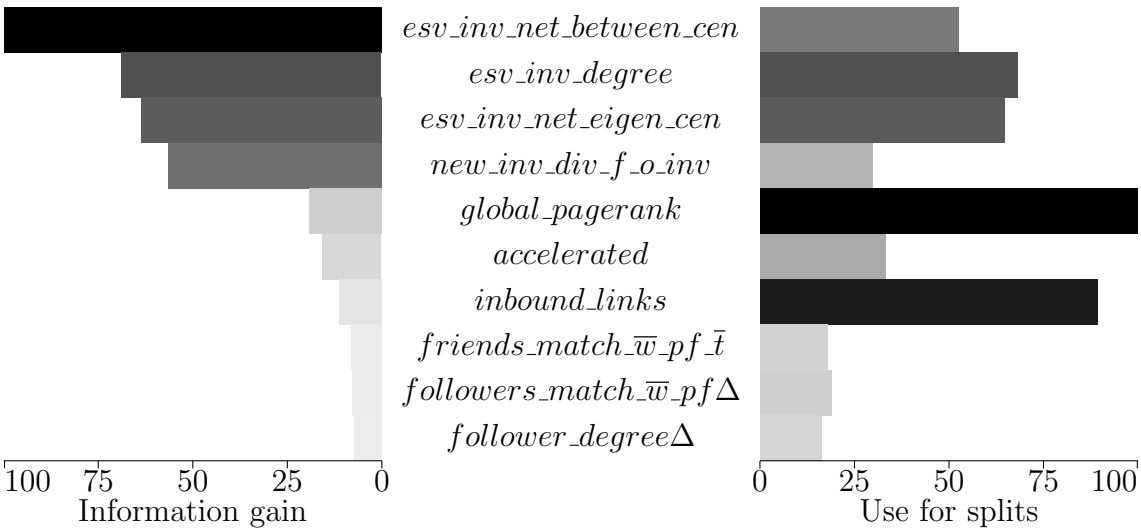
Table 7.13 shows the accuracy, precision, recall, and F_1 score for the fundraise frequency models.

Table 7.13: Fundraise amount ML model performance

Model	Accuracy	Precision	Recall	F_1
DT	0.69	0.70	0.69	0.69
GBT	0.70	0.68	0.70	0.69
RF	0.69	0.52	0.69	0.59

The achieved results are substantially improved compared to the fundraise frequency and range around 70%. Again, the GBT model achieved the best results of the different ML techniques. The model performance was best for the $no\_funding$ and mid to high range fundraise amounts six_figure, $five\_mil$, and $seven\_figure$ categories. However, the precision and recall scores for the lower fundraise amounts, $five\_figure$ and $half\_mil$, were only in the 10 to 40% range.
Figure 7.6 shows results of closer inspection of the the GBT model's ten most important metrics.

This inspection of the individual metric importance reveals an ESV's location in among other ESVs and VCs, which can be interpreted as a support of the network position Hypothesis 7.2. ESVs fundraise higher amounts when they inhabit positions on shortest paths ($esv\_inv\_net\_between\_cen$) and are highly connected to many investors (esv_inv_degree) who are actively investing. Active investing and syndicating makes investors themselves highly connected to other ESVs and VCs ($esv\_inv\_net\_eigen\_cen$). Other important metrics in the model are previous acceler-



Note: All metric strengths were normalised to calibrate the most important metric to "100".

Figure 7.6: Metric importance in fundraise amount GBT model

ation and the ratio of new to follow-on investors (*new_inv_div_f_o_inv*). ESVs with higher fluctuation of investors raised, on average across the sample, more capital. In the GBT model, the web metrics play an important role and are used in many tree splits. As for the fundraise frequency model, the number of content matches between ESV and its Twitter network bring an information gain, again a support of the network relevance hypothesis. This time, the average word matches between ESVs and their friends ($friends\_match\_\overline{w}\_pf\_\bar{t}$) and the increase in followers word matches ($followers\_match\_\overline{w}\_pf\Delta$) are factored in higher than the absolute change in followership ($follower\_degree\Delta$).

(c) Valuation

The last set of ML models categorise the valuation achieved by the ESVs into the same categories as the fundraise amounts. Table 7.14 shows the accuracy, precision, recall, and F_1 score for the fundraise frequency models.

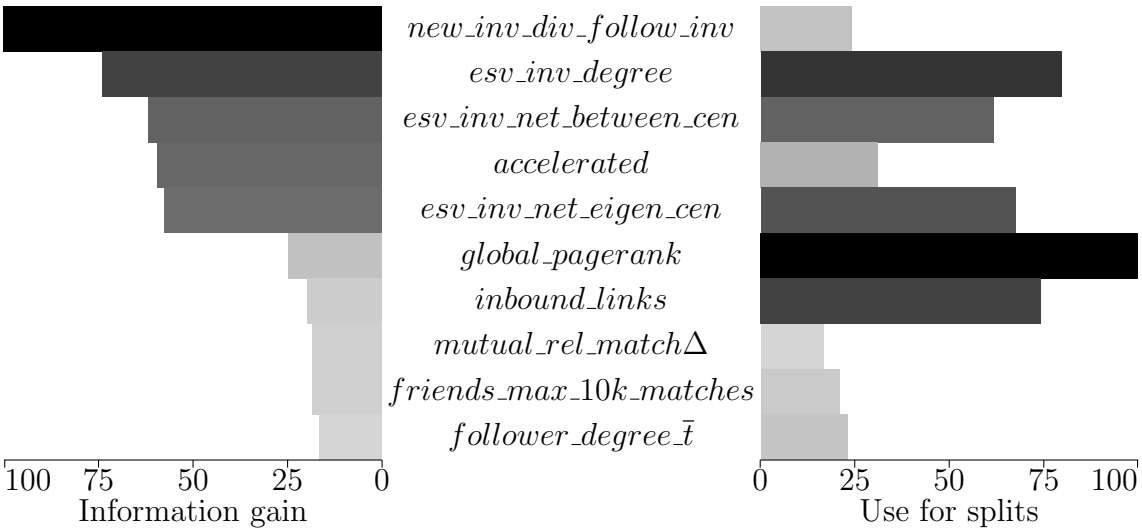
Table 7.14: Valuation ML model performance

Model	Accuracy	Precision	Recall	F_1
DT	0.69	0.80	0.79	0.79
GBT	0.70	0.81	0.86	0.82
RF	0.69	0.75	0.87	0.81

For the third time, the GBT model achieved the highest modelling performance. Particularly the lower valuations, *five_figure* and *six_figure*, were classified reliably by the model, followed by ESVs with *no_valuation*. The higher valuations are

predicted unreliably. It should be noted that the valuation information was only available for 162 ESVs which severely impacts the classification success[29]. A reason for the higher accuracy can be traced back to the fact that most accelerator funding comes in priced rounds with known valuations which are classified reliably.

Figure 7.7 shows the ten most important metrics of the GBT ESV valuation model, which performed the best in predicting the ESVs' valuation.



Note: All metric strengths were normalised to calibrate the most important metric to "100".

Figure 7.7: Metric importance in valuation GBT model

Similar to the results obtained for the GBT fundraise amount model, the position in the ESV-investor network resulted in information gains which supports Hypothesis 7.5. Regarding the social media metrics, this time the mutual relationships, where a Twitter friend is a follower and vice versa, factor in the highest ($friends\_match\_\overline{w}\_pf\_\bar{t}$). Matches of content with such Twitter users can be seen as a support for the network relevance hypothesis. Lastly, the connectedness to the 10,000 highest connected nodes in the network, which includes all ESVs and Twitter users, as well as the followership are used in the GBT model to classify ESV fundraise amounts.

As the last evaluation of the ML models, the GBT model was used to obtain binary classifications of *seed*, *series_a*, and *series_b*[30] and was used to conduct a prediction experiment.

[29] The classifier cannot discern between an ESV that has no available valuation information because it has never fundraised or raised capital an "unpriced" round, versus an ESV which has raised a priced round but valuation information is not available.

[30] 1 means the ESV fundraised the respective round, 0 means it did not, or not yet fundraise the round.

(d) Results: prediction experiment

The GBT model was finally used to identify ESVs which, form a social network perspective, are better situated than their competitors at similar or later fundraising stages. The model helped create predictions for ESVs which should, according to their current social media metrics, be more likely to fundraise than others. The prediction experiment investigated whether ESVs would receive Seed and Series A funding nine months after the end of the survey period[31]. Table 7.15 presents the predicted and actual fundraise events in the post-survey period.

Table 7.15: Series A and Series B fundraise prediction and evaluation

			Model			
Current	**Future**	**ESVs**	**Prediction**		**Evaluation**	
Seed	Series A	233	Fundraise	62	True positive	34 (55%)
			Not fundraise	171	False negative	21 (12%)
Series A	Series B	86	Fundraise	17	True positive	6 (35%)
			Not fundraise	69	False-negative	4 (6%)

As no direct comparison predicted fundraising for ESVs was available from existing literature, it was not possible to compare the predictive quality with other studies. The results clearly indicated that the rate of true positive predictions significantly outweighs the true negative predictions. Thus, a practitioner using the model, could identify a significantly more ESVs which are likely to fundraise than falsely excluding promising ESVs. Of the 233 ESVs that were Seed funded at the end of the survey period, the GBT model predicted 63 seed rounds, of which 34 fundraises were correctly identified. Similarly, of 86 ESVs which were Series A funded, 17 were predicted and 6 fundraised a Series B.

This analysis concludes the presentation of the study's results, and the next section evaluates the robustness.

7.4.3 Robustness

Robustness of the results of the time series analysis and ML models was ensured by taking specific measures aligned with those of previous studies (Vismara, 2016; Arroyo et al., 2019).

For the time series, a high threshold was set at one standard error for changes to be considered significant. Furthermore, the analysis of time series yielded consistent results across all metrics. This consistency reassures that the metric changes timing-wise coincide with with fundraise events.

Robustness of the results generated from the ML models was ensured in five ways.

[31] From June 2019 to February 2020

Firstly, to avoid introducing irrelevant dependent variables, Cramér's V was calculated and only features with associations above 0.1 were included. Secondly, the chosen ML models are tolerant of multicollinearity, nevertheless a sensitivity analysis was performed by selectively excluding metrics from the model (Leung and Yu, 2000; Wooldridge, 2002). The sensitivity analysis did not show noticeable problems originating from multicollinearity.
Third, the ML models randomly split data sets for training, validating, and testing the models (Goodfellow et al., 2016), to ensure that the random split did not accidentally introduce a bias in the resulting sets, cross-validation through k-folds (with k=10) was performed and models achieved consistent results (He and Ma, 2013; Fushiki, 2011).
Fourthly, the logarithmic loss curves of the models' performance on training and validation data were analysed to ensure the models do not over-fit (Brownlee, 2019). For all three models, the log-loss training curves showed asymptotic behaviour, and the maximum deviation between training and validation data never exceeded 11% for the fundraise frequency, 8% for the fundraise and validation model. The fact that model training and logarithmic loss developed in lockstep, which implies that over-fitting has unlikely occurred during the training of the ML models.
Finally, the robustness of fundraise amount and valuation model was tested for its applicability to fundraising stages ($fund\_raise\_stage$). Here, inconsistent results were found, especially for higher fundraise amounts and valuations within the same investment stage. This limits the generalisability of the models as categorisation results across stages are not as precise as for the fundraise amounts and valuations. One identified reason for the imprecise categorisation was the high variance in investment-round size[32].
Overall, the adopted measures and the conservative design ensure confidence in the robustness of the results and repeatability of the study.

7.5 Discussion

Summary. The final study presented in this thesis used a unique data set to identify how social networks can be used as a proxy for ESV success. The focus was on fundraising success metrics, after a review of all identifiable studies in the field suggested this research gap. Classification of ESVs based on these fundraise success metrics highlighted the relevance of a dynamic social network perspective in ESVs evaluation and could serve as an evaluation tool for practitioners. In many ways, the study aggregates the suggested research opportunities found while conducting the research for this thesis and other researchers' studies. Firstly, the study integrates

[32]For instance the classifier would struggle to explain how an ESV raised a larger Seed round of $US3m compared to a smaller $US2m Series A round albeit at a later stage of investment.

concepts of stakeholders, in this case, investor and accelerator networks as well as engagement with the Twitter community. Secondly, the study honed in on a specific form of signalling, online signalling, through ESVs' web and social media presence. Thirdly, established metrics which were validated through a treatment-experiment in Chapter 6 were applied in a real-world case.

Theoretical contribution. The study of social network proxies using a combination of established and new metrics expands the existing knowledge on ESV evaluation. As outlined in the literature review, this study supported the notion that traditional statistical tests are impractical as they failed to describe the non-linear, outlier-rich data (Nahata, 2008; Allison, 2010). Instead, the successful application of ML models based on the size, diversity, position, and relevance of ESVs' networks demonstrated their meaningfulness as ESV success proxies. The only category of SNA metrics that never ranked among the ones with the highest information gain were density-based metrics as described in Hypothesis 7.3. The lack of support for the density hypothesis is in contrast to the previous study in Chapter 6 in which it was the second strongest effect after network size.

Notably, in every GBT model, which consistently outperformed DT and RF models, relevance-based metrics were among those yielding the highest information gain. An analysis of and further research into metrics based on content has been called for in existing research (Xiang et al., 2012; Sharchilev et al., 2018). Consequently a contribution to theory has been made by this study by being the first to consider relevance-based metrics in a study of social network metrics and ESV success indicators. Moreover, the study expands a number of studies that stated relative dominance of offline versus online social networks for ESVs because only offline networks allow an exchange of nuanced content (Tan and Tan, 2012; Song, 2015). As detailed in the literature review, proxy metrics can be applied in ESV modelling. This study contributes by expanding the candidates of metrics for such modelling by online social media metrics. It was demonstrated that online social media content can similarly be analysed and used for ESV success modelling.

A further contribution to theory can be found in the application of state-of-the-art ML models to an important, practice-oriented cause. The literature review discussed a controversy about the feasibility to model the inherently non-linear maturation process and ESV success. Linking back to this controversy this study demonstrated tangible information gains by applying ML models. Thus, the classification results generated by the ML models illustrate how even testing a single perspective, that of social network metrics, can complement the overall assessment of an ESV evaluation by practitioners.

Another contribution to theory can be found in closing a theory practice gap. In the

given case, applications in practice are ahead of academic understanding. This can be observed in the increase of VC funds employing data-driven investment strategies and practitioners who emphasised the importance of relevant online exchange. A concrete example can be found in anecdotal supporting evidence of content and thus the relevance of social network interactions given by AdVC5. In an interview during the study, the Partner of a VC fund that heavily invests into their data-driven decision platform stated that

> *"to get a clear picture of a start-up and its network, understanding content over merely counting instances of something is key, especially when building models based on social media engagement. Whoever cracks that nut first might win the race to build an investment decision AI." (AdVC5)*

Moreover, a Partner at Lightspeed Venture Partners, another US based VC fund with a proprietary data-driven investment platform (Clark, 2019b), recently stated on Twitter: "An ounce of engagement is worth 1,000x more than a pound of audience online. Just having one person interact with and/or be impacted by a piece of content (even as small as a tweet) contains energy - having lots of followers or fishing for likes are often just empty calories."[33].

Implications for practice. The study surfaces several important points to be considered by entrepreneurs and VCs. First, results increased the understanding of online social networks' role for ESVs for fundraising and investor signalling. Second, it highlights that dynamic development of social networks could serve as a measurable signal of ESV fundraising activity. The underlying signalling process relates to the main literature review in Chapter 2, where it was found that many founders are unaware of signals they emit and VCs unaware of the existence of signals (Connelly et al., 2011). Thus, from this study, entrepreneurs of ESVs could not only learn about the importance of their firm's social media presence but also see the identified metrics as guidance for their online social network strategy. Third, founders can learn about the meaningfulness of the content-related metrics. Fourth, founders with mutual connections to the highest connected individuals might have fundraising advantages. This finding supports evidence of other studies that found affiliation to key individuals in the Twitter and VC community to be a competitive advantage (Liang and Yuan, 2016). Together, these points underline how ESV social networks can be purposely built, a process that requires a founder's attention and digital acumen (Fischer and Rebecca Reuber, 2014). Fifth, VCs building data-driven investment tools can seek inspiration from the methods used in this chapter, as well as the metrics that were identified to yielding the highest information gain.

[33]The original Tweet can be found on https://Twitter.com/semil/status/1212948489111425024.

Lastly, the results of the time series analysis yielded that continuous signalling of ESVs could be beneficial for ESVs' success. The rapid decay of signal strength and the merit of constantly signalling has been previously documented in the literature, and the results of this study support these mechanisms (Islam et al., 2018; Ko and McKelvie, 2018).

7.5.1 Limitations and research opportunities

Despite the extensive efforts during the research design, the study has some inherent limitations. It is worth reemphasising that this study aimed at finding correlation and serve as a decision-aid to VCs and does not claim to find causation between online social network, and fundraising metrics or to serve as the sole perspective during pre-investment evaluation.

Although the sampling process identified a sample that should be statistically representative and allow for generalisations, the sample was purposely chosen to have high Twitter prevalence and a technology-oriented industry. It is therefore likely, that samples with a lower prevalence could yield different results and higher statistical deviations. Next, this study's sample comprised firms from one industry vertical, which helped to rule out several methodological threats but limits the conclusions to be drawn for the entire ESV population. Thus, researchers should exercise caution when attempting to generalise the findings of this study in other industries. Nevertheless, within this analysis, it was not apparent that the firms at the extreme ends of the industry spectrum displayed any particular behaviour. Therefore, it could well be that the findings apply to a broader sample.

As discussed in the 3, the challenge with selecting and using proxies is to balance between availability, obtainability, and operationalisation, i.e. how relevant the proxy in measuring the not directly measurable metric. Using Twitter metrics as a proxy is limited in terms of the generalisability on the influence of fundraising outcomes. Thus, it is important to note that the derived evaluation tool only supports and objectifies one slice of a holistic evaluation. Furthermore, the data quality of private market databases is a limiting factor. For instance, not all ESVs were featured in every database and different methodologies used by the database providers could induce biases. As privately owned firms are not required to disclose their reporting as public companies do, a ground-truth information basis is not achievable. Private market databases also provide potentially incomplete or even wrong information. Further biases can be expected to result from inadequately logged, completed and uncompleted deals as well as survivor bias that leads to over-representation of successful ventures. Moreover, the reported deal data inherently lags the fundraising event as the information has to either be picked up online by the private market database or directly reported to them by the participating VC or ESV. Unfortu-

nately, these biases are inevitable when working with this data type and ESVs and VCs are incentivised to not report negative events such as failed investments or even deliberately delete information to polish an entrepreneur's or a fund's history. The introduced bias is hard to estimate, the database provider AngelList admitted that the dark figure of unlisted deals could exceed 50% (Bernstein et al., 2017).

Several further research opportunities can be listed that could build on this study. Future research could attempt to include different data types to explain ESV success. It would be conceivable to use web scraping and extract investors' and accelerators' portfolios for sentiments of value propositions and using online social media to identify these in other ESVs. Including patent data, code-repositories from GitHub, product and app ranking websites, hiring websites, or evaluating entrepreneurship podcasts could yield additional promising signals.
Alternatively, different success metrics as listed in the literature review could be considered. As highlighted in the limitations, different geographies or industries could be tested to identify whether the same metrics apply. For instance, Asian social media networks were excluded for language reasons and sparse use of Twitter. Other researchers could repeat the study for non-western geographies.
Though the study was designed as a longitudinal study with a six month survey period followed by a nine-month post-survey period, the success of ESVs only becomes observable in significantly longer time-frames. Using data sources which facilitate looking back in the past, or surveying for more extended periods, could yield additional findings.

8. Summary and conclusion

Contents

8.1 Thesis summary

An overarching theme governed the research questions explored in this thesis: the process of ESVs emitting signals of investability and the reception and evaluation of these signals by VCs. A detailed literature review contrasting the VC and entrepreneurial perspective on ESV evaluation set the scene. Following the literature review, five dedicated studies were subsequently planned and executed. Over those five studies, the research focus gradually shifted from understanding the pre-investment ESV signalling towards the exploration of social networks as an ESV evaluation perspective.

The research project started with two sub-studies described in Chapter 4. One study qualitatively enquired into the pre-investment signalling process between ESV founders and VCs. The following sub-study examined visualisations of social networks that were provided by founders. While sketching their social network visualisations founders emphasised the primary stakeholder groups in ESV networks. The first sub-study served as the pilot study for this thesis, which identified the potential of taking a social network perspective on ESV evaluation. Results drawn from the second sub-study highlighted differences of ESV social network structures and gave a more nuanced understanding of key stakeholders for ESVs. Furthermore, the two studies reflected the contrasting views of ESVs founders and VCs on signalling, in particular, social network signalling.

In Chapter 5, ESVs' social network stakeholders and their involvement in shaping ESVs' business functions were analysed from a BMI perspective. ESVs researched in the study have incorporated a variety of approaches to leverage their social network for integral business functions and enabled entrepreneurs to optimised the ESVs' operations.

Chapter 6 investigated previous qualitative findings from a more theoretical perspective. A scenario experiment of different ESVs' stakeholder network constellations was used to determine the influence on the perceived evaluation of ESVs by founders and VCs under controlled circumstances. The study also showed that ESV networks could be parameterised by four established social network metrics, size, diversity, density, and position.

The final Chapter 7 synthesised the findings from previous studies into a novel, social network focused evaluation methodology for VCs. Considering the dynamic nature of social networks, helped develop a nuanced understanding of real-world signals that can be used as proxies to improve the evaluation of ESVs' fundraising activity.

8.2 Contrasting individual studies

The methodology used for the studies was developed in Chapter 3 to reflect the multifaceted nature of the ESV evaluation process and the exploratory nature of the research project. By acknowledging the merits and shortcomings of the individual studies, collectively they addressed the particular limitations and enabled a more nuanced, less biased perspective. The individual studies described in Chapters 4 to 7 differed fundamentally in their methodology, which included the enquiry methods, reasoning, utilised theories, and data types. Likewise, the studied subjects, sampling strategy, and consequently, the samples, were varied. Table 8.1 shows an overview of the different studies and summarises their main characteristics.

Table 8.1: Contrasting of research studies

Study of ESV...	Signalling (RQ1)	Stakeholders (RQ2)	Social network functions (RQ3)	Evaluation experiment (RQ4)	Evaluation tool (RQ5)
Number of study	1	2	3	4	5
Chapter	4	4	5	6	7
Enquiry, starting point/ observer's interest	Exploratory; understand the pre-investment process between ESVs and VCs	Exploratory; investigate which stakeholders ESVs include in their social networks	Descriptive; seek and explain approaches that ESVs take to leverage social networks in support of essential business functions	Descriptive; understand the role of social networks in ESV evaluation by studying influence of network constellations	Explanatory; identify relevant social media metrics which are associated with ESV fundraising success
Chapter finding/ Subsequent influence	Stakeholder importance$^{\rightarrow 2}$; network constellations$^{\rightarrow 3,4}$	$^{1\rightarrow}$Stakeholder roles; $^{1\rightarrow}$stakeholder importance for ESV/VC$^{\rightarrow 3}$	$^{1,2\rightarrow}$Stakeholder support of business functions	$^{1\rightarrow}$Influence of constellation on evaluation$^{\rightarrow 5}$	$^{4\rightarrow}$Social network influence on fundraising
Method	Qualitative	Qualitative	Qualitative	Quantitative	Quantitative
Enquiry/data	Semi-structured interviews, primary	Semi-structured interviews, primary	Semi-structured longitudinal interviews, primary	Online survey, primary	Database, secondary
Reasoning	Inductive	Inductive	Inductive	Deductive	Abductive
Unit of analysis	Entrepreneur and VC pre-investment signalling	Entrepreneurial social support networks	Business support through social network	Perceived value of ESV based on social network constellation	ESV fundraising success based on social network metrics
Participants	Entrepreneurs; VCs	Entrepreneurs	Entrepreneurs	Entrepreneurs; VCs; Academics	NA
Sample	34 ESVs and 31 VCs	8 ESVs	5 ESVs	70 VCs, 30 ESVs, 10 academics, 11 other	1103 ESVs and their Twitter and investor social networks
Contribution to theory	Expands the knowledge on signalling theory, by focusing on ESVs, their actions to facilitate pre-investment engagement with VCs, and the perception of this process by founders and VCs.	Contributes to signalling and strategic alliance theory through an elementary understanding of stakeholders found in ESVs' social networks and establishes variance in perceived importance of stakeholders by founders and VCs.	Detailed descriptions of approaches performed by ESVs to leverage external stakeholders for business functions contributes to ESV strategy and dynamic capability theory.	Expands the knowledge on ESV evaluation by isolating the social network perspective. Combining stakeholder constellations with perceived ESV evaluation to increase investability contributes to signalling theory.	Contributes to the literature on ESV evaluation parameters, strategic choices to increase investability through online signalling, and knowledge on overcoming liabilities of newness and smallness. The study expands social network theory to the area of ESV evaluation.

Notation explanation: Influence on subsequent study$^{\rightarrow x}$; $^{x\rightarrow}$Influence from previous study

8.3 Conclusion and outlook

The studies conducted for this thesis have demonstrated the importance of considering social networks for a more comprehensive ESV evaluation. Additional research into this specific problem could yield promising results. Across the chapters in this thesis, several future research opportunities were identified. The findings and identified research avenues present a substantial contribution to the academic and practitioner community by enhancing the knowledge about social network influence on ESV evaluation.

Especially the trend of data-driven investing in VC is relatively nascent. It will be interesting to observe, both from an academic as well as a practitioner perspective, how metrics influence behaviour. As the relationship between VCs and entrepreneurs is increasingly centered around data, it is imaginable that either side aims to optimise or conceal their actions which could lead to new, or a change of biases. Whether in natural sciences or in economic disciplines, the identification and agreeing on new standards has historically taken years. The relevant academic and practitioner communities will curiously observe where the debate might settle.

Another contribution of this work can be seen in the methodological approach. Only collectively can the studies make a promising attempt to bring clarity to a complex, non-linear, non-transparent, and uncertainty-laden process. The additions to theories by the studies, the development of models, and the increased practitioner understanding by this research project present a step towards more comprehensive investment decision-aids in an ESV context.

In the future, both research and practice will advance, and the granularity and precision with which patterns of the ESV founding process can be modelled will increase. Nonetheless, a substantial amount of uncertainty will prevail in ESV investment decision making, which is both challenging and intriguing. Successful and unsuccessful founding stories will continue to have unexpected outcomes.

"Not everything that can be counted counts, and not everything that counts can be counted." (Cameron, 1963, p. 13)

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A. VC data

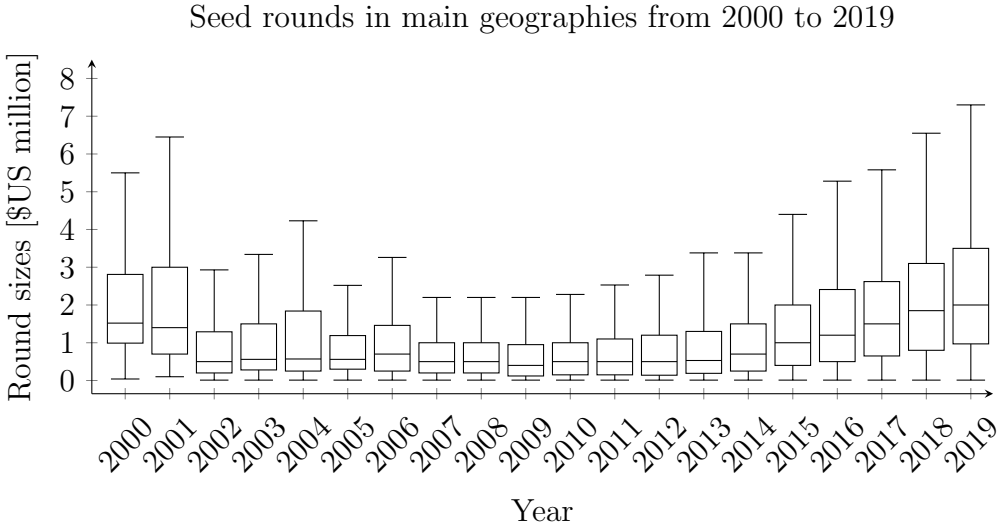


Figure A.1: Seed rounds in main geographies US, UK, Germany, and France, based on Pitchbook data

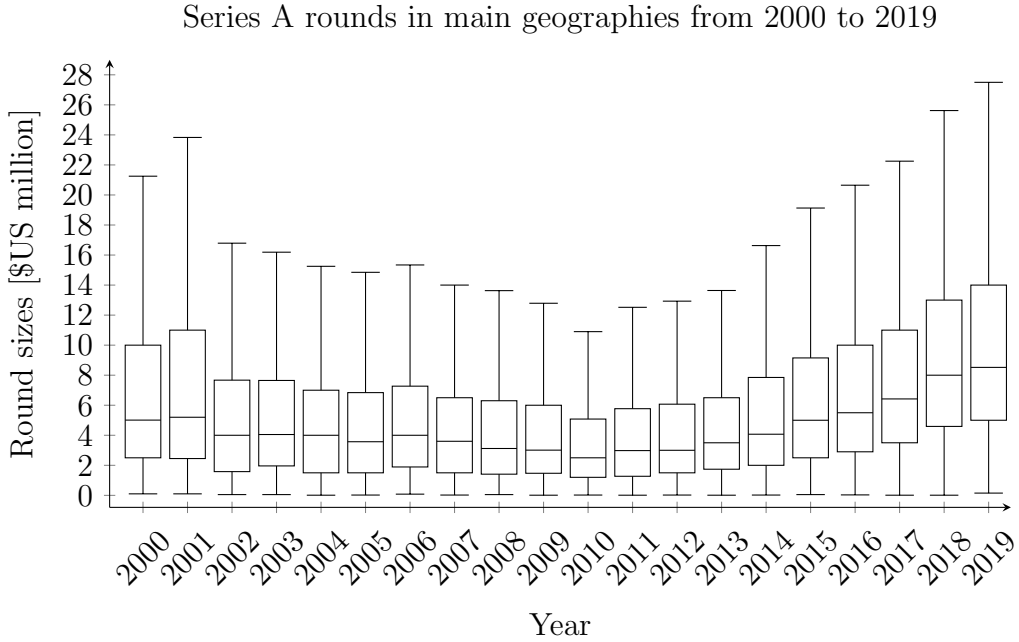


Figure A.2: Series A rounds in main geographies US, UK, Germany, and France, based on Pitchbook data

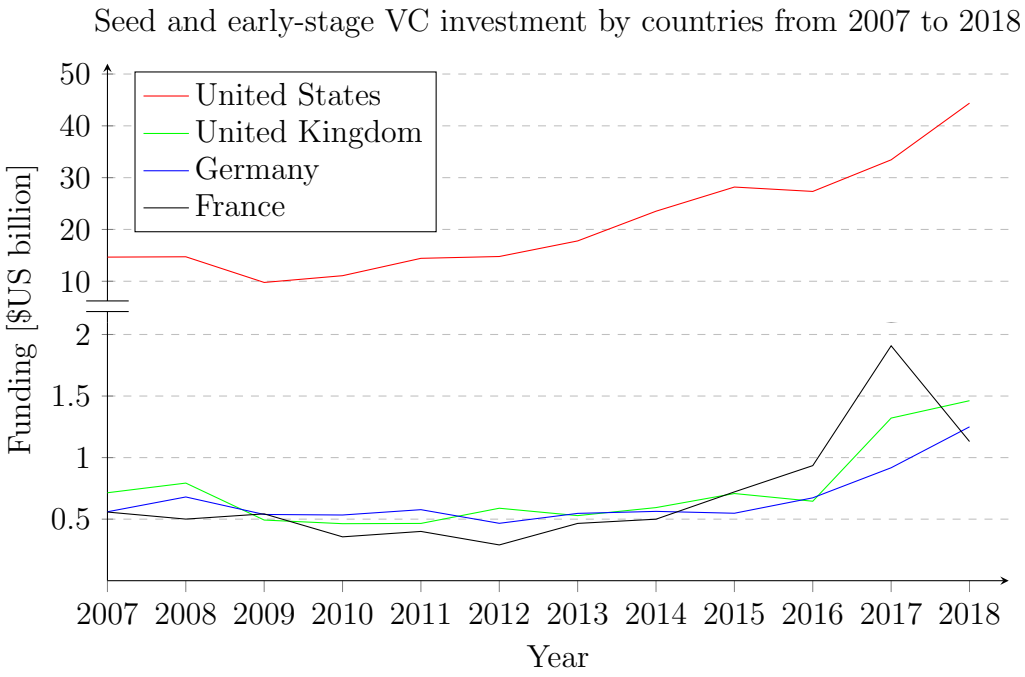


Figure A.3: Seed and early-stage VC investment volume in main geographies US, UK, Germany, and France, based on Pitchbook data

B. Valuation approaches

B.1 Overview of valuation methods

The following overview can also be viewed as an extended version including descriptions of the valuation procedures on:
https://github.com/Marcfelske/VC-valuation-approaches

Table B.1: Overview of traditional valuation approaches

Method name	**Qualitative/ quantitative**	**Post-revenue/ pre-revenue**	**Source**
Venture capital	quantitative	pre- and post-revenue	(Barrell et al., 2013)
Book value	quantitative	pre- and post-revenue	(Koller et al., 2015)
Liquidation value	quantitative	pre- and post-revenue	(Koller et al., 2015)
Replacement value	quantitative	pre- and post-revenue	(Mothersill, 2009)
Discounted cash flow	quantitative	post-revenue	(González Jiménez and Pascual, 2008; Jennergren, 2008; Holloway et al., 1999; Koller et al., 2015).
Net present value	quantitative	post-revenue	(Koller et al., 2015)
First Chicago quantitative	quantitative	post-revenue	(Achleitner and Lutz, 2005)

Table B.2: Overview of non-traditional valuation approaches

Method name	**Qualitative/ quantitative**	**Post-revenue/ pre-revenue**	**Source**
Berkus	qualitative	pre-revenue	(Berkus, 2009; Sahlman and Scherlis, 1987)
Risk factor summation	qualitative	pre-revenue	(Berkus, 2009; Sahlman and Scherlis, 1987)
Scorecard valuation	qualitative	pre-revenue	(Payne, 2011)
High-tech start-up valuation	qualitative and quantitative	pre-revenue	(Cayenne Consulting, 2015)
Comparable transactions	quantitative	pre- and post-revenue	(Campbell, 2003)

C. Samples

The following appendix chapter lists the participants of the studies described in Chapter 4 to 6, and the stakeholders who advised the researcher at various points throughout the research period.

Table C.1: Signalling study ESV case studies

Case-ciphre	Interviewee position	Experience [years]	Country	B2B/ B2C	Industry-vertical	Current stage	Angel	Seed	Series A	Series B	Recruited via	Interview form
SigF1	CEO	2	England	B2B	5, 50	Angel	1	0	0	0	PN	IP
SigF2	CEO	2	England	B2B	2, 5	Angel	1	0	0	0	PN	IP
SigF3	CEO	2	England	B2B	24, 50	Seed	1	1	0	0	L	VCC
SigF4	CEO	8	Singapore	B2C	24, 41	Series A	0	0	1	0	L	VCC
SigF5	CEO	4	England	B2B	50	Angel	1	0	0	0	L	VCC
SigF6	CEO	1	Israel	B2C	41	Seed	0	1	0	0	L	VCC
SigF7	CFO	1	England	B2C	5, 28, 37	Series A	0	1	1	0	L	VCC
SigF8	CEO	7	England	B2B	11, 24	Seed	1	1	0	0	PN	VCC
SigF9	CEO	2	Wales	B2C	50	Unfunded	0	0	0	0	PN	IP
SigF10	CEO	3	England	B2B	5, 27, 34, 44	Seed	0	1	0	0	PN	IP
SigF11	CEO	2	England	B2C	25, 34	Seed	0	1	0	0	PN	IP
SigF12	CEO	4	England	B2B	2, 5, 10, 37	Angel	1	0	0	0	E	IP
SigF13	CEO	2	England	B2B	10, 35, 37	Angel	0	0	0	0	E	IP
SigF14	CTO	1	England	B2C	27, 34	Unfunded	0	0	0	0	PN	IP
SigF15	CEO	1	Scotland	B2B	3, 5, 49	Angel	1	0	0	0	E	IP
SigF16	CEO	1	England	B2B	27, 34, 42	Unfunded	0	0	0	0	E	IP
SigF17	CEO	3	England	B2B	4, 5	Unfunded	0	0	0	0	E	IP
SigF18	CEO	1	England	B2B	27, 34	Unfunded	0	0	0	0	L	VCC
SigF19	CEO	6	England	B2B	5	Seed	0	1	0	0	L	IP
SigF20	CTO	7	England	B2B	27	Series B	0	0	0	1	PN	IP
SigF21	CEO	3	England	B2B	5	Seed	0	1	0	0	PN	IP
SigF22	CEO	4	England	B2B	11	Seed	0	1	0	0	PN	IP
SigF23	CEO	2	England	B2B	5, 30, 33, 36	Seed	0	1	0	0	L	IP
SigF24	CEO	2	England	B2B	27	Seed	0	1	0	0	L	IP

Continued on next page

Case-ciphre	Interviewee position	Experience [years]	Country	B2B/ B2C	Industry-vertical	Current stage	Angel	Seed	Series A	Series B	Recruited via	Interview form
SigF25	CEO	2	England	B2B	5, 18, 27, 54	Seed	0	1	0	0	L	IP
SigF26	CEO	1	England	B2C	25	Angel	1	0	0	0	L	IP
SigF27	CEO	1	England	B2C	2, 10, 19, 40	Unfunded	0	0	0	0	PN	IP
SigF28	CEO	3	England	B2B	3, 5, 33, 36	Seed	1	1	0	0	PN	IP
SigF29	CEO	8	US	B2B	5, 28	Series A	1	0	1	0	PN	IP
SigF30	CEO	6	US	B2B	4	Series B	0	0	0	1	PN	IP
SigF31	CEO	8	US	B2B	7, 30, 53	Series A	1	1	1	0	PN	IP
SigF32	CEO	5	England	B2B	5	Angel	1	0	0	0	PN	IP
SigF33	CEO	4	US	B2B	15	Series B	1	1	1	1	PN	IP
SigF34	CEO	8	US	B2C	26	Series B	1	1	1	1	PN	IP

Legend: Case study interviewee recruited via (PN = Personal network, L = LinkedIn, E = Event);
Interview conducted (IP = In person, (V)CC = (Video) conference call)
Note: Columns Angel to Series B list completed funding rounds; for industry-vertical codes confer Table G.1 on page 273

Table C.2: Signalling study VC case studies

Case-ciphre	Interviewee position	Experience [years]	Country	B2B/ B2C	Angel	Seed	Series A	Series B	Recruited via	Interview form
SigVC1	Sen. Associate	2	Germany	Both	0	0	0	1	PN	CC
SigVC2	Director	14	England	Both	0	1	1	1	L	IP
SigVC3	Director	4	England	Both	0	1	1	0	PN	VCC
SigVC4	Associate	2	England	Both	0	0	1	1	E	IP
SigVC5	Director	2	China	B2B	0	0	0	1	PN	VCC
SigVC6	Associate	2	US	Both	0	1	1	0	L	VCC
SigVC7	Angel	5	US	Both	1	1	1	0	L	VCC
SigVC8	Principal	2	US	B2B	1	1	1	0	PN	IP
SigVC9	Director	7	US	B2B	1	1	1	0	PN	IP
SigVC10	Director	10	US	B2B	1	1	0	0	PN	CC
SigVC11	Associate	5	France	Both	0	1	1	0	L	CC
SigVC12	Partner	5	England	Both	0	1	1	0	L	IP
SigVC13	Partner	10	US	B2B	1	1	1	0	PN	IP
SigVC14	Partner	7	US	B2B	0	1	1	0	PN	IP
SigVC15	Associate	7	US	Both	0	1	1	0	PN	IP
SigVC16	Angel	4	England	Both	1	1	0	0	L	IP
SigVC17	Angel	8	England	Both	1	1	0	0	E	IP
SigVC18	Angel	3	US	Both	1	0	0	0	PN	IP
SigVC19	Angel	9	England	Both	1	1	0	0	PN	IP
SigVC20	Angel	3	England	B2C	1	0	0	0	PN	IP
SigVC21	Associate	1	England	Both	1	1	0	0	E	IP
SigVC22	Angel	8	England	Both	1	0	0	0	E	IP
SigVC23	Angel	7	England	Both	0	1	0	0	E	IP
SigVC24	Director	3	England	Both	0	1	0	0	E	IP

Continued on next page

Case-ciphre	Interviewee position	Experience [years]	Country	B2B/ B2C	Angel	Seed	Series A	Series B	Recruited via	Interview form
SigVC25	Associate	2	Germany	Both	0	1	1	0	PN	IP
SigVC26	Associate	3	England	Both	0	1	0	0	PN	IP
SigVC27	Associate	1	England	Both	1	1	0	0	E	IP
SigVC28	Sen. Associate	1	England	Both	0	1	0	0	E	IP
SigVC29	Associate	2	England	Both	1	1	0	0	PN	IP
SigVC30	Sen. Associate	1	England	Both	0	1	1	0	L	IP
SigVC31	Partner	14	England	Both	0	1	1	1	E	IP

Legend: Recruited via (PN = Personal network, L = LinkedIn, E = Event)
Interview form (IP = In person (V)CC = (Video) conference call)

Note: Columns Angel to Series B list VC fund investment focus

Table C.3: Stakeholder study ESV case studies

Case-ciphre	Interviewee position	Experience [years]	Country	B2B/ B2C	Industry-vertical	Current stage	Angel	Seed	Series A	Series B	Recruited via	Interview form
StaF1	CEO	5	England	B2B	3, 5	Angel	1	0	0	0	PN	IP
StaF2	CEO	3	England	B2C	14, 31, 33	Angel	1	0	0	0	L	IP
StaF3	CTO	7	England	B2B	5	Series A	1	1	1	0	L	IP
StaF4	CEO	15	England	B2B	32	Angel	1	0	0	0	PN	IP
StaF5	CEO	4	US	B2B	5, 6	Seed	0	1	0	0	PN	IP
StaF6	COO	9	US	B2C	5, 54	Series A	1	1	1	0	L	IP
StaF7	CEO	21	US	B2C	17, 30	Seed	0	1	0	0	L	IP
StaF8	CEO	2	England	B2B	18, 35, 54	Series A	0	1	1	0	L	IP

Legend: Case study interviewee recruited via (PN = Personal network, L = LinkedIn, E = Event);
Interview conducted (IP = In person, (V)CC = (Video) conference call)
Note: Columns Angel to Series B list completed funding rounds; for industry-vertical codes confer Table G.1 on page 273

Table C.4: Advising stakeholders for global thesis

Cipher	Interviewee position	Experience [years]	Country	B2B/ B2C	Angel	Seed	Series A	Series B	Recruited via
AdVC1	Partner	8	US	Both	0	1	0	0	L
AdVC2	Principal	7	UK	Both	0	1	1	1	PN
AdVC3	Partner	12	US	B2B	0	1	1	1	PN
AdVC4	Sen. Associate	6	US	Both	0	1	1	1	PN
AdVC5	Partner	7	US	Both	0	1	1	1	L
AdF1	CEO	4	UK	B2B	0	1	0	0	PN
AdF2	CEO	3	UK	B2B	0	1	0	0	PN
AdF3	CEO	3	UK	B2B	1	1	1	0	L
AdLaw1	Partner	16	UK	B2B	1	1	1	1	E

Legend: Recruited via (PN = Personal network, L = LinkedIn, E = Event)
Note: Columns Angel to Series B list all completed funding rounds for founders, investment foci for VCs, and legal representation for fundraising by lawyers

D. Methods

D.1 Schematic coding procedure

Legend:
Interview = I, Answer = A, Summary = S, Category = C

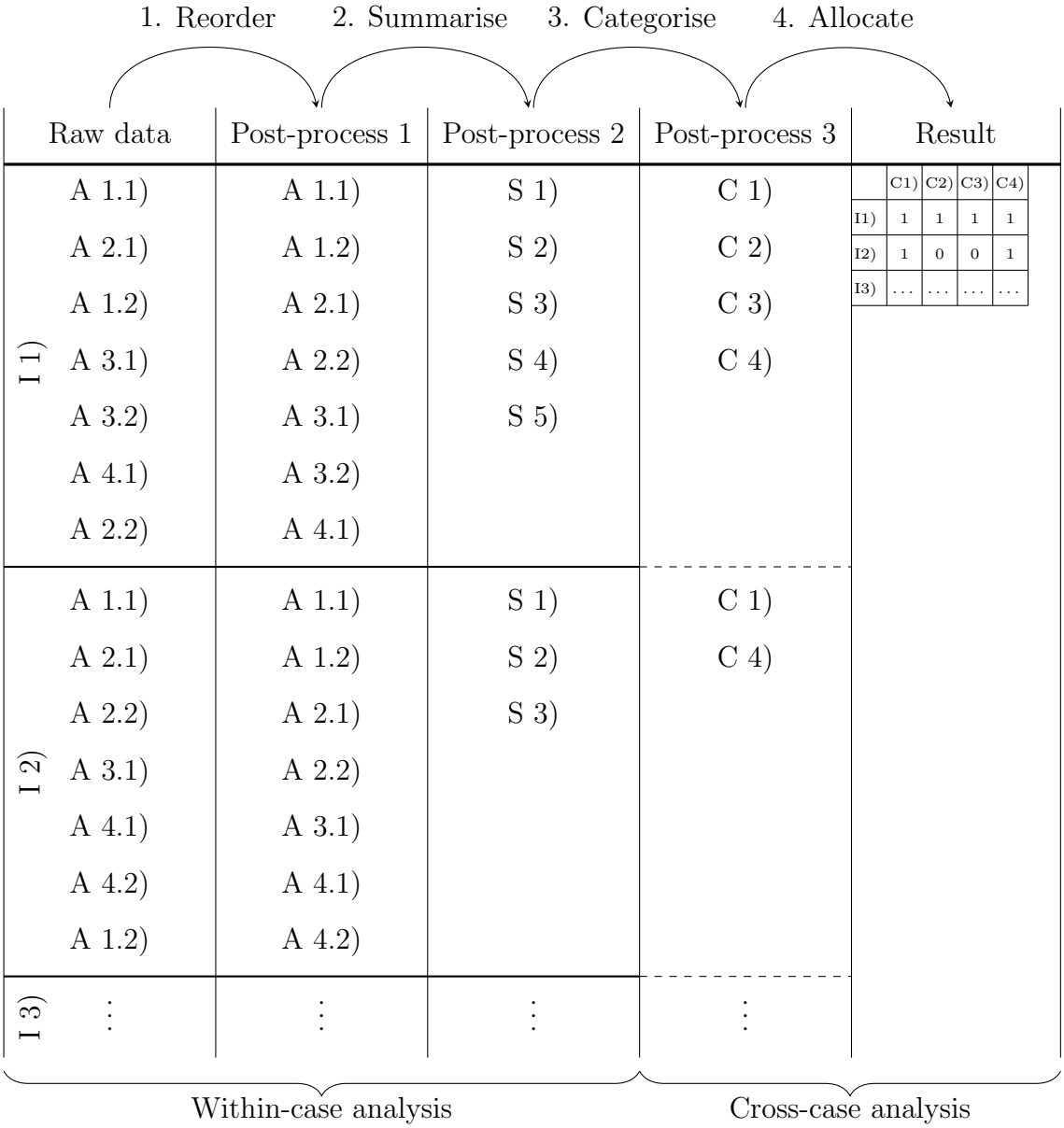


Figure D.1: Schematic coding procedure

D.2 Exemplary coding procedure

The following coding example illustrates how the coding procedure applies to exemplary answers given by the study participants. Consider the example question to VCs: "Which part of your job is the most challenging?"
Table D.1 shows three answers in their raw form as they were given by participants. Table D.2 shows how the answers were summarised and Table D.3 demonstrates how summarised answers were categorised in code-groups.

Table D.1: Example sorted raw answers

Participant	Answer
SigVC2	"It's difficult to separate high quality deal flow from the vast amount of total deal flow." (SigVC2)
SigVC4	"One of the biggest problems for us is how to reduce the amount of DD for each startup and be able to decide faster than the competing investors. Say I'm a sector expert for x-technology, I'll decide faster than someone who first needs to do their homework on x-technology." (SigVC4)
SigVC8	"A challenge is always to get to a quick no. Time you waste on a deal which fails late in DD and you could've weeded out earlier can't be spent on another which looks great." (SigVC8)

Table D.2: Example summarised answer themes

Participant	Summarised answer theme
SigVC2	(Theme 1) Quick identification of high quality deals
SigVC4	(Theme 2) Reduce decision-making time
SigVC8	(Theme 1) Quick identification of high quality deals (Theme 2) Reduce decision-making time

Table D.3: Example classified answers

Summarised answer theme	Code category number
Theme 1	(Code category 1) Managing diligence extent
Theme 2	(Code category 1) Managing diligence extent

D.3 Python Scripts

The following section summarises the python scripts used for the data mining and statistical analysis.

D.3.1 Corrected Cramér's V

For tables larger than 2x2 the bias of Cramér's V increases and should be corrected as follows (Bergsma, 2013).

Formula 8:

$$\tilde{V} = \sqrt{\frac{\tilde{\phi}^2}{min(\tilde{c}-1, \tilde{r}-1)}}$$

with

$$\tilde{\phi}^2 = max(0, \phi^2 - \frac{(r-1)*(c-1)}{n-1}),\ \phi^2 = \frac{\chi^2}{n}$$

and

$$\tilde{r} = r - \frac{1}{n-1} - (r-1)^2$$

and

$$\tilde{c} = c - \frac{1}{n-1} - (c-1)^2$$

where:

- c is the number of columns
- $\tilde{c}$ is the corrected number of columns
- r is the number of rows
- $\tilde{r}$ is the corrected number of rows
- n is the number of observations

The implementation in the used Python code used for the statistical analysis was modified from (Bergsma, 2013; Stackoverflow, 2017):

```
def cramers_v(x, y, nan_strategy=REPLACE,
    nan_replace_value=DEFAULT_REPLACE_VALUE):
    """
    Calculates Cramer's V statistic for categorical-categorical
    association.
    This is a symmetric coefficient: V(x,y) = V(y,x)
    **Returns:** float in the range of [0,1]
    Parameters
    ----------
    x: list / NumPy ndarray / Pandas Series
        A sequence of categorical measurements
    y: list / NumPy ndarray / Pandas Series
        A sequence of categorical measurements
```

```
    nan_strategy: string, default = 'replace'
        How to handle missing values: can be either 'drop' to
        remove samples with missing values, or 'replace'
        to replace all missing values with the nan_replace_value.
        Missing values are None and np.nan.
    nan_replace_value: any, default = 0.0
        The value used to replace missing values with. Only applicable
        when nan_strategy is set to 'replace'.
    """
    # replacing strategy:
    if nan_strategy == REPLACE:
        x, y = replace_nan_with_value(x, y, nan_replace_value)
    elif nan_strategy == DROP:
        x, y = remove_incomplete_samples(x, y)

    # confusion matrix:
    confusion_matrix = pd.crosstab(x,y)

    # chi_squared, phi_squared and size corrected phi_squared:
    chi2 = ss.chi2_contingency(confusion_matrix)[0]
    n = confusion_matrix.sum().sum()
    phi2 = chi2/n
    r,c = confusion_matrix.shape
    phi2corr = max(0, phi2-((k-1)*(r-1))/(n-1))
    r_corr = r-((r-1)**2)/(n-1)
    c_corr = k-((k-1)**2)/(n-1)
    c_v = np.sqrt(phi2corr/min((c_corr-1),(r_corr-1)))

    # pvalue p_v, with degrees of freedom dof:
    dof = (c_corr-1)*(r_corr-1)
    p_v = 1 - ss.chi2.cdf(chi2, dof)

    return c_v, p_v
```

D.3.2 Theil's U

Before calculating Theil's U, the uncertainty coefficient, also called conditional entropy needs to be calculated (Shannon and Weaver, 1969; Press et al., 2007).

Formula 9:

$$CE(X|Y) = -\sum_{x,y} P_{X,Y}(x|y)\ log P_{X|Y}(x|y)$$

with:

$$P_{X|Y}(x,y) = \frac{P_{X,Y}(x,y)}{P_Y(y)}$$

```
def conditional_entropy(x, y, nan_strategy=REPLACE,
    nan_replace_value=DEFAULT_REPLACE_VALUE):
    """
    Calculates the conditional entropy of x given y: S(x|y)
    **Returns:** float
    Parameters
    ----------
    x: list / NumPy ndarray / Pandas Series
        A sequence of measurements
    y: list / NumPy ndarray / Pandas Series
        A sequence of measurements
    nan_strategy: string, default = 'replace'
        How to handle missing values: can be either 'drop' to remove
        samples with missing values, or 'replace'
        to replace all missing values with the nan_replace_value.
        Missing values are None and np.nan.
    nan_replace_value: any, default = 0.0
        The value used to replace missing values with. Only
        applicable when nan_strategy is set to 'replace'.
    """
    if nan_strategy == REPLACE:
        x, y = replace_nan_with_value(x, y, nan_replace_value)
    elif nan_strategy == DROP:
        x, y = remove_incomplete_samples(x, y)
    y_counter = Counter(y)
    xy_counter = Counter(list(zip(x,y)))
    total_occurrences = sum(y_counter.values())
    entropy = 0.0
    for xy in xy_counter.keys():
        p_xy = xy_counter[xy] / total_occurrences
        p_y = y_counter[xy[1]] / total_occurrences
        entropy += p_xy * math.log(p_y/p_xy)
    return entropy
```

With the conditional entropy function, Theil's U can be defined (Zychlinski, 2019).

Formula 10:

$$U(X|Y) = \frac{CE(X) - CE(X|Y)}{CE(X)}$$

with

$$CE(X) = -\sum_{x} P_X(x)\ logP_X(x)$$

```
def theils_u(x, y, nan_strategy=REPLACE,
    nan_replace_value=DEFAULT_REPLACE_VALUE):
    """
    Calculates Theil's U statistic (Uncertainty coefficient) for
    categorical-categorical association.
    This is the uncertainty of x given y: value is on the range of
    [0,1] - where 0 means y provides no information about
    x, and 1 means y provides full information about x.
    This is an asymmetric coefficient: U(x,y) != U(y,x)
    **Returns:** float in the range of [0,1]
    Parameters
    ----------
    x: list / NumPy ndarray / Pandas Series
        A sequence of categorical measurements
    y: list / NumPy ndarray / Pandas Series
        A sequence of categorical measurements
    nan_strategy: string, default = 'replace'
        How to handle missing values: can be either 'drop' to remove
        samples with missing values, or 'replace'
        to replace all missing values with the nan_replace_value.
        Missing values are None and np.nan.
    nan_replace_value: any, default = 0.0
        The value used to replace missing values with. Only applicable
        when nan_strategy is set to 'replace'.
    """
    if nan_strategy == REPLACE:
        x, y = replace_nan_with_value(x, y, nan_replace_value)
    elif nan_strategy == DROP:
        x, y = remove_incomplete_samples(x, y)
    s_xy = conditional_entropy(x,y)
    x_counter = Counter(x)
    total_occurrences = sum(x_counter.values())
    p_x = list(map(lambda n: n/total_occurrences, x_counter.values()))
    s_x = ss.entropy(p_x)
    if s_x == 0:
        return 1
    else:
        return (s_x - s_xy) / s_x
```

D.3.3 Post-processing ML categorisation

The detailed report of the classifications of all variables can be viewed on:
https://github.com/Marcfelske/machine-learning-models/blob/master/ML-data-categories.json

The variables acc_fund_raise $max\_valuation$ were logarithmically converted as follows:
$log_{10}(acc\_fund\_raise)$, and $log_{10}(max\_valuation)$. Table D.4 shows the categorisations for the three independent variables.

Table D.4: Categorisation of independent variables

acc_fund_raise	
Interval	**Category**
$(-0.0, 5.0]$	$no\_funding$
$(5.0, 5.699]$	$five\_figure$
$(5.699, 6.0]$	$half\_mil$
$(6.0, 6.699]$	six_figure
$(6.699, 7.0]$	$five\_mil$
$(7.0, 8.0]$	$seven\_figure$
$(8.0, inf]$	$eight\_figure\_plus$

max_valuation	
Interval	**Category**
$(0.0, 5.0]$	$no\_valuation$
$(5.0, 5.699]$	$five\_figure$
$(5.699, 6.0]$	$half\_mil$
$(6.0, 6.699]$	six_figure
$(6.699, 7.0]$	$five\_mil$
$(7.0, 8.0]$	$seven\_figure$
$(8.0, inf]$	$eight\_figure\_plus$

fund_raise_t̄	
-	$NA\_fund\_raise\_\bar{t}$
$(-3.0, 0.0]$	$pre\_inc\_fund\_raise\_\bar{t}$
$(0.0, 205]$	$fast\_fund\_raise\_\bar{t}$
$(205, 315]$	$medium\_fund\_raise\_\bar{t}$
$(315, inf)$	$slow\_fund\_raise\_\bar{t}$

E. Questionnaires

E.1 Signalling study

The following section presents the ESV and VC specific versions of the questionnaires which were presented to ESV founders and VCs during the signalling study.

E.1.1 ESV questionnaire

Interviewee details

First name: _____

Last name: _____

Position in an ESV*: _____

e.g. co-founder, CTO, employee, or else

Email address*: _____

Please provide an email address which allows me to contact you.

ESV details

Name of the ESV: _____

ESV founding date?*:

(MM/YYYY) _____

ESV legal incorporation date?*:

(MM/YYYY) _____

State the target industry of the ESV*:

B2B/B2C, Hard-, or software, and closer _____

description of the industry vertical _____

Which rounds of financing did ESV^{Name} complete to date?

_____

Please provide a short description of the ESV^{Name}

_____

_____

* required, all other fields are optional

Open questions

What are the main responsibilities of your position?

Which part of your job is the most challenging?

Have you spoken to investors? If yes, tell me about your interactions with investors to fund ESV^{Name}

What information/documentation did you share with the investors?

How do you convince investors to fund ESV^{Name}?

What is makes ESV^{Name} unique, wherein lies the unfair advantage?

How would you respond to the following statement:
"I am familiar with VC investment criteria and preferences"
Please select:

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree nor disagree
- ◯ Agree
- ◯ Strongly agree

What do investors care about when looking at ESV^{Name}?

Did you face any issues during your previous interactions and the overall process of seeking investment? If yes, what is the matter, and how could it be improved?

What would help ESVs demonstrate value in an even more convincing/ efficient/transparent way?

Post interview info

Interview location:
How was the interview conducted?:
Recommended future interview partners:

E.1.2 VC questionnaire

Interviewee details

First name: _____

Last name: _____

Position in VC firm: _____

Email address*: _____

Please provide an email address which allows me to contact you.

VC firm details

Name of VC firm*: _____

Investment focus: _____

Seed, Series A, etc. _____

Please give some examples of companies in your portfolio:

_____

_____

Open questions

What are the main responsibilities of your position?

_____

_____

Which part of your job is the most challenging?

_____

_____

How do you deal with uncertainty when evaluating a startup?

_____

_____

* required, all other fields are optional

Can you explain the procedure how you evaluate ESVs?

Do you use any software, tools, work-flow, or decision-aids? If yes, for what?

Does the use of the above differ for scouring, diligence, etc.? If yes, how?

Do you face any issues during your engagement and diligence with founders? If yes, what is the matter, and how could it be improved?

Which is the most critical piece of information you would want to know about an ESV which so far is unattainable?

Post interview info

Interview location:

How was the interview conducted?:

Recommended future interview partners:

E.2 Stakeholder study

The following section presents the questionnaire presented to ESV founders during the stakeholder study.

E.2.1 ESV questionnaire

Interviewee details

First name: _____

Last name: _____

Position in ESV*: _____

e.g. co-founder, CTO, employee, or else

Email address*: _____

Please provide an email address which allows me to contact you.

ESV details

Name of the ESV: _____

ESV founding date?*:

(MM/YYYY) _____

ESV legal incorporation date?*:

(MM/YYYY) _____

State the target industry of the ESV*:

B2B/B2C, Hard-, or software, and closer _____

description of the industry vertical _____

Which rounds of financing did ESV^{Name} complete to date?

_____

Please provide a short description of the ESV^{Name}

_____

_____

* required, all other fields are optional

Can you draw a representation of ESV^{Name}'s social network with all the connections to stakeholders?

Which are the five most important stakeholder groups for ESV^{Name}

Post interview info

Interview location: _____

How was the interview conducted?: _____

Recommended future interview partners: _____

E.3 Online survey

Section E.3 details the online survey as it was presented to participants.

E.3.1 ESV evaluation experiment study explanation for survey participants

This study focuses on a selection of key metrics which define ESVs social networks. You will be asked to evaluate which social network depictions you perceive as valuable. First, you will be presented with charts that feature four different constellations of ESV social networks, imagine them to be the social network visualisations of four different exemplary ESVs. Each chart contains four constellations which vary according to two metrics.

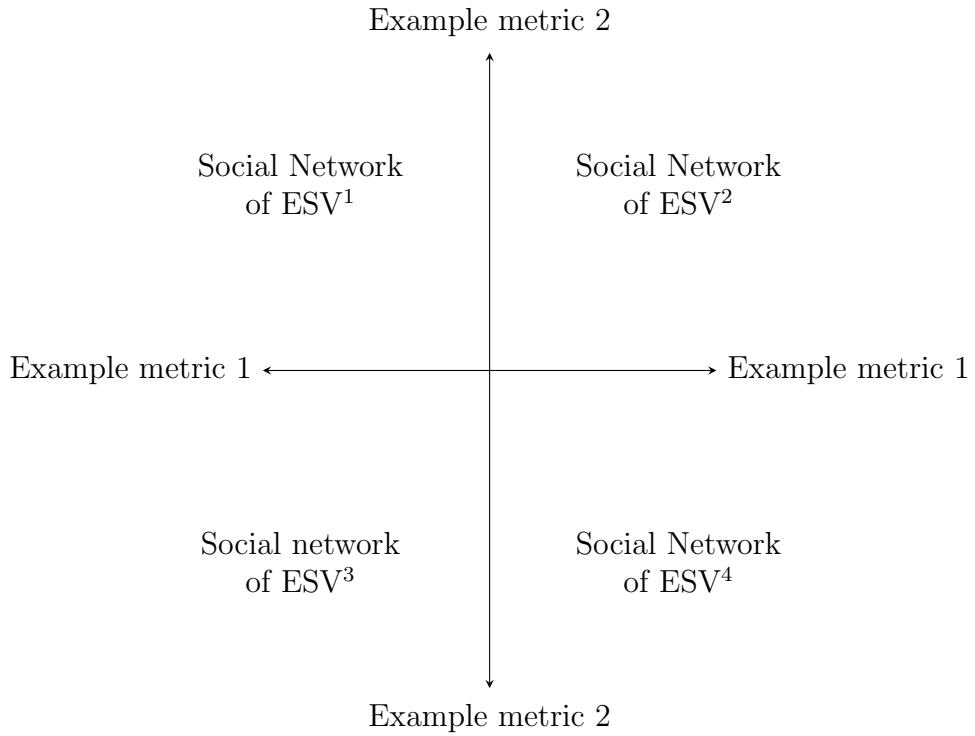
Network metric	**Description**	**Example**
Small or large	How many entities does an ESV know and engage with?	Does the ESV's social network compose of 5 or 50 entities?
Homogeneous or heterogeneous	How diverse are the stakeholder groups in the ESV's social network?	5 VC investors or 1 VC, 1 mentor, 1 accelerator, 1 researcher, and 1 lawyer
Interconnected or dispersed	Do the people and entities in a ESV's network know each other?	Is it beneficial that your mentor knows the VC who is invested in the ESV?
Central or peripheral	Does the ESV know a collaborator directly or via someone else?	e.g. a VC is invested directly or a ESV only knows lawyer via mentor

Using these metrics to create different constellations allows to test the perception of the resulting ESV social network. To increase understanding, the different constellations are visualised as four extreme ESV social networks labelled: ESV^1, ESV^2, ESV^3, and ESV^4. The visualisations are placed in a coordinate system and you are asked to give their professional opinion and evaluate the four fictitious ESV social network constellations. To do so, you have to agree or disagree with the presented statements (example: The social network of ESV^A is valuable) on the Likert scale provided. We will understand your agreement or disagreement with the statement as follows:

- If you agree with the statement, you perceive the social network configuration is valuable and positively influencing the ESV's evaluation.
- If you disagree with the statement, you perceive little value of the a social network configuration which negatively influences the ESV's evaluation.
- If you neither agree nor disagree with the statement, you perceive the social

network configuration to have neither a positive or negative relevance for the ESV's evaluation.

Figure E.1 shows an exemplary evaluation task.



	Disagree strongly	**Disagree**	**Somewhat disagree**	**Neither agree nor disagree**	**Somewhat agree**	**Agree**	**Agree strongly**
ESV[1]'s social network is valuable	○	○	○	○	○	○	○
ESV[2]'s social network is valuable	○	○	○	○	○	○	○
ESV[3]'s social network is valuable	○	○	○	○	○	○	○
ESV[4]'s social network is valuable	○	○	○	○	○	○	○

Figure E.1: Evaluation explanation, own illustration.

E.3.2 Treatment A: size vs. diversity

Some ESVs engage with a limited array of stakeholder types **(homogeneous network)**, whereas others engage with a broader spectrum of stakeholders **(heterogeneous network)**. In the following illustration, colours represent stakeholder groups. In addition, the size of a ESV's social network can vary. Below you see four different ESV networks.

Network metric	Description	Example
Small or large	How many entities does an ESV know and engage with?	Does the ESV's social network compose of 5 or 50 entities?
Homogenous or heterogenous	How diverse are the stakeholder groups in the ESV's social network?	5 VC investors or 1 VC, 1 mentor, 1 accelerator, 1 researcher, and 1 lawyer

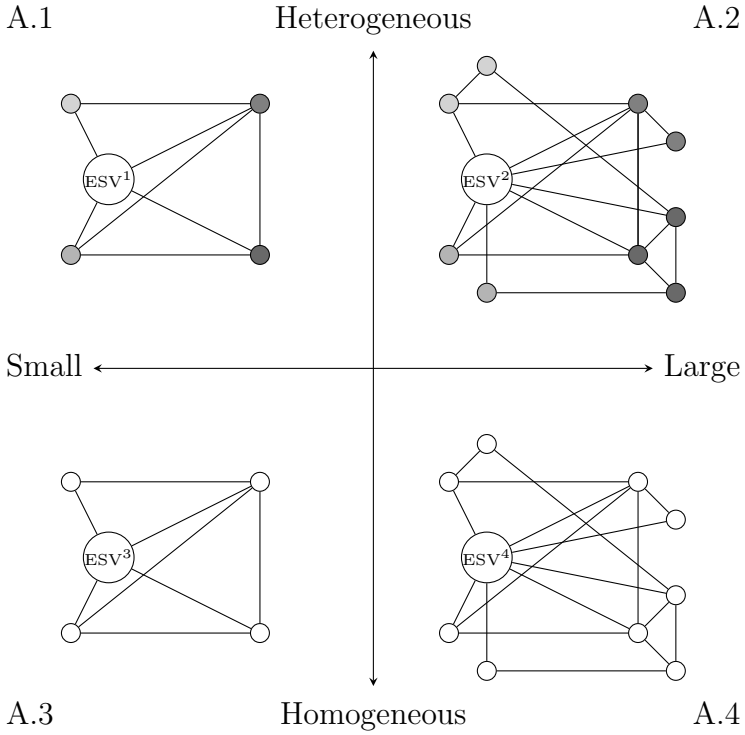


Figure E.2: Social network size and diversity, own illustration.

E.3.3 Treatment B: size vs. density

ESV networks can compose of people/organisations who are **interconnected** or who are **not connected (dispersed)** to one another. Below you see four different ESV networks. You are asked to evaluate them based on their networks.

Network metric	Description	Example
Small or large	How many entities does an ESV know and engage with?	Does the ESV's social network compose of 5 or 50 entities?
Interconnected or dispersed	Do the entities in a ESV's network know each other?	Is it beneficial that your mentor knows the VC who is invested in the ESV?

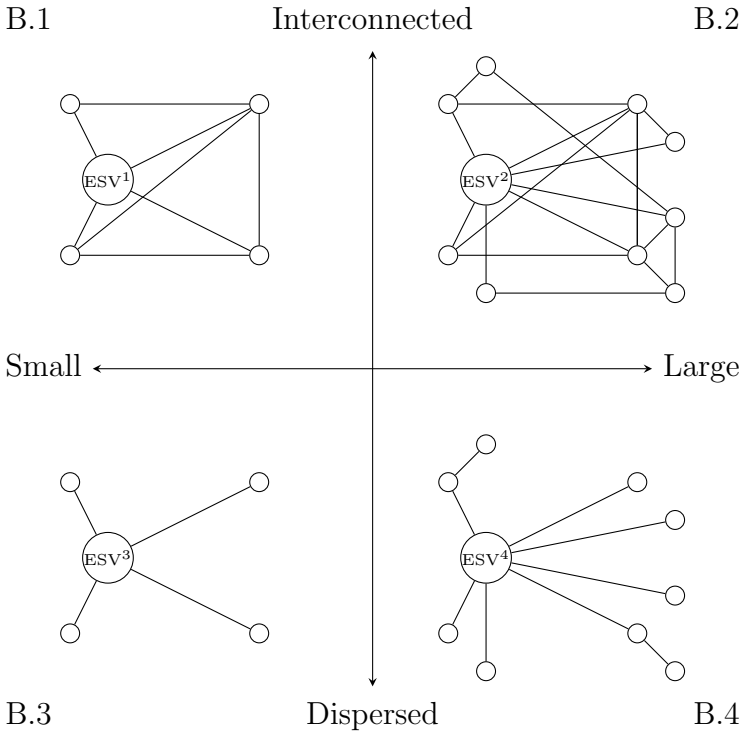


Figure E.3: Social network size and density, own illustration.

E.3.4 Treatment C: size vs. position

An ESV can either occupy a core position in a social network, where stakeholders converge on the ESV itself **(ESV densely connected/ a hub)** or occupy a peripheral position, where their role is not the focal point in the network **(few connections/not a hub)**. Below you see four different ESV networks. You are asked to evaluate them based on their networks.

Network metric	Description	Example
Small or large	How many entities does an ESV know and engage with?	Does the ESV's social network compose of 5 or 50 entities?
Central or peripheral	Does the ESV know a collaborator directly or via someone else?	e.g. a VC is invested directly or a ESV only knows lawyer via mentor

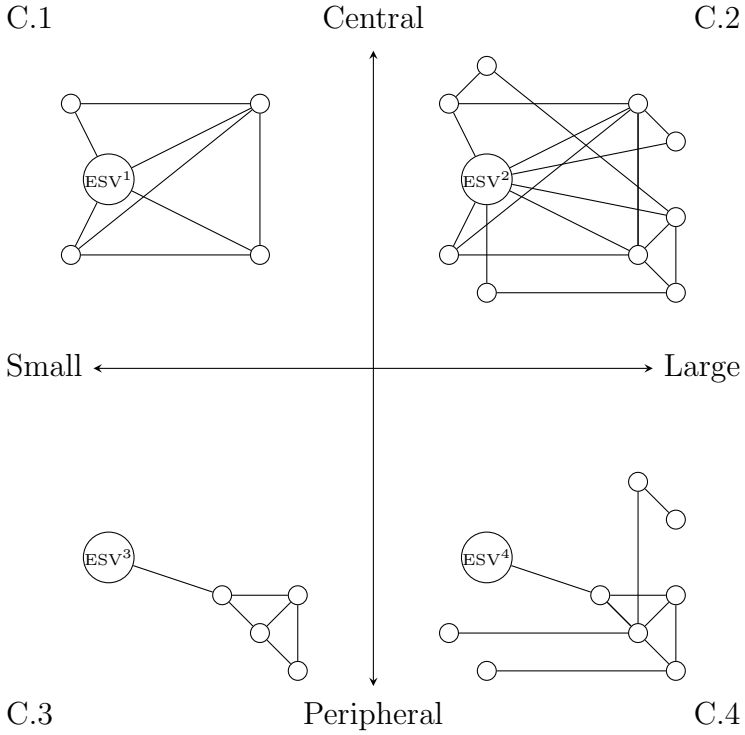


Figure E.4: Social network size and centrality, own illustration.

F. Results

F.1 Stakeholder study (Chapter 4)

Table F.1: 29 stakeholder categories and their importance to ESVs and VCs in alphabetic order

	Mentions				
Stakeholder	**Importance to ESVs**			**Importance to VCs**	**Total**
Accelerator	4	(80%)	<	5 (100%)	5
Adviser	3	(60%)	<	5 (100%)	5
Competitor	2	(100%)	>	0 (0%)	2
Contract researcher	1	(100%)	>	0 (0%)	1
CRO	1	(100%)	=	1 (100%)	1
Customer	4	(67%)	<	6 (100%)	6
Consultant	1	(100%)	>	0 (0%)	1
Corporate (buyer)	5	(100%)	=	5 (100%)	5
Corporate (user)	3	(75%)	<	4 (100%)	4
Former employee	2	(100%)	>	1 (50%)	2
Former employer	3	(100%)	>	2 (67%)	3
Incubator	2	(100%)	=	2 (100%)	2
Investor	7	(100%)	>	4 (57%)	7
Other Start-up	3	(100%)	>	2 (67%)	3
Other SME	0	(0%)	=	0 (0%)	1
Supplier	1	(100%)	=	1 (100%)	1
Journal editor	1	(50%)	>	0 (0%)	2
Journalist	1	(33%)	>	0 (0%)	3
Lawyer	4	(100%)	>	0 (0%)	4
Industry expert	3	(100%)	>	1 (33%)	3
Mentor	2	(67%)	<	3 (100%)	3
Policy maker	1	(100%)	=	1 (100%)	1
PR firm	0	(0%)	<	2 (100%)	2
Media analyst	0	(0%)	<	2 (100%)	2
Publisher	2	(100%)	=	2 (100%)	2
Recruiter	3	(75%)	<	4 (100%)	4
Technology expert	0	(0%)	<	3 (100%)	3
University	4	(80%)	<	5 (100%)	5
Uni. researcher	3	(100%)	=	3 (100%)	3
Sum	66		>	64	

F.2 ESV evaluation experiment (Chapter 6)

Table F.2: Combined treatment A, B, C (network size) regression results, OLS model 1 to 3

		Treatment A (Diversity)	Treatment B (Density)	Treatment C (Position)
Effect variable (*size*)				
1	*ESV_eval*	0.599***	0.909***	0.574***
		(0.137)	(0.134)	(0.160)
Control variables				
0	*constant*	4.809***	4.734***	4.507***
		(0.364)	(0.340)	(0.413)
2	*age*	−0.086	−0.133	−0.053
		(0.094)	(0.102)	(0.106)
3	*gender*	−0.141	0.078	−0.092
		(0.192)	(0.181)	(0.230)
4	*tenure*	0.023	−0.014	−0.022
		(0.039)	(0.041)	(0.046)
5	*active_investor*	0.274	0.590	0.416
		(0.502)	(0.445)	(0.535)
6	*MWE*	−0.177	0.256	0.073
		(0.287)	(0.291)	(0.326)
7	*investor*	−0.252	−0.448	−0.388
		(0.540)	(0.487)	(0.579)
8	*founder*	0.190	−0.134	0.083
		(0.230)	(0.237)	(0.261)
9	*academic*	−0.070	0.090	0.193
		(0.263)	(0.241)	(0.274)
R^2		0.046	0.106	0.034
F-statistics		2.711***	6.861***	1.915***

Notes: N=121; MWE = multiple work experiences; (standard deviations);
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table F.3: Treatment A (network diversity) regression result, OLS model 4 to 9

		Model 4 (A1 vs A2)	**Model 5 (A1 vs A3)**	**Model 6 (A1 vs A4)**	**Model 7 (A2 vs A3)**	**Model 8 (A2 vs A4)**	**Model 9 (A3 vs A4)**
Effect variable (*diversity*)							
1	*ESV_eval*	−0.686***	1.198***	0.686***	1.884***	1.372***	−0.512
		(0.155)	(0.176)	(0.175)	(0.177)	(0.174)	(0.192)
Control variables							
0	*constant*	6.295***	3.586***	4.925***	4.008***	5.346***	4.522
		(0.424)	(0.484)	(0.467)	(0.463)	(0.450)	(0.472)
2	*age*	−0.185	−0.080	−0.114	−0.058	−0.093	0.012
		(0.115)	(0.120)	(0.118)	(0.122)	(0.119)	(0.129)
3	*gender*	−0.054	0.111	−0.311	0.029	−0.394	−0.228
		(0.233)	(0.255)	(0.239)	(0.249)	(0.240)	(0.259)
4	*tenure*	0.045	0.062	0.014	0.033	−0.015	0.001
		(0.040)	(0.049)	(0.050)	(0.044)	(0.044)	(0.053)
5	*active_investor*	−0.015	−0.067	0.252	0.296	0.615	0.563
		(0.450)	(0.624)	(0.672)	(0.664)	(0.672)	(0.865)
6	*MWE*	−0.225	−0.036	−0.533	0.178	−0.319	−0.130
		(0.345)	(0.389)	(0.406)	(0.371)	(0.393)	(0.426)
7	*investor*	−0.059	0.173	−0.071	−0.434	−0.678	−0.446
		(0.512)	(0.687)	(0.727)	(0.726)	(0.733)	(0.928)
8	*founder*	−0.154	0.160	0.452	−0.073	0.219	0.533
		(0.293)	(0.308)	(0.318)	(0.308)	(0.313)	(0.330)
9	*academic*	0.201	0.113	0.044	−0.184	−0.253	−0.341
		(0.308)	(0.322)	(0.350)	(0.319)	(0.340)	(0.326)
R^2		0.109	0.175	0.086	0.330	0.240	0.064
F-statistics		3.815***	5.563***	2.562***	13.264***	8.761***	1.894

Notes: N=121; MWE = multiple work experiences; (standard deviations); $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table F.4: Treatment B (network density) regression result, OLS model 10 to 15

		Model 10 (B1 vs B2)	**Model 11 (B1 vs B3)**	**Model 12 (B1 vs B4)**	**Model 13 (B2 vs B3)**	**Model 14 (B2 vs B4)**	**Model 15 B3 vs B4)**
Effect variable (*density*)							
1	*ESV_eval*	−0.760***	1.074***	0.017	1.835***	0.777***	−1.058***
		(0.171)	(0.179)	(0.177)	(0.184)	(0.180)	(0.184)
Control variables							
0	*constant*	7.107***	3.701***	5.292***	4.160***	5.751***	4.180***
		(0.398)	(0.469)	(0.456)	(0.466)	(0.449)	(0.459)
2	*age*	−0.263**	−0.165	−0.195	−0.071	−0.101	−0.003
		(0.133)	(0.127)	(0.139)	(0.130)	(0.139)	(0.132)
3	*gender*	−0.403	0.334	0.087	0.069	−0.177	0.560**
		(0.253)	(0.240)	(0.245)	(0.270)	(0.267)	(0.247)
4	*tenure*	0.014	0.027	0.025	−0.053	−0.055	−0.042
		(0.051)	(0.052)	(0.055)	(0.053)	(0.055)	(0.055)
5	*active_investor*	−0.060	0.578	0.406	0.774	0.602	1.240**
		(0.545)	(0.376)	(0.552)	(0.556)	(0.686)	(0.559)
6	*MWE*	0.422	0.151	0.137	0.375	0.361	0.089
		(0.383)	(0.405)	(0.414)	(0.374)	(0.388)	(0.400)
7	*investor*	−0.082	−0.246	−0.344	−0.552	−0.650	−0.815
		(0.592)	(0.447)	(0.611)	(0.611)	(0.741)	(0.630)
8	*founder*	−0.367	−0.219	−0.126	−0.142	−0.049	0.099
		(0.309)	(0.311)	(0.318)	(0.314)	(0.322)	(0.323)
9	*academic*	−0.249	0.093	0.156	0.025	0.087	0.430
		(0.286)	(0.344)	(0.312)	(0.316)	(0.279)	(0.336)
R^2		0.123	0.168	0.025	0.315	0.110	0.174
F-statistics		4.424***	5.845***	0.729	14.588***	4.185***	6.190***

Notes: N=121; MWE = multiple work experiences; (standard deviations); $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table F.5: Treatment C (network position) regression results, OLS model 16 to 21

		Model 16 (C1 vs C2)	**Model 17 (C1 vs C3)**	**Model 18 (C1 vs C4)**	**Model 19 (C2 vs C3)**	**Model 20 (C2 vs C4)**	**Model 21 (C3 vs C4)**
Effect variable (*position*)							
1	*ESV_eval.*	−0.587***	2.041***	1.479***	2.628***	2.066***	−0.562***
		(0.155)	(0.177)	(0.189)	(0.181)	(0.188)	(0.210)
Control variables							
0	*constant*	6.671***	2.690***	3.872***	3.662***	4.845***	3.491***
		(0.398)	(0.458)	(0.488)	(0.467)	(0.492)	(0.527)
2	*age*	−0.052	−0.110	−0.089	−0.016	0.005	−0.053
		(0.117)	(0.115)	(0.123)	(0.132)	(0.134)	(0.138)
3	*gender*	−0.431*	0.485*	0.037	−0.221	−0.670**	0.246
		(0.250)	(0.271)	(0.288)	(0.289)	(0.291)	(0.320)
4	*tenure*	−0.025	0.047	−0.018	−0.025	−0.090*	−0.018
		(0.047)	(0.050)	(0.054)	(0.053)	(0.053)	(0.059)
5	*active_investor*	0.766	0.323	0.082	0.750	0.509	0.066
		(0.546)	(0.620)	(0.694)	(0.699)	(0.712)	(0.825)
6	*MWE*	0.181	0.176	−0.119	0.265	−0.030	−0.035
		(0.301)	(0.370)	(0.369)	(0.390)	(0.395)	(0.458)
7	*investor*	−0.798	−0.372	0.078	−0.854	−0.403	0.022
		(0.594)	(0.651)	(0.711)	(0.746)	(0.750)	(0.850)
8	*founder*	−0.151	−0.032	0.227	−0.061	0.198	0.317
		(0.237)	(0.287)	(0.294)	(0.314)	(0.327)	(0.363)
9	*academic*	−0.077	0.182	0.270	0.116	0.204	0.463
		(0.230)	(0.283)	(0.282)	(0.296)	(0.298)	(0.343)
R^2		0.090	0.377	0.210	0.481	0.369	0.050
F-statistics		2.789***	16.549***	7.747***	24.537***	16.738***	1.311

Notes: N=121; MWE = multiple work experiences; (standard deviations); $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

G. ESV industries

G.1 Pitchbook database industry-verticals

The following categories can also be viewed including their descriptions on: https://github.com/Marcfelske/pitchbook-industry-verticals

Table G.1: Pitchbook database industry-verticals

#	Industry vertical	#	Industry vertical
01	3D Printing	28	HRTech
02	AdTech	29	Impact Investing
03	Advanced Manufacturing	30	Industrials
04	AgTech	31	Infrastructure
05	AI & ML	32	InsurTech
06	AudioTech	33	Internet of Things
07	Augmented Reality	34	Life Sciences
08	Autonomous Cars	35	LOHAS & Wellness
09	B2B Payments	36	Manufacturing
10	Beauty	37	Marketing Tech
11	Big Data	38	Micro-Mobility
12	Cannabis	39	Mobile
13	Car-Sharing	40	Mobile Commerce
14	CleanTech	41	Mortgage Tech
15	Construction Technology	42	NanoTech
16	Cryptocurrency & Blockchain	43	Oil & Gas
17	Cybersecurity	44	Oncology
18	Digital Health	45	PetTech
19	E-Commerce	46	Real Estate Tech & PropTech
20	EdTech	47	Restaurant Tech
21	Ephemeral Content	48	Ride-sharing
22	eSports	49	Robotics and Drones
23	FemTech	50	SaaS
24	FinTech	51	SpaceTech
25	FoodTech	52	TMT
26	Gaming	53	Virtual Reality
27	HealthTech	54	Wearables & Quantified Self