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Master Thesis

Exploring the Intersection of Early-Stage Deep Tech Hardware Startups in Europe and Venture Capital Investments

What Investment Criteria do VCs Apply for Early-Stage Deep Tech Hardware Startups in Europe, and How do their Characteristics Vary across Pre-Seed, Seed, and Series A Funding Rounds?

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Abstract

This thesis explores the investment criteria applied by venture capitalists (VCs) for early-stage Deep Tech hardware startups in Europe, focusing on how these criteria and their characteristics vary across Pre-Seed, Seed, and Series A funding rounds. Drawing from a dataset of 102 relevant investment rounds spanning from 2022 to 2024, the study employs quantitative methods to analyse funding dynamics, post-money valuations, equity distribution, public funding trends, industry classifications, and technological maturity milestones.

Findings reveal that VCs prioritise technological innovation and founder expertise at the Pre-Seed stage, market validation and early customer traction at the Seed stage, and scalability and proven market fit at the Series A stage. The research underscores the significance of strategic partnerships and public funding in enhancing investor confidence.

This study builds on Hall and Hofer's (1993) framework, and provides a detailed analysis of VC investment behaviour in the Deep Tech sector. It highlights the higher equity stakes and larger round sizes required for Deep Tech hardware startups, compared to other sectors, among other insights. The thesis contributes to existing literature by offering practical insights for both investors and founders, helping to deal with the complex funding landscape of the Deep Tech hardware sector.

Keywords: Entrepreneurship; Venture Capital; Deep Tech; Hardware Startups; Pre-Seed Funding; Seed Funding; Series A Funding; Investment Criteria

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1. Introduction

In an era defined by rapid technological advancements, the domain of "Tech" stands for the relentless pursuit of innovation. Tech implies a broad spectrum of scientific knowledge and engineering practices dedicated to software development, information technology, and internet-based services, being applied to innovations within the digital and electronic domains (Brynjolfsson & McAfee, 2014; Lyytinen & Rose, 2003). As the world gravitates towards a more complex age, the significance of technology in catalysing societal and economic transformation becomes apparent (Carlsson & Stankiewicz, 1991). Among the various sectors of technological innovation, Deep Tech hardware startups emerge as pioneers, driving forward the boundary of innovation through significant scientific advances and high levels of technical complexity (Dionisio et al. 2023; Heirman & Clarysse, 2004). Due to startups' agility and their potential to challenge the status quo, as well as their ambition to seize market opportunities, startups generally play a crucial role in the transformative process of today's world (Giardino et al. 2014; O'Reilly & Binns, 2019). Looking at Deep Tech specifically, it stands out as disruptive and increasingly integral to securing a competitive edge in the global economy (Braja & Gemzik-Salwach, 2020). Startups in the Deep Tech sector benefit from a market size that is expanding rapidly, as their technologies are central to the next wave of industrial and social revolutions (Dionisio et al. 2023). Timely examples of sectors within Deep Tech hardware include the global markets for solar power, advanced manufacturing, robotics, and space-based innovations. These technologies are experiencing wider adoption, highlighting the immense economic and strategic potential of investing in this field (Dionisio et al. 2023). Moreover, the impact of Deep Tech extends beyond economic metrics, as it promises substantial enhancements in quality of life, environmental sustainability, and the efficiency of industries (Dionisio et al. 2023). Within this thesis, Deep Tech encompasses innovative, tangible products based on advanced scientific and engineering breakthroughs (Dionisio et al. 2023; Heirman & Clarysse, 2004), aiming to address complex challenges across multiple sectors.

1.1 Purpose and Aim of the Research

Despite the potential of Deep Tech hardware startups to address some of the most pressing global issues, they face unique challenges in securing venture capital (VC) funding, especially due to their complexity, coupled with longer development cycles and higher initial capital requirements as compared to conventional technology ventures (Florida & Kenney, 1988; Gompers & Lerner, 2001; Porter & Heppelmann, 2014; Surana et al. 2005; Tibazarwa, 2021). As VCs provide crucial financial resources, as well as strategic and network support for early-stage companies, their funding is central within the startup ecosystem (Dávila, Foster & Gupta, 2003; Florida & Kenney, 1988; Gompers & Lerner, 2001). In academia, there is an existing research gap in investment criteria employed by VCs when evaluating Deep Tech hardware startups, as well as a quantification of those, making the research problem both timely and critical. The gap to be analysed is identified for the European market, where diverse economic environments and innovation ecosystems present unique characteristics to venture funding dynamics (Pradhan et al. 2018).

The scope of this thesis sets focus on traditional VCs operating within the high-risk, high-innovation context of Deep Tech hardware, known for their proficiency in managing the unique risks and complexities associated with high-tech innovation. Traditional VCs are especially relevant, as the complexity of Deep Tech products demands a clear approach to evaluating their potential, and because Deep Tech hardware startups are typically lacking revenue in their early-stages and have longer time to revenue timeframes, demanding professional support (Heirman & Clarysse, 2004; Jiang, Qu & Jain, 2019).

This research aims to highlight the complex interplay between VC investment criteria and the unique characteristics of Deep Tech hardware startups. To the best of the authors' knowledge, recent research sets a focus on software that is less complex and promising more immediate returns, while hardware with untested technologies remains to be more closely examined (Dionisio et al. 2023; Tibazarwa, 2021). Hence, the need for tailored research into investment strategies that enable impactful hardware innovations becomes apparent.

The findings of this research are expected to provide insights into the criteria that are most indicative of successful VC investments in early-stage Deep Tech startups, while shedding light on the characteristics of successful hardware Deep Tech startups, thereby contributing valuable strategic tools for investors and entrepreneurs. By presenting the characteristics that distinguish these startups, the study should enhance academic understanding, offer practical guidance for structuring more effective investment strategies, and foster the growth of this crucial sector. Further, the study aims to offer a detailed analysis of current VC funding trends within the Deep Tech sector, providing a fresh perspective on the interaction between venture funding and technological innovation.

1.2 Focus and Scope of Research

This thesis adopts a focused quantitative and descriptive cross-sectional approach to investigate VC investment criteria and their characteristics for early-stage Deep Tech hardware startups in Europe. Central to this research is a survey tailored to capture detailed responses from VCs actively involved in this sector. This helps to quantify the most impactful investment criteria and analyse the data points across different round stages in different areas, such as team composition, maturity of technology, market traction, and intellectual property strategies. Through this comprehensive approach, this research aims to assess financial and non-financial factors.

Subsequently, the research question of this thesis is:

"What investment criteria do VCs apply for early-stage Deep Tech hardware startups in Europe, and how do their characteristics vary across Pre-Seed, Seed, and Series A funding rounds?"

This question supports the methodical analysis of existing gaps in the literature and adds to contemporary needs of the industry. By adopting a quantitative approach, this study examines in what way VCs have really acted based on past investments, as compared to a qualitative approach that would limit insights to be retrieved based on hypothetical investment preferences.

1.3 Structure and Contribution

This thesis is organised into five main sections. The introduction outlines the economic and technological context, establishes the research question, and highlights the importance and challenges of VC in the Deep Tech hardware sector. The literature review builds on this foundation by examining existing studies, presenting the theoretical background of the topic. This section ensures that the study is grounded in a robust academic framework and directly engages with the existing body of knowledge. The methodology section describes the research design and methods used to collect and analyse data, ensuring the study's findings are reliable and valid. It also introduces the survey this study is based on. The fourth section focuses on results, including an analysis, presenting the core findings of the survey and integrating these empirical insights with theoretical knowledge, discussing how actual investment decisions of VCs align with or diverge from existing literature. Finally, the conclusion synthesises all findings, reflecting on their implications for VCs and entrepreneurs. It assesses the contributions of the study to the broader academic field, discusses limitations, and suggests directions for future research.

2. Relevant Literature and Theoretical Framework

The following sections will scrutinise relevant academic theory on startups and its development stages, Deep Tech, VC, funding rounds, and VC investment criteria to provide an understanding of the status quo in research on these topics, and highlight existing gaps in research.

2.1 Startups and Early-Stage Ventures

The term "startup" holds a variety of meanings in the business world, each looking at different aspects of what makes these ventures unique. A startup is a loosely structured venture on a continuous search for the ideal combination of product and market, while pursuit is about creating something new, and about finding a scalable and profitable way to meet market demands and customer needs (Blank & Dorf, 2012; Picken, 2017). They describe that startups are often seen as the drivers of disruptive innovation, introducing products or services that significantly alter existing markets or create new ones. They tap into uncharted territories with the goal of rapid financial growth, using limited resources to seize large opportunities (Giardino et al. 2014; O'Reilly & Binns, 2019). What sets startups apart from traditional small businesses is their focus on rapid growth, which is central to their identity (Giardino et al. 2014). Founders face high levels of uncertainty as they work to bring new products or services to market, typically in fields that are on the brink of technological breakthroughs (Heirman & Clarysse, 2004; Blank & Dorf, 2012; O'Reilly & Binns, 2019). Further, startups find themselves in different stages of progression, which can be facilitated by utilising the startup stage framework. According to Kollmann (2019), there are three stages of startups: the early stage, the growth stage, and the later stage, as shown in Table 1.

Table 1. Three Stages of a Startup (based on Kollmann, 2019)

Stage of Startup	Overarching Goal
Early Stage	Searching for, creating, and applying ideas
Growth Stage	Gaining substantial traction and generating revenue sustainably
Later Stage	Focusing on expanding market share further and generating significant revenue

The early stage involves searching for, creating, and applying ideas (Kollmann, 2019). According to Blank and Dorf (2012), startups differ from one another in their characteristics, as most early-stage startups, for example, do not generate any revenue, while others do. An early-stage startup's structure is often informal, slackly defined, and changeable (Picken, 2017). Generally, the challenge for the entrepreneurs is to define and validate the business concept, which includes the market opportunity (e.g., critical need, target market, size, and timing), the offering (e.g., product or service and value proposition), the business model (e.g., resources, processes, and economic model), and the go-to-market strategy required to deliver the offering to the target customer consistently and profitably (Picken, 2017). Building on this, the stages will be defined according to Kollmann (2019), who states that a startup's product and its functionalities are typically developed during the early stage. They state that if the startup successfully gains substantial traction and generates revenue sustainably, it will enter the growth stage. This is the stage where the startup focuses on expanding its customer base and increasing its revenue. Also, their findings show that the startup lifecycle's final stage is when it has established itself as a successful business. At later stages, the focus shifts from growth to maintaining and expanding the market share of the business. However, this thesis focuses solely on early-stage startups.

In conclusion, a startup, particularly in its early stage as focused on in this thesis, is defined as a loosely structured venture characterised by its innovative drive to create novel solutions, navigating high uncertainty with limited resources to achieve rapid growth and scalability.

2.2 Technology and Deep Tech Industry

Before delving into the definition of “Deep Tech” it is essential to establish an understanding of technology (Tech). Tech includes a comprehensive spectrum of scientific knowledge and engineering practices (Brynjolfsson & McAfee, 2014). Predominantly, the term is applied to innovations within the digital and electronic domains, such as software development, information technology, and internet-based services (Brynjolfsson & McAfee, 2014; Lyytinen & Rose, 2003). Moreover, Tech signifies the application of technological processes aimed at solving practical problems, enhancing efficiency, improving existing solutions, and introducing novel functionalities across various industries and business operations (Brynjolfsson & McAfee, 2014). Tech builds the foundation for Deep Tech, and embodies tools and systems that are based on technological developments that drive innovation and change (Schwab, 2016).

Deep Tech, a term that has increasingly gained attention within the entrepreneurial ecosystem, refers to startups and technologies at the forefront of innovation. They distinguish from Tech through their strong reliance on breakthroughs in science and engineering of novel, often disruptive technologies that offer scalable solutions to complex challenges across various sectors (Dionisio et al. 2023; Heirman & Clarysse, 2004; Lyytinen & Rose, 2003; Rotolo, Hicks & Martin, 2015). These technologies, among others, include semiconductors, quantum computing, and advanced materials, which will be examined in this study. The complex nature of designing, producing, and bringing hardware products to market presents a distinct set of challenges and research opportunities (Heirman & Clarysse, 2004; Giardino et al. 2014). While software startups benefit from the ability to quickly develop and iterate products with lower capital requirements, hardware startups face the challenges of dealing with the difficulties of physical product development, obtaining regulatory approvals, and managing manufacturing and logistics (Porter & Heppelmann, 2014; Surana et al. 2005; Tibazarwa, 2021). Hence, distinguishing them from software counterparts, hardware startups naturally deal with longer development cycles, extended research and development (R&D) phases, higher initial capital requirements, and more complex supply chain and manufacturing processes, highlighting the need for specialised research on hardware startups (Porter & Heppelmann, 2014; Surana et al. 2005; Tibazarwa, 2021). Mazzucato and Semieniuk (2018) and Stam and Wennberg (2009) discuss the central role of R&D in Deep Tech startups' growth, particularly highlighting the significance of innovative startups as drivers of economic growth.

The complexity of startups impacts how they are perceived and evaluated by potential investors in an investment process (Tyebjee & Bruno, 1984), which this thesis will elaborate on in Chapter 2.4. Despite their potential, Deep Tech startups face unique challenges in building a business around emerging technologies whose market applications may still be evolving and require significant funds (Andries & Debackere, 2007; Hoyer et al. 2020). Hence, the role of venture capital becomes crucial in this context, which will be further examined in the following Chapter.

In conclusion, this thesis defines Deep Tech as developing innovative, tangible products based on advanced scientific and engineering breakthroughs, aiming to address complex challenges across multiple sectors. Hence, an early-stage Deep Tech hardware startup is defined as a startup characterised by its innovative drive to create novel solutions, navigating high uncertainty with limited resources to achieve rapid growth and scalability within Deep Tech.

2.3 Venture Capital and Venture Capital Firms

VC serves as a mechanism within the entrepreneurial ecosystem, fuelling high-potential startups with dilutive capital across funding rounds, and strategic guidance necessary for groundbreaking innovation and rapid growth in exchange for equity in the startup (Dávila, Foster & Gupta, 2003; Florida & Kenney, 1988; Sahlman, 1990). VC is a form of private equity specifically designed to invest in early-stage companies that exhibit the potential for outsized returns (Gompers & Lerner, 2001; Sahlman, 1990). This thesis will explore investment criteria relevant to VCs investing into Deep Tech hardware startups in Chapter 2.5. The VC investment process consists of several steps, including sourcing, screening, selecting, analysing, and deciding, as indicated in Figure 1. It ensures a clear evaluation process from the initial encounter with potential investment opportunities to an investment decision assuming an eventual exit from successful investments (Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022; Gompers et al. 2020).

Figure 1. VC Investment Process

VC firms pool funds from individual and institutional investors and allocate these resources to promising startups in exchange for equity stakes (Hellmann & Puri, 2002). Considering the risks involved in investing into early-stage companies in often untested markets, literature explains how VCs deal with these risks by diversifying their investment in financing a variety of startups (Coombs & Huang, 1970; Chaplinsky & Gupta-Mukherjee, 2016; Ruhnka & Young, 1991).

Generally, various types of VC firms can be distinguished, such as traditional VCs, corporate VC (CVC), limited partnership VC, governmental VCs, labour-sponsored, or private equity firms (Cumming, 2005). This thesis focuses on traditional VCs with a focus on financial gain, due to the unique capabilities of traditional VC firms in dealing with the high uncertainty and significant information asymmetry characteristic of Deep Tech startups (Kaplan & Strömberg, 2004). Traditional VCs have developed specialised mechanisms for managing the investment process at early stages, significantly mitigating risks and facilitating the growth and development of startups (Dávila, Foster & Gupta, 2003; Florida & Kenney, 1988), as scrutinised in Chapter 2.1. Additionally, traditional VCs prioritise potential high returns, aligning their investment strategies with the high-risk, high-reward profile of Deep Tech startups, which, despite their high failure rates, offer the promise of substantial returns (Andries & Debackere, 2007; Cantamessa et al. 2018; Dimov & De Clercq, 2006; Kaplan & Strömberg, 2004). The extended cycles in Deep Tech pose challenges for maintaining momentum and investor interest, emphasising the need for VCs who are committed to long-term investments and who possess a deep understanding of the technological domain (Florida & Kenney, 1988; Hall & Lerner, 2010).

According to Cumming and Johan (2008), and Hsu (2004), the goal is to steer the company towards a profitable exit. Thus, VCs often take an active role in the startups they invest in by providing valuable mentorship, access to extensive networks, and strategic advice, to accelerate startup growth, support market entry, and ensuring long-term success in competitive industries (Gompers & Lerner, 2001; Hsu, 2006; Kaplan & Strömberg, 2004). Startups backed by VCs achieve greater economic success and show enhanced resilience compared to non-VC-funded ventures (Hsu, 2006; Popov & Roosenboom, 2013). According to Hall and Lerner (2010), and Stam and Wennberg (2009), the financial support from VCs enables startups to accelerate their growth trajectory, pushing beyond the limitations of bootstrapping or debt financing, as capital requirements in Deep Tech are significant due to the costs associated with research, development, and scaling of innovative technologies. Hence, selecting a suitable VC partner for startups is essential, as Dimov and De Clercq (2006) state by examining the relationship between VC investment strategies and their portfolio failure rates. Their findings reveal that VCs with specialised development stage expertise have lower default rates, highlighting the importance of niche expertise in mitigating investment risk. Further, being associated with a reputable VC firm or having a strong lead investor when fundraising can serve as a powerful endorsement of a startup's potential, enhancing its credibility in the eyes of customers, partners, and future investors (Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022; Dávila, Foster & Gupta, 2003; Kaplan & Strömberg, 2004; Stuart, Hoang & Hybels, 1999; Khaire, 2009).

Ultimately, VCs serve as an instrument within the entrepreneurial ecosystem, fuelling high-potential startups with dilutive capital across funding rounds, and strategic guidance necessary for groundbreaking innovation and rapid growth in exchange for equity in the startup, having a tolerance for risk and long-term investment, making them uniquely suited to support the development and commercialisation of breakthrough innovations. This thesis focuses on VCs investing into hardware Deep Tech startups.

2.4 Funding Rounds

In VC financing, funding rounds represent distinct stages where startups fundraise equity capital from VCs under specific terms at different points in their development, catering to the startup's changing financial needs and valuation milestones (Drover et al. 2017; Kollman, 2019). According to Botella-Carrubi, Maqueda-Llongo and Valero-Moya (2022), VC financing is typically structured into several rounds, starting from Pre-Seed to Seed to subsequent rounds labelled as Series A, Series B, and so on, as following letters indicate a later financing round. Syndication, where multiple VCs participate in a funding round, is common in VC financing as it spreads the risk among various investors, provides additional resources and expertise to the startup, and validates the startup's potential through the collective analysis and involvement of multiple VCs (Lerner, 1994; Lockett & Wright, 1999). Sequential financing lets VCs reduce risk by releasing funds in stages to high-potential, yet unproven startups, meaning the payout of funds depends on the startup meeting predefined milestones and goals (Lockett & Wright, 1999).

The following section looks at the different stages mentioned above, examining the evolution of financing (Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022):

1) **Pre-Seed:** Commonly, this is the initial round of financing that startups raise. It helps entrepreneurs validate their business idea and develop a prototype. The funding frequently comes from friends, family, angel investors, and VCs.
2) **Seed:** A seed financing round typically follows the Pre-Seed financing round or might be the initial financing round used to help the entrepreneurs develop their product or service. The objective is to assist the startup in reaching the point where it can scale and grow.
3) **Series A:** This is the next round of financing, where the startup raises capital from VCs to help them develop their product or service and gain more traction in the market. Often, this follows a more finance-driven investment approach conducted by institutional VCs and surpasses the capabilities of most business angels or private individuals.
4) **Series B and beyond:** If the startup is thriving and continues to grow, it may go through additional financing rounds. The startup raises additional capital from external investors to help gain a stronger foothold in its market and position itself for long-term success. At this stage, startups should have made initial revenue already.

Typically, after going through various financing rounds, startups have several options to exit: acquisition, liquidation, and IPOs, which dictate the returns to its founders and investors (Cumming & Johan, 2008; Hsu, 2004). Hence, exiting is beyond the scope of this thesis. As established, this research focuses on startups which received VC funding in Pre-Seed, Seed, and Series A rounds in the Deep Tech hardware sector, aligning with Kollmann's (2019) definition of early-stage (Chapter 2.1).

2.5 Investment Criteria

Investment criteria are central to understanding VC decision-making. As discussed in Chapters 2.3 and 2.4, VC decision-making is complex and multidimensional, demanding a comprehensive analysis of various criteria that influence investment choices at different stages of a startup's development. The investment criteria are crucial in identifying startups with the highest potential for success and innovation (Hall & Hofer, 1993; Tyebjee & Bruno, 1984), and often serve as quantifiable metrics that allow startups to measure their progress toward business goals. While these metrics are subject to change, they underscore the need for adaptability in the assessment processes (Hall & Hofer, 1993; Stuart & Abetti, 1987; Tyebjee & Bruno, 1984). According to works by Hall and Hofer (1993), Gompers and Lerner (2001), and Stuart and Abetti (1987), these criteria provide a critical framework through which both startups and VCs can monitor progress, make informed decisions, and demonstrate their growth trajectory and operational effectiveness.

In the specific context of hardware Deep Tech startups, investment criteria extend beyond conventional growth metrics (Hall & Hofer, 1993; Heirman & Clarysse, 2004; Greenberg, 2013; Popov & Roosenboom, 2013). These elements are particularly relevant given the challenges and high stakes involved in Deep Tech startups, which often create new markets by pushing the boundaries of current technological capabilities, enriched with scientific knowledge (Andries & Debackere, 2007; Brynjolfsson & McAfee, 2014; Hoyer et al. 2020).

A study conducted by Hall and Hofer (1993) allows deeper exploration of specific investment criteria of VC assessment, providing a basis to understand how VCs evaluate potential investments, and the foundational framework to identify relevant investment criteria within this thesis. Their work emphasises that a better understanding of the criteria VCs apply could lead to an improvement in the startups' success rate, help founders raise the significant funds they need to obtain to bring their products to market, and initiate economic growth as well as societal change. Their insights guided the approach to defining and selecting investment criteria that are relevant and critical for assessing the potential of investments in early-stage Deep Tech startups (Table 2).

Table 2. Findings on Venture Capitalists' Investment Criteria (in Hall & Hofer, 1993)

	Wells, 1974	Poin-dexter, 1976	Tyebjee & Bruno, 1984	MacMillan et al. 1985	MacMillan et al. 1987
Venture capital firm requirements					
Cash out potential		x	x	x	
Equity share		x			
Technology, product, market			x		
Financial provisions for investors			x		
Geographic location			x		
Investor control		x			
Investor group	x				
Rate of return		x			
Risk		x			
Size of investment		x	x		
Stage of development	x	x	x		
Characteristics of the proposal					
Requirement additional material	x				
Stage of plan	x				
Characteristics of the entrepreneur / team					
Ability to evaluate risk				x	
Articulate re: venture					x
Background/experience	x	x			x
Capable of sustained effort				x	

	Wells, 1974	Poin-dexter, 1976	Tyebjee & Bruno, 1984	MacMillan et al. 1985	MacMillan et al. 1987
Managerial capabilities	x	x	x	x	x
Management commitment	x				
References	x				
Stake in firm	x				
Nature of the proposed business					
Product/market considerations	x		x		
Economic environment of proposed industry					
Market attractiveness			x	x	
Potential size	x				
Technology	x				
Threat resistance			x		
Strategy of the proposed business					
Product differentiation			x		
Proprietary product	x			x	x

Drawing from Hall and Hofer (1993), several critical investment criteria were identified, including IP protection strategy, technology phase, investment structures, human capital, and market dynamics. These criteria help VCs assess the financial health, growth potential, and valuation of startups, as well as measure the capabilities of the team to execute business strategies and navigate challenges. Additionally, the market and industry dynamics assess a startup's market engagement and ability to capitalise on industry trends. By integrating these insights, a structured approach was developed to delve deeper into relevant investment criteria, ensuring that the selection is scientifically robust, relevant, and aligned with established VC evaluation practices (Chapter 3.4). Hall and Hofer's (1993) framework bridges the gap between theoretical exploration and practical application.

Supplemented by relevant literature, the most dominant investment criteria will be explained more thoroughly in the following.

Round Stage: The financing stage reflects the developmental phase of the startup, highlighting its risk profile and operational maturity. Each stage demands a distinct investment rationale, aligning with the venture's growth phase and strategic needs (Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022).

Round Size: The size of investment rounds mirrors the venture capitalists' confidence in a startup's potential, and serves as a catalyst for scaling operations and accelerating growth trajectories, as evidenced by research focusing on the implications of round size on startup success (Ang, Chia & Saghafian, 2020; Zubakina & Koliasov, 2023). According to Botella-Carrubi, Maqueda-Llongo & Valero-Moya (2022), round sizes for startups range between €0.005 to €0.5 million at Pre-Seed, €0.5 to €2 million at Seed, and €2 million to €10 million at Series A.

Post-Money Valuation: Post-money valuation, which can be assessed employing various methods, captures the market's valuation of a startup post-investment (Ang, Chia & Saghafian, 2020). Their research found that the metric integrates expectations concerning a startup's future growth and profitability, serving as a measure for assessing both current value and future potential by multiplying the share price with the total amount of shares. According to their study, typical post-money valuations in the Silicon Valley range from $3 million and $6 million at Pre-Seed and Seed, and $10 million to $15 million at Series A (Ang, Chia & Saghafian, 2020), while a research gap was identified on valuation figures in Europe.

Combined Ownership of Founding Team: This metric underscores the founders' vested interest and alignment with the venture, influencing negotiation dynamics and investment terms (Eldar, Grennan & Waldock, 2020; Fitza, Matusik & Mosakowski, 2009; Frid, Wyman &

Gartner, 2015). In Europe, VCs typically acquire 10-20% equity in Pre-Seed financing rounds, 20-25% in Seed rounds, and 25-30% in Series A rounds (Eldar, Grennan & Waldock, 2020; Hellmann & Puri, 2002).

Previous Funding Rounds: The number of financing rounds a startup raises signifies its capacity to achieve growth milestones and sustain development, indicative of its long-term viability, equity dilution, and development (Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022; Broughman & Fred, 2012; Talmor & Cuny, 2005). A research gap on previous rounds figures in Europe was identified.

Previous Funding Amount: The sources of previous funding indicate a startup's financial situation, offering insights into its financial resilience based on past dilutive financings (Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022; Talmor & Cuny, 2005). A research gap on previous funding amount figures in Europe was identified.

Public Funding: Insights into public funding offer additional perspectives on the startup's financial health and external validation, contributing to a holistic view of its financial ecosystem (Cecere, Corrocher & Mancusi, 2018). Islam, Fremeth and Marcus (2018) elucidate the signalling value of winning prestigious government research grants for early-stage startups, finding that it increases the likelihood of subsequent VC funding by 12%.

Industry: The startup's industry informs its attractiveness to VCs, with sectors demonstrating high growth potential and innovation capacity often viewed as more lucrative due to their transformative prospects, and whether it suits the VCs' portfolio focus (Andersson, Evers & Kuivalainen, 2014; Audretsch, 1995; Siegel et al. 1993).

Revenue: A startup's revenue generation is central to evaluate its market viability and scalability potential, when assessing the financial sustainability of startups (Popov & Roosenboom, 2013; Zubakina & Koliasov, 2023). Bednar, Tariskova and Zagorsek (2018) found that 90.7% in 2016, and 97.3% in 2015 of early-stage startups in Slovakia, generate less than €0.5 million in revenue, while 37.3% in 2016, and 44% in 2015 respectively, have no generated revenue across numerous industries.

Revenue Growth Rate: The startup's revenue growth rate indicates its sales traction and operational effectiveness, as high growth rates signal strong market demand and efficient business strategies, which are used for evaluating the scalability, competitive positioning, and long-term potential of the startup (Hooley et al. 2001). Picken (2017) and Pugliese, Bortoluzzi and Balzano (2021) underscore the importance of revenue growth in demonstrating a startup's ability to capture market share and sustain its business model. There exists a research gap on growth rates of Deep Tech hardware startups in Europe.

Time to Revenue: The anticipated time frame to revenue generation offers a critical lens into a startup's market entry strategy and financial sustainability, reflecting the operational and strategic milestones in motion to market presence (Jiang, Qu & Jain, 2019). As indicated in Chapter 2.2, Deep Tech hardware startups face longer cycles overall, compared to other startups, while no figures on time to revenue were determined in existing literature.

Business Model: Business models can be categorised into economic, operational, and strategic levels (Morris, Schindehutte & Allen, 2005). They found that at the economic level focus lies on profit generation, while operational models emphasise internal processes and infrastructure, and strategic models concern market positioning and competitive advantage. No predominant solution can be determined due to the great variety across startups.

Leadership Team: The composition and expertise of the founding team are very important, driving the startup's strategic vision and execution capability, as they are viewed as foundational pillars for success (Roure & Maidique, 1986; Hall & Hofer, 1993). Moreover, studies have found that startups with founders who have a clear understanding of the target market, and the ability to adapt to changes, are more likely to succeed (Roure & Maidique, 1986; Skawińska & Zalewski, 2020).

Team Headcount: Reflecting the organisational scale and operational capacity, team headcount is correlated with a venture's development stages and operational complexity, informing assessments of scalability and resource allocation, while startups traditionally operate with small teams (Roure & Maidique, 1986; Skawińska & Zalewski, 2020).

Technology Phase: The developmental stage of the technology underpins a startup's innovation trajectory, impacting its risk assessment and capital requirements (Hall & Hofer, 1993). Douglas and Shepherd (2002) emphasise that VCs perceive startups to be more marketing- and management-ready than technology-ready, and found that VCs rely on gut feeling when it comes to technological adaptation. The technology phase that startups should reach to justify investments differs in various stages, industries and business models, which is why there is no derivable consensus in the literature within the scope of this work.

Market Traction: Early market traction validates the startup's go-to-market strategy, and market potential (Zaheer et al. 2018). Understanding the market, and continuously engaging with potential customers throughout the development process, ensures that the final product meets real-world needs and has a clear path to adoption in often still unproven markets (Picken, 2017; Zaheer et al. 2018). VCs preferred market traction differs across various stages, industries, and business models, hence, there is no clear consensus in literature.

Risk: Comprehensive risk assessment, encompassing market, technological, team, regulatory, and operational dimensions, guides both the decision to invest for VCs and the focus of the startup operations (Chaplinsky & Gupta-Mukherjee, 2016; Coombs & Huang, 1970; Ruhnka & Young, 1991). Aligned with the high-risk, high-reward nature of Deep Tech startups, they comprise high failure rates, and there is no one-fits-all solution to derisk (Cantamessa et al. 2018; Dimov & De Clercq, 2006).

Intellectual Property, Patents, and Type of Licence: The strength and scope of intellectual property, including patents, trademarks, and copyrights, protection are essential in safeguarding the startup's competitive advantage, particularly in technology-driven startups (Graham & Sichelman, 2016; Greenberg, 2013; Popov & Roosenboom, 2013). Moreover, patents and other forms of IP protection enhance the venture's valuation and attractiveness to investors, where IP protection should grow with the overall startup maturity (Greenberg, 2013).

To conclude, this extensive literature review establishes a theoretical framework that serves as the foundation for the methodology and anticipated results. The framework is designed to bridge the gap between academic theory and the practicalities of VC investments in early-stage Deep Tech hardware startups in Europe, laying a solid foundation for the exploration of the characteristics of the investment criteria throughout Pre-Seed, Seed, and Series A, as well as guiding the development of a detailed survey.

3. Methodology

3.1 Research Strategy

The research strategy adopted for this thesis is focused on uncovering and analysing the characteristics of investment factors that are relevant to VCs to evaluate and invest in early-stage Deep Tech hardware startups in Europe, as defined in Chapter 2.

According to Bell, Bryman and Harley (2022), quantitative research strategies facilitate the testing of hypotheses by enabling precise measurement and analysis of variables. Consequently, the decision to employ a quantitative research strategy for this thesis is grounded in its suitability for capturing and analysing large, complex datasets. This method is particularly effective in identifying patterns and trends in investment behaviours and criteria. By examining past investments, the authors can ensure that the findings are robust and reflective of actual market practices. To support the quantitative approach, a descriptive cross-sectional approach to explore VC investment criteria in early-stage Deep Tech hardware startups is employed. This design is specifically chosen for its capability to address the research question within the constraints of available resources and the project's timeline, as outlined by Bell, Bryman, and Harley (2022).

3.2 Research Design

This thesis employs a descriptive cross-sectional research design to explore the investment criteria applied by VCs for early-stage Deep Tech hardware startups in Europe. This methodology involves developing a comprehensive quantitative survey, aimed at collecting data on investment decisions from VCs who have completed investments in this sector. The cross-sectional approach is particularly effective for identifying patterns and trends in VC investment strategies at a single point in time, providing a robust snapshot of current practices without the need for longitudinal tracking, and facilitating the examination of a wide range of variables simultaneously. This method is particularly suitable given the constraints of time and resources, allowing for the efficient collection and analysis of data. By focusing on completed investments, the study ensures that the findings are reflective of actual market practices, enhancing the validity and reliability of the results. Focus is set exclusively on European startups based on regional differences in investment criteria, as highlighted by Botella-Carrubi, Maqueda-Llongo, and Valero-Moya (2022), who found significant valuation disparities between the US and Europe. By limiting the scope to Europe, this study aims to provide a detailed understanding of VC behaviour within this specific context.

3.3 Sampling

In the selection of VCs for participation in this study, the authors implemented a systematic approach, undermined by clearly defined selection criteria and methodical sampling decisions to create a list of 167 potentially relevant venture capitalists in Europe (Appendix 1), to ensure a representation of a broad spectrum of perspectives within the VC ecosystem.

The following criteria ensure a comprehensive understanding of the considered selection factors that the authors applied to determine relevant VCs for this study, in order to leverage both academic literature and empirical validation through the distributed survey:

1. **Firm Size**: VC funds of all sizes were included to capture a broad spectrum of fund sizes.
2. **Geographical Focus**: As investment criteria and valuations can vary across geographies, the selection was limited to VCs investing in Europe.
3. **Deep Tech Specialisation**: VCs with a focus on the Deep Tech sector were targeted, ensuring alignment with the domain of this study.
4. **Early-Stage Investments**: Focus on VCs investing in early-stage startups, reflecting the unique challenges and opportunities of startups, (Chapter 2.1).
5. **Type of VCs**: Only traditional VCs whose investment decisions are predominantly driven by the potential for high returns (Chapter 2.3).

Subsequently, leveraging databases and platforms renowned for their extensive directories of VC firms, such as Dealroom and LinkedIn, a preliminary list of 167 venture capitalists across various positions and countries (Appendix 1), representing 85 potentially relevant Deep Tech VCs, was compiled (Appendix 2). By utilising aforementioned platforms inclusion criteria, this list was refined to 73 VCs (Chapter 4.1) through the application of criteria as detailed previously, to ensure a focus on VCs within the scope of this study.

3.4 Data Collection

The following section presents the survey, outlines the linkage of survey questions to previously identified literature (Chapter 2), and explains the survey's structure and significance. Further, the data collection process is explained in connection to the survey adaptation and distribution.

Based on the literature review, an initial survey draft was developed. To validate the initial survey design, 15 VCs were contacted, out of which two agreed to participate in preliminary interviews (Appendix 3), helping to ensure the focus of the survey is set correctly, and the scope is well-defined. The initial feedback was utilised to refine the survey questions and potential answers to successfully bridge theory and practice, ensuring the survey's alignment with industry practitioners and empirical validation. Based on the feedback, a revised survey draft addressing the identified investment criteria (Chapter 2.5), with a total of 22 questions, has been created. This survey aims to facilitate a deeper understanding of the criteria that drive VC investments in early-stage Deep Tech hardware startups in Europe. Based on feedback by VCs, and to facilitate straightforward data analysis, most questions were formatted to allow either single-choice, multiple-choice answers or manual value entry. The survey was constructed using clear instructions and concise, neutral language to ensure respondents have a common understanding of the questions. Three open-ended questions were included to capture qualitative insights, while some questions are optional due to VC feedback.

The organisation of questions follows a logical order, beginning with general information about the investment and gradually delving into more specific details. The identified investment criteria were categorised into distinct themes (Table 3) that include “investment structure”, which examines the financial aspects of the financing round. “Maturity of the startup” focuses on the developmental stage of the company, evaluating aspects such as its technology, IP protection, risk profile, and market traction. The “industry” category assesses in which sector the startup operates. “Revenue and business model” analyses how startups generate revenue and their market engagement strategies. Lastly, “human capital” considers the skills and experiences of the startups' team. Each category allows mapping the investment criteria to a broader context, enhancing the understanding of how these factors interrelate, thus providing a structured approach for the analysis. Ultimately, all criteria are linked to relevant literature, aligning outlined categories with investment criteria to provide a solid foundation for empirical investigation.

Table 3. Final Survey, Investment Criteria and Literature Connection

Question	**Possible Input**	**Category**	**Investment Criterion**	**Literature Reference**
1. Your email address *Optional*	*Open text field*	-	-	-
2. What was the year of the investment? *	2022; 2023; 2024	-	-	-
3. What was the round stage? *	Pre-Seed; Seed; Series A; Series B; Series C and beyond	Investment Structure	Round Stage	Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022
4. What was the round size? *	*In million €, e.g. use 1.7 for 1 700 000*	Investment Structure	Round Size	Ang, Chia & Saghafian, 2020; Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022; Zubakina & Koliasov, 2023
5. What was the post-money valuation? *	*In million €, e.g. use 1.7 for 1 700 000*	Investment Structure	Post-Money Valuation	Ang, Chia & Saghafian, 2020
6. What is the combined ownership of the founding team pre-round? *	0 to 9%, 10 to 19%, 20 to 29% 30 to 39%, 40 to 49%, 50 to 59%, 60 to 69%, 70 to 79%, 80 to 89%, 90 to 99%, 100%; Unknown	Maturity of Startup	Combined Ownership	Eldar, Grennan & Waldock, 2020; Fitza, Matusik & Mosakowski, 2009; Frid, Wyman & Gartner, 2015; Hellmann & Puri, 2002
7. How many private rounds has the startup raised before? *	*Number*	Maturity of Startup	Previous Rounds	Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022; Broughman & Fred, 2012; Talmor & Cuny, 2005

Question	Possible Input	Category	Investment Criterion	Literature Reference
8. How much private funding has the company raised prior? *	*In million €, e.g. use 1.7 for 1 700 000*	Maturity of Startup	Previous Funding Amount	Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022; Talmor & Cuny, 2005
9. How much public funding (e.g. grants) has the company raised in total? *	No public funding; Less than 0.5m; 0.5m to 1m; 1m to 5m; 5m to 10m; More than 10m; Unknown	Investment Structure	Public Funding	Cecere, Corrocher & Mancusi, 2018; Islam, Fremeth & Marcus, 2018
10. Which category is most fitting for the startup? *	Robotics & Manufacturing; Semiconductors, microelectronics & photonics; Industrial plants/facilities (green chemistry, power to gas etc.); Advanced materials (e.g. bio-based plastics); Space Tech; Battery and Energy Storage; Quantum; Other	Industry	Industry	Andersson, Evers & Kuivalainen, 2014; Audretsch, 1995; Siegel et al. 1993
11. Has the startup generated revenue with their core technology product prior to the investment round? *	Yes; No	Revenue and Business Model	Revenue	Bednar, Tariskova & Zagorsek (2018); Popov & Roosenboom, 2013; Zubakina & Koliasov, 2023
12. How high was the annualised revenue? *Conditional (previous question "yes")*	*In million €, e.g. use 1.7 for 1 700 000*	Revenue and Business Model	Revenue	Bednar, Tariskova & Zagorsek (2018); Popov & Roosenboom, 2013; Zubakina & Koliasov, 2023

Question	Possible Input	Category	Investment Criterion	Literature Reference
13. What was the year-on-year growth rate? *	Less than 50%; 50 to 100%; 101 to 200%; More than 200%; Unknown	Revenue and Business Model	Growth Rate	Hooley et al. 2001; Picken, 2017; Pugliese, Bortoluzzi & Balzano, 2021
14. What is the time to revenue that you were expecting when investing? *	Less than 1 year; 1 to 2 years; 2 to 5 years; 5 to 8 years; More than 8 years	Revenue and Business Model	Time to Revenue	Jiang, Qu & Jain, 2019
15. How is the startup primarily earning (or planning to earn) money? Choose from the options below (multiple answers possible) *	Hardware as a Service; IP licensing; Selling materials (e.g. methanol); Service fees or operational licensing; Software on top of hardware; Unit sales; Other	Revenue and Business Model	Business Model	Hooley et al. 2001; Picken, 2017; Pugliese, Bortoluzzi & Balzano, 2021
16. Which of the following boxes did the leadership team check (founders & first line of management)? (multiple answers possible) *	Founder with PhD in the field; Commercial CEO; Technical CEO; Founder with less than 5 years relevant industry experience; Founder with more than 5 years relevant industry experience; First commercial executives hired; First tech executives hired; First operations executives hired; Serial Founder	Human Capital	Team	Hall & Hofer, 1993; Roure & Maidique, 1986; Skawińska & Zalewski, 2020

Question	Possible Input	Category	Investment Criterion	Literature Reference
17. How many full-time employees did the company have? (chose a range below) *Optional*	1 to 5; 6 to 10; 11 to 20; 21 to 50; 51 to 100; More than 100	Human Capital	Headcount	Roure & Maidique, 1986; Skawińska & Zalewski, 2020
18. Which technology phase would you assign to the startup? *	Whitepaper stage; Lab demonstrator stage; Industrial PoC stage; Commercial pilot stage; Full commercialisation	Maturity of Startup	Technology Phase	Douglas & Shepherd, 2002; Hall & Hofer, 1993
19. Which highest form of market traction had the team achieved when you invested in them? (answers ranked from lowest - highest, multiple answers possible) *	Customer interviews; Tech or feasibility demonstration; Customer interest formalized (e.g. LOIs); Secured partnerships; Off-take agreements; Pilot projects; Project sales; Full commercialisation	Maturity of Startup	Market Traction	Picken, 2017; Zaheer et al. 2018
20. What are/were the startup's next steps to derisk and validate the case? *Optional*	*Open text field*	Maturity of Startup	Risk	Cantamessa et al. 2018; Coombs & Huang, 1970; Chaplinsky & Gupta-Mukherjee, 2016; Dimov & De Clercq, 2006; Ruhnka & Young, 1991
21. What was true about the startup's IP protection? (multiple selections possible) *	No patents / licences; Currently negotiating a licensing agreement; Licensing agreement with third party; Patent filed or in preparation; Patent granted; Unknown	Maturity of Startup	Intellectual Property	Graham & Sichelman, 2016; Greenberg, 2013; Popov & Roosenboom, 2013

Question	Possible Input	Category	Investment Criterion	Literature Reference
22. Do you have any feedback, or are there any other points you would like to share or mention aspects that did not fit to any of the questions above? Thank you for your support! *Optional*	*Open text field*	-	-	-

The star (*) indicates a mandatory question.

Based on the revised survey draft, a pre-test followed the described preliminary VC interviews to ensure validity, comprehensibility, and logical consistency. This survey pre-test was conducted with a group of six out of 21 contacted VCs (response rate of 28.57%) selected for their diverse experiences and insights (Appendix 1 and 4). This pre-testing phase was critical for evaluating the survey's ability to capture the different practical perspectives of respondents while maintaining high scientific standards. The gathered feedback and analysis of the pre-test responses, which were not included in the final data set, enabled the authors to make informed adjustments to the survey, optimising its design for clarity and effectiveness, and ensuring the relevant investment criteria are covered. The result of this iterative, multistep process was the finalisation of the survey, to be found in Table 3, while the distribution will be explained in Chapter 4.1.

Each survey submission of a startup funding round is expected to last between 7 and 15 minutes, as several self tests and gathered feedback indicate. Note, that the survey can be filled out multiple times, allowing for multiple data entries by one survey participant. The choice of Airtable Forms for the survey's implementation was motivated by its user-friendly interface, as well as robust and GDPR-compliant data management features, which enhanced both the researchers' and respondents' experience. The distribution strategy employed personalised outreach via professional networking platforms, direct email, and participation in VC events, ensuring a broad and relevant reach within Deep Tech VCs in Europe (Chapter 2.3). Note that some insights into possible answers to industry-, team- and technology-related survey questions were supplemented by VC interviews (Appendix 5, 6, and 7).

3.5 Data Analysis

To handle and analyse the gathered quantitative data, Microsoft Excel is used due to its capabilities for data organisation, calculation, and visualisation. Excel's advanced functionalities facilitate the analysis of the dataset. The investment criteria are analysed overall for the data set, and dissected per funding round, while ensuring to eliminate duplicates. This will provide a solid empirical foundation to identify patterns and correlations between VCs' investment decisions and the criteria of Deep Tech startups at each round stage. The results are critical and require a careful balance between theoretical insight and empirical evidence to ensure that the conclusions are both robust and meaningful to the existing body of knowledge.

3.6 Ethical Considerations

In this study, importance is placed on the ethical integrity and confidentiality of the data collected. Prior to survey participation, all VCs were provided with an introductory note that highlighted the strict confidentiality with which their responses would be treated. This was reinforced by not gathering startups' names, and limited access to this data strictly to the authors of this study, ensuring strong privacy protection. Furthermore, the delivery of the survey via a link guarantees the voluntary nature of participation, allowing respondents to liberally decide their involvement and number of contributions.

3.7 Validity and Reliability

Ensuring the validity and reliability of the findings is essential to establishing the credibility of this study. To achieve this, the survey questions for this quantitative study were designed based on a detailed review of academic literature and were further refined with input from industry experts to ensure construct validity. Further, by considering a variety of investment criteria relevant to VCs in the Deep Tech sector, the survey ensures content validity, capturing the breadth of factors influencing investment decisions. To enhance reliability, a clear data collection process was implemented and outlined in Chapter 3.4. Preliminary interviews with VCs and a pre-test of the survey were conducted to refine the questions, eliminate ambiguities, and ensure clarity, thereby enhancing the reliability of the responses. Moreover, a detailed documentation of the methodology fosters reproducibility, allowing other researchers to replicate the study and verify the findings independently. This transparency is crucial for validating the results and contributes to the robustness of the conclusions. By employing a descriptive cross-sectional design, the study captures a snapshot of current investment practices, providing a valid representation of the market at a specific point in time. This rigorous approach ensures that the methodology is well-suited to produce results that are both valid and reliable, thereby setting a solid foundation for drawing meaningful and credible conclusions about VC investment criteria in early-stage Deep Tech hardware startups in Europe.

The chosen research approach was critically analysed against several alternatives to ensure robustness and alignment with the research objectives. One potential approach was a longitudinal study, which involves collecting data from the same VCs over multiple time points. This method could provide insights into how investment criteria and behaviours evolve, offering a dynamic perspective on the VC decision-making process, but time constraints made it unsuitable. Panel studies were also considered, which involve repeated measures from the same subjects over time, which also helps in understanding changes, but its resource intensity made it impractical. Another potential approach was qualitative research, such as conducting in-depth interviews with VCs (Eisenhardt & Graebner, 2007). This method could yield rich insights into the subjective experiences and motivations behind investment decisions through thematic analysis to analyse qualitative data (Gioia, Corley & Hamilton, 2013). While qualitative methods could enhance the depth of understanding, they might lack the breadth and generalisability provided by a quantitative survey. A mixed-methods approach, which was originally discussed, combining both quantitative and qualitative techniques, could have offered a more balanced perspective, capturing both quantitative trends and the underlying reasons for those trends. Triangulation would have enhanced the robustness of the findings by validating them through multiple methods. However, resource and time constraints made this unfeasible. Experimental and quasi-experimental designs, which test specific hypotheses about VC behaviour under controlled conditions, were another option. However, the complexity of simulating real-world investment decisions and ethical considerations around manipulating actual investment scenarios were not within the scope of this thesis. To ensure the representativeness of the sample, stratified sampling was considered, which could ensure different types of VCs (e.g., CVC or governmental VCs) by scrutinising participants into subgroups, but is also not within the scope of this work.

4. Results

The exploration of VC investment in early-stage Deep Tech hardware startups in Europe is complex, shaped by a variety of investment criteria. The focus of this research is guided by the research question “What investment criteria do VCs apply for early-stage Deep Tech hardware startups in Europe, and how do their characteristics vary across Pre-Seed, Seed, and Series A funding rounds”, and seeks to gain insights on the complexity of VC funding within this sector, utilising a quantitative approach. In the following, the structure for the result section will be clearly organised to facilitate a clear understanding of the findings and their implications. Initially, a brief overview of the survey respondents and the country allocation of VCs who were targeted, and which responded to the survey, is presented. Afterwards, the results are looked at based on the underlying categories of investment criteria (Table 3), which are: investment structure, maturity of the startup, industry, revenue and business model, and human capital. They serve as a basis for understanding and organising the data obtained through the survey. Lastly, the results will be connected to the academic literature (Chapter 2), allowing to interpret the findings based on existing knowledge and theoretical constructs, situating the new data within the broader academic discourse. Note, that the discussion and analysis of the results are integrated into this chapter.

4.1 Overview of Respondents

As detailed in Chapter 3, the survey was distributed to 73 VCs who met specific inclusion criteria (Appendix 8). Of those 73 relevant VCs, respondents from 31 funds completed the survey, providing a rich dataset of 106 funding rounds conducted between 2022 and 2024 (Appendix 9). Note that four responses were excluded from the analysis as they related to startups that had progressed to Series B funding rounds, thus not aligning with the early-stage criterion set for this study. Overall, the survey completion rate was at 41.89%, forming the foundation of this thesis. The respondents reflected a broad spectrum of investment philosophies, firm sizes, positions within the VC, and industry specialisations within the European context (Appendix 2 and 8).

Germany was the most significant survey contributor with 11 participating VCs, closely followed by the United Kingdom with eight respondents (Figure 2). France, Austria, the Netherlands, and

Switzerland had three VCs each participating in the survey, as well as Luxembourg, Poland, and the United States, each providing one respondent, which added a valuable layer of international perspective, and diversity to the study.

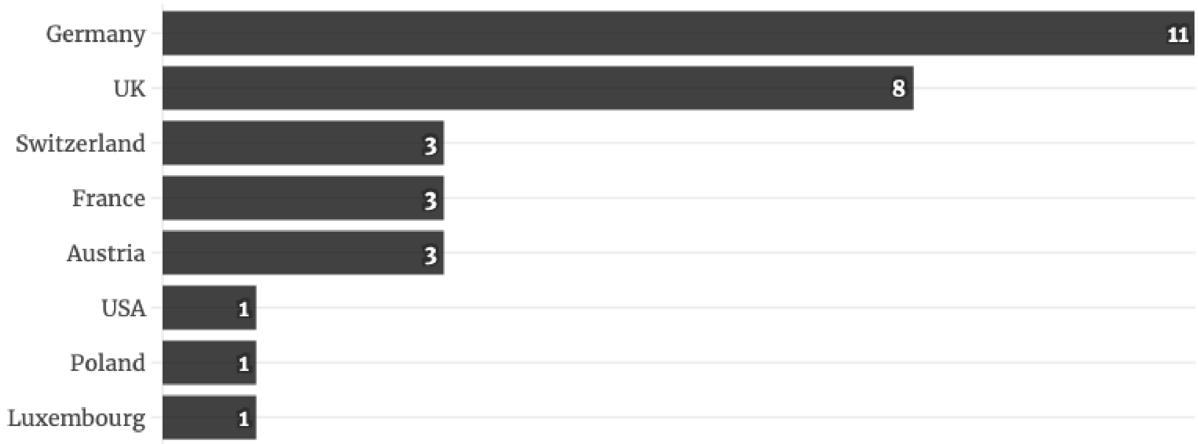

Figure 2. Country Distribution of Venture Capitalists that Completed Survey

The distribution of responses in Figure 2 from VCs in Germany and the UK mirrored the initial target list (Appendix 10) where these countries were identified as key players in the European VC market for Deep Tech startups. Moreover, the responses from countries with fewer participants, as previously mentioned, were critical. They provided unique insights into the investment landscape that might differ from the more dominant European markets, thereby enriching the diversity of the dataset. This varied participation ensured that the analysis created a comprehensive overview of the VC environment across different economic contexts, making the findings significant and representative of broader European trends, also representing the countries that did not respond. The correlation between targeted and participating VCs suggested that the insights derived from this study are reflective of the current investment criteria used by active market participants across Europe, providing a robust and varied data foundation.

The data points and results obtained from the survey were of significant relevance and form a robust foundation for this thesis for several reasons. Firstly, the comprehensive coverage of different VCs across European countries provided a broad dataset that was critical for this research, as it ensured that the findings were not biased towards a single market or investment style, but rather reflected a wide range of investment behaviours and strategies across different cultural and economic environments. Moreover, the alignment of the survey data with the theoretical frameworks discussed in earlier chapters ensured that the analysis is grounded in real-world data and is framed within established academic discourse. This enhanced the scholarly value of the thesis, bridging the gap between theory and practice, and offering well-founded conclusions that contributed to the literature on VC in the Deep Tech sector.

4.2 Investment Structure

4.2.1 Findings on Round Stage

In examining the results of the survey, the analysis differed in three round stages: Pre-Seed, Seed, and Series A. The dataset of 102 relevant investment rounds across funding stages included 26 Pre-Seed investments, 55 Seed rounds, and 21 Series A rounds. Hence, the data on Pre-Seed and Series A startups might have an information bias due to a smaller sampling size.

4.2.2 Findings on Round Size

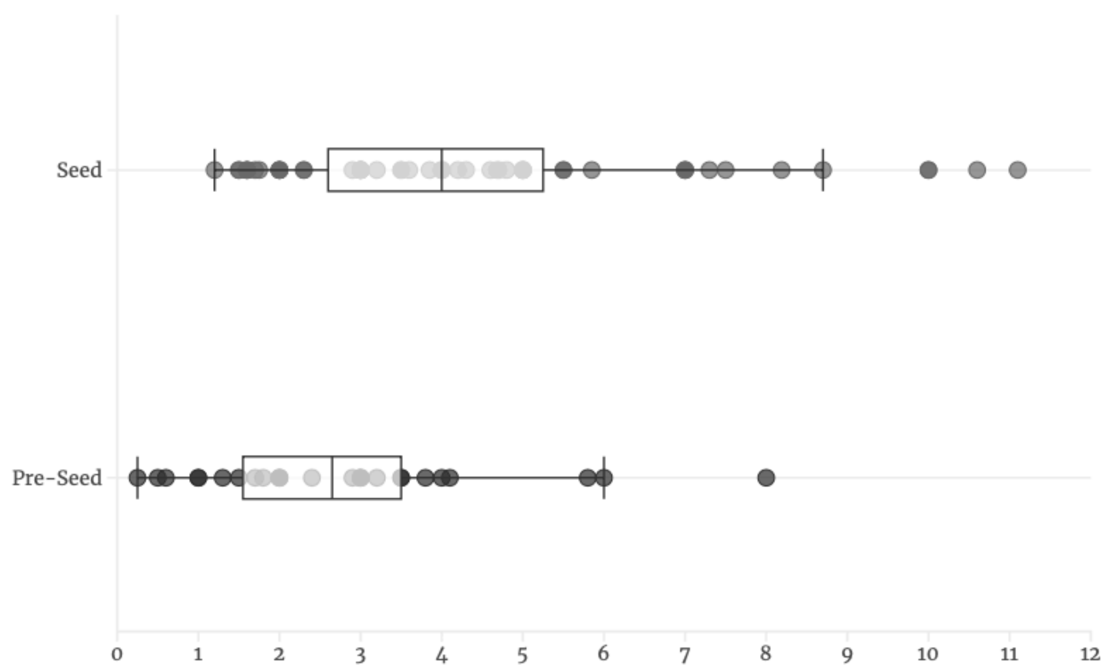

Figure 3. Round Size Distribution for Pre-Seed and Seed (in million €)

Overall, the median round size for the data sample was €4 million. At the Pre-Seed stage, the median round size was at €2.65 million, while the upper quartile was at €3.50 million, and the average round size was at €2.76 million, aligning closely with the median and pointing to a relatively balanced distribution of funding amounts at this stage. The 25% quantile at the Seed stage was €2.60 million, showing that Seed-stage startups raised more substantial initial funds, while the median round size grew to €4.00 million. The 75% quantile reflected a more significant spread in the round sizes, topping at €5.25 million, while on average, Seed rounds amounted to €4.40 million. At the Series A stage, the funding dynamics shifted considerably. The 25% quantile began at €9.00 million, more than triple the same quantile for Seed rounds, while the median increased to €18.00 million.

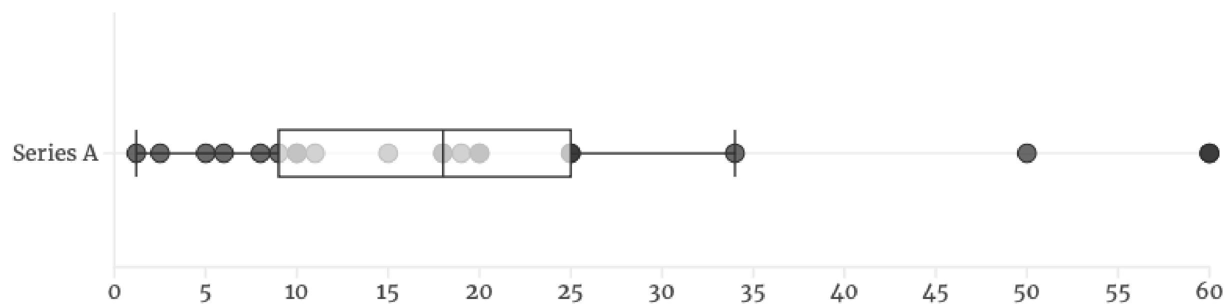

Figure 4. Round Size Distribution for Series A (in million €)

4.2.3 Findings on Post-Money Valuation

The findings of post-money valuations across different funding stages offer insights into the perceived value of startups subsequent to investment. The valuation is an indicator of a startup's growth potential and market value, as assessed by founders and VCs.

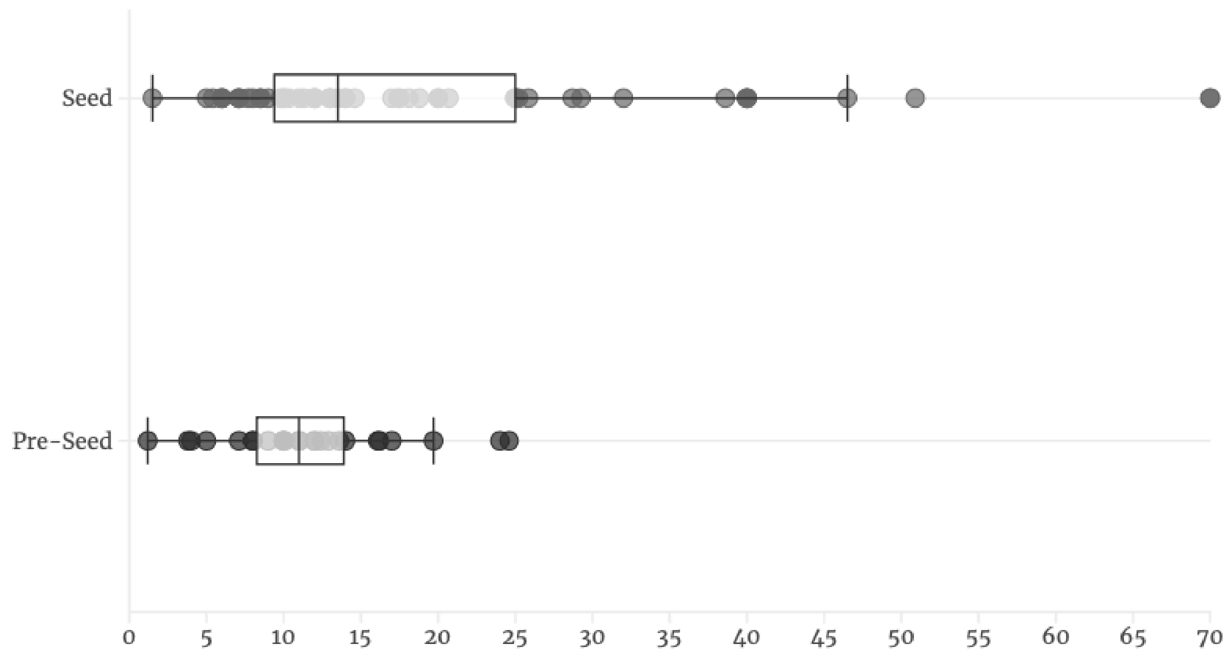

Figure 5. Post-Money Valuation Distribution for Pre-Seed and Seed (in million €)

Overall, the median post-money valuation for the data sample was €16.15 million, while it averaged at €39.78 million. For Pre-Seed rounds, the median was €11 million, while the average was €11.64, which served as a baseline for the earliest stages of startup funding. The 75th percentile reached €13.9 million. Startups who closed a Seed investment round exhibited a 25th percentile valuation of €9.4 million, while the median valuation was marked at €13.5 million, with the 75th percentile reaching €25 million.

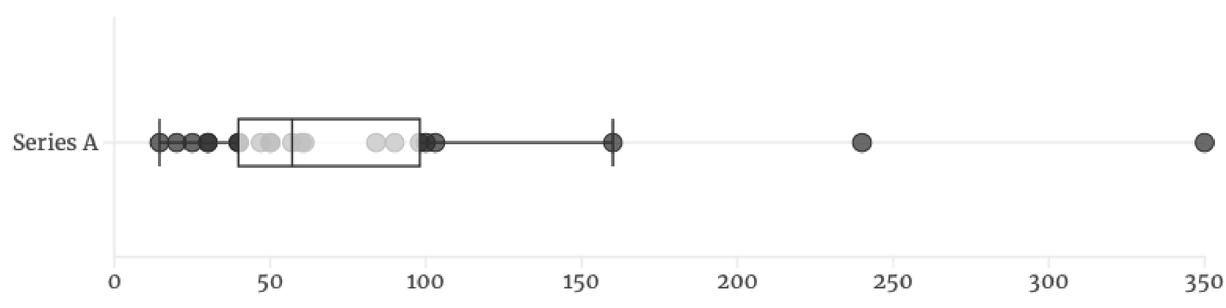

Figure 6. Post-Money Valuation Distribution for Series A (in million €)

Series A rounds presented a notable increase, with the 25th percentile at €39.8 million, and median at €57 million. The average valuation was at €83.3 million, while the top 75% quartile showcased valuations as high as €98 million.

4.2.4 Findings on Combined Ownership

The ownership findings reflect the distribution of founder ownership percentages before investment rounds across Pre-Seed, Seed, and Series A stages.

Table 4. Distribution of Combined Ownership Across Stages

	Stages		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
100%	15	16	0
90% to 99%	8	5	0
80% to 89%	2	5	0
70% to 79%	1	16	6
60% to 69%	0	8	2
50% to 59%	0	2	7
40% to 49%	0	3	5
30% to 39%	0	0	1
20% to 29%	0	0	0
10% to 19%	0	0	0
0% to 9%	0	0	0
Unknown	0	0	0
Total	**26**	**55**	**21**

In total, every founding team had an equity stake larger than 29%, while the median was at 70%. At the Pre-Seed stage, founders tended to retain higher equity stakes, with all startups maintaining above 70% ownership. Seed-stage startups exhibited a gradual decrease in founder ownership, evidencing increased equity dilution as companies mature and require more significant capital injections. Here, 42 startups reported more than 70% founder ownership, while 13 startups had less than 70%. Series A startups depicted a landscape where founders had notably less equity, with no startups retaining more than 79% ownership. The substantial capital, typically raised during Series A rounds, often led to significant equity dilution. The results showed that investors at Series A stages tended to demand higher stakes, with ownership ranging between 30% and 79%.

4.2.5 Findings on Previous Funding and Previous Funding Rounds

The findings on the ownership of founders go along with the findings of previous funding rounds, which provides insights into the fundraising journey of startups at different investment stages. Moreover, examining the amount of private funding raised by startups prior to their current round offers additional insights into their funding trajectory.

Table 5. Distribution of Previous Funding Rounds Across Stages

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
0	23	23	0
1	2	23	8
2	1	5	9
3	0	2	2
4	0	1	1
5	0	1	1
Total	**26**	**55**	**21**

A total of 46 startups did not have a previous funding round, while 56 startups raised at least one round previously, with a median of €1.94 million. In the Pre-Seed stage, it was notable that 23 of 26 startups had zero previous rounds, reflecting the initial stage in the startup lifecycle. The three startups that raised at this stage were responsible for a median and average private funding amount of €0.45 million.

Totally, 23 out of 55 Seed startups had gone through one previous round, showcasing that these companies conducted their Pre-Seed round, while 23 startups had no previous round. The median private funding amount stood at €1 million, while the average increased to €2.18 million.

Eight Series A startups had one previous round, while nine startups had two previous rounds, and four startups had more than two previous rounds. At this stage, the median jumped significantly to €5 million, with an average of €8.10 million.

4.3 Analysis of Investment Structure Findings

The analysis of the survey results underscores the characteristics of investment decisions as startups progress through different funding stages.

This study aligns with findings from research, as a consistent increase in capital raised, and post-money valuations can be observed as startups move from early to later round stages. Contrary to findings of Botella-Carrubi, Maqueda-Llongo and Valero-Moya (2022), the round sizes of Deep Tech hardware startups differ significantly. The authors state that round sizes range between €0.005 to €0.5 million at Pre-Seed, €0.5 to €2 million at Seed, and €2 to €10 million at Series A, while this thesis reveals a median round size of €2.65 million the Pre-Seed stage, €4.00 million for Seed startups, and a median investment at the Series A stage of €18.00 million. This either suggests a valuation premium for Deep Tech startups, less perceived risk, stronger potential, or more capital required to bring hardware products to market. Moreover, the outlined gap between the median and average round sizes and post-money valuations suggests that outliers, raising significantly more, skew the average upwards.

Further, at the Pre-Seed stage, founders tend to maintain higher equity stakes, with all analysed startups holding above 70% ownership. This indicates less equity dilution for early capital, aligning with the trade-offs between capital acquisition and equity retention discussed by Gompers and Lerner (2001), but is comparably higher in Deep Tech, as the findings of Hellmann and Puri (2002), and Kaplan and Strömberg (2004) indicate. Aligning with their findings, higher ownership in Pre-Seed indicates larger round sizes, while this study finds that less founder ownership leads to larger round sizes in Seed and Series A (Appendix 11). Moreover, Hellmann and Puri (2002) and Kaplan and Strömberg (2004) state that VCs typically acquire 10-20% equity in Pre-Seed financing rounds, 20-25% in Seed rounds, and 25-30% in Series A rounds, which is contrary to the findings of this study, as VCs obtain significantly higher stakes (Table 4). This could be due to the involved risks in Deep Tech hardware, as outlined in Chapter 2.2.

The startups that have previously raised funds suggest a relatively modest sum compared to the analysed data set, as the previous funding amount of Seed startups is at €1 million for their Pre-Seed, while the data set reveals it is at €2.65 million for Pre-Seed startups, underlining the objectivity of the information provided, as investors demonstrated full transparency across both minor and major investment rounds, ensuring the accuracy and completeness of the data shared. This can also be observed, as several startups exhibit more previous funding rounds than typically expected at their current stage, indicating an extended period of development, which suggests this is the nature of Deep Tech investments and is not distracting investors injecting further investments. This could also be indicative of a more complex product or technology requiring substantial investment, or might reflect strategic choices where startups opt for extensions or bridge rounds rather than advancing to subsequent funding rounds, a common practice in VC as discussed by Mason and Harrison (2000).

Lastly, the trend in valuation supports the findings of Tyebjee and Bruno (1984) and is consistent with the maturation model of startups, which suggests a phased financing strategy to achieve market readiness and scalability. Overall, the round sizes and post-money valuations in Deep Tech are significantly larger compared to the findings on traditional startups concluded by Ang, Chia, and Saghafian (2020).

4.4 Findings on Maturity of Startups

4.4.1 Findings on Public Funding

The distribution of non-dilutive, public funding, such as grants, across the different stages of startup investment provides a view of how early-stage ventures leverage this financial instrument.

Table 6. Distribution of Public Funding Across Stages

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
No Public Funding	11	8	2
Less than 0.5 million	11	14	3
0.5 to 1 million	0	13	2
1 to 5 million	2	17	11
5 to 10 million	0	2	1
More than 10 million	1	1	1
Unknown	1	0	1
Total	**26**	**55**	**21**

A total of 79 startups received public funding, with the most common occurrence of the €1 million to €5 million bracket, and a median of €0.5 to €1 million, while 21 did not receive any non-dilutive funding. For Pre-Seed startups, 11 startups secured public funding of less than €0.5 million. At the Seed stage, a shift towards larger grants occurred, with 17 (approx. 36%) startups obtaining €1 million to €5 million, and two startups receiving funding in the ranges of €5 million to €10 million and one above €10 million. The bracket for public funding broadened significantly, with the most common occurring amount ranging from €1 million to €5 million, and the median bracket was €0.5 million to €1 million. Series A rounds see a continuation of this trend, with the majority of 11 (approx. 61%) startups securing between €1 million to €5 million. Additionally, one startup in the Series A phase obtained public funding of over €10 million.

4.4.2 Findings on Technology Phase

This section delves into the significance of the technology phase as an investment criterion, exploring its characteristics through the analysis of the survey data.

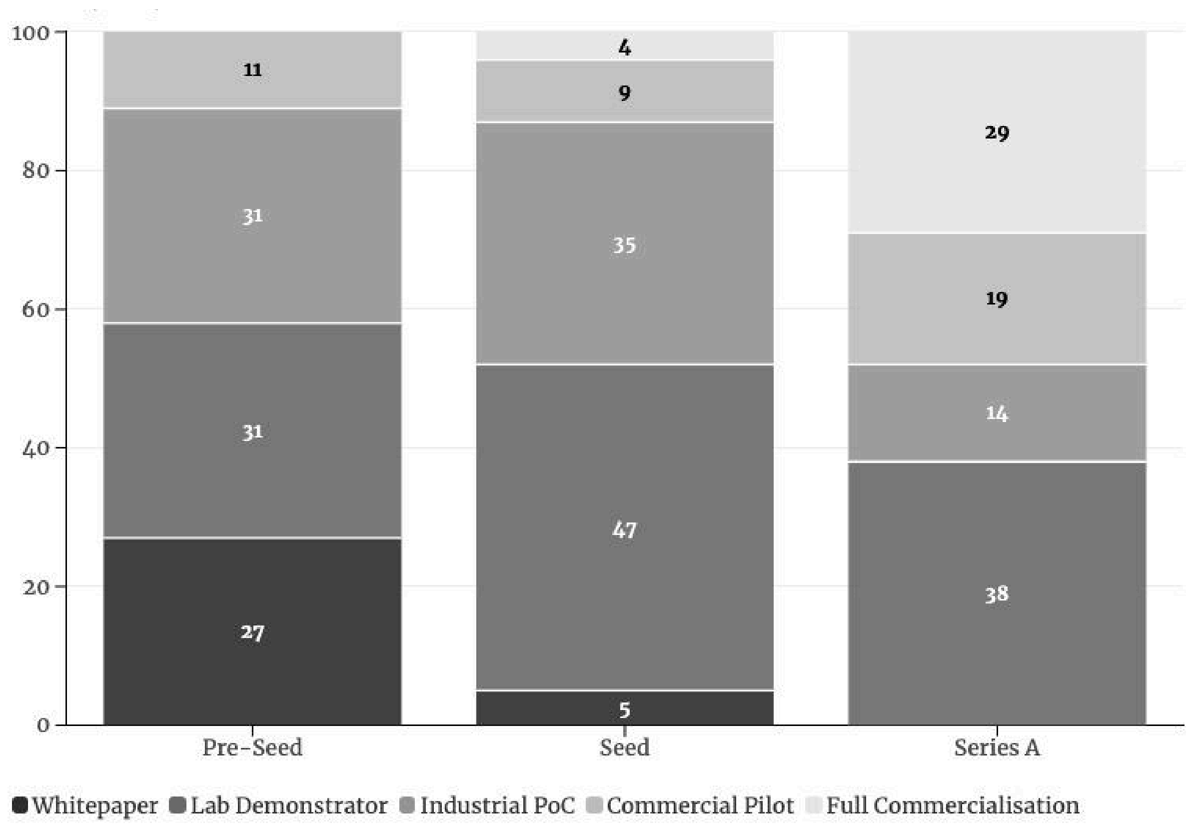

Figure 7. Technology Phase Distribution Across Stages

The lab demonstrator stage was the most common technology phase in this sample, while the industrial proof of concept (PoC) stage was the second most common. Full commercialisation was reached by eight startups overall, while it was not reached by any startup at the Pre-Seed stage, emphasising the typical early phase of development. Approximately 31% of Pre-Seed startups were each in the lab demonstrator and industrial PoC stages, validating in industrial settings. At the Seed stage, a notable shift towards advanced development was evident, with 47.27% of startups at the lab demonstrator stage and 34.55% were at the industrial PoC stage. Five startups advanced to the commercial pilot stage, signifying that they are testing their technologies with potential users or customers. As startups progress to Series A, a significant maturation was observed, with 28.57% of startups reaching full commercialisation, while 38.1% remained at the lab demonstrator stage, and no startups remained at the whitepaper stage.

4.4.3 Findings on Market Traction

The traction analysis evaluates the progress startups have made in market engagement and validation across stages. Due to the nature of the survey question, multiple options may apply to startups, hence, the total sum of results differs from the total of 102 analysed startups.

Table 7. Distribution of Market Traction Phases Across Stages

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
Customer Interviews	14	30	5
Tech / Feasibility Demonstration	19	38	10
Pilot Projects	5	12	2
Full Commercialisation	0	0	2
Customer Interest Formalised (LOIs etc)	3	8	4
Secured Partnerships	8	26	6
Project Sales	2	11	4
Off-take Agreements	1	2	1
Total	**52**	**127**	**34**

In total, the tech and feasibility demonstration was the most common market traction phase of this sample size, with 67 occurrences, while full commercialisation was the least common phase, reached only by two startups. At the Pre-Seed stage, customer interviews were a common starting point, with 14 startups utilising them for market validation. A total of 19 startups moved forward to technology or feasibility demonstrations. Five startups initiated pilot projects, and three had formalised customer interest through letters of intent (LOIs) or similar instruments. Project sales and off-take agreements were less common at this phase, with two and one instance, respectively. For Seed startups, customer interviews remained significant with 30 of 55 startups, and technology or feasibility demonstrations were prominent, with 38 startups conducting them, underscoring the ongoing technology validation, while 12 startups reported running pilot projects, a transition to testing in real-world settings. Secured partnerships increased compared to the Pre-Seed stage with 47.27% of startups. Ten Series A startups were at the technology or feasibility demonstration phase.

4.4.4 Findings on Risk

In the realm of VC, risk mitigation is a strategic imperative that shapes the trajectory of growth and the ability to attract further investment over multiple dimensions and investment criteria. The analysed startups in this study depicted a variety of derisking steps crucial for validating their technological solutions and market potential. However, this was an optional field in the survey, and was only answered for 17 of 102 analysed investments, six at Pre-Seed, ten at Seed, and one at Series A. Hence, the results did not offer quantifiable data, as they were not of representative nature for the whole sample size or the industry in general, even though they align with gathered insights from other investment criteria.

4.4.5 Findings on Intellectual Property, Patents, and Type of Licence

The IP analysis across different funding stages reveals how startups prioritise their IP strategy as they progress. As this was an optional field in the survey, this question was answered for 70 of 102 investment rounds.

Table 8. Distribution of Intellectual Property Phases Across Stages

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
Patent Filed or in Preparation	11	12	6
Currently Negotiating a Licensing Agreement	1	0	0
Patent Granted	2	10	9
Licensing Agreement with Third Party	0	1	0

	Pre-Seed	Seed	Series A
No Patents and Licences	3	5	0
Unknown	2	4	4
Total	**19**	**32**	**19**

Overall, 50 of 60 startups either had patents in preparation (29) or granted patents (21), the status is unknown for 42 startups, reported for 10 startups and not answered by 32 startups. For Pre-Seed startups, IP was in its early stage, with 11 of the 19 startups having patents filed or in preparation, while two had been granted patents. Three startups did not have patents or licences, potentially due to the early stage of their development. The Seed stage comprised 32 startups, with 12 having patents filed or in preparation, and 10 startups with granted patents. Notably, there was a decrease in companies without any patents or licences to five. Series A startups showed a heightened emphasis on IP protection, with 47.37% of startups having patents granted, while there were no Series A startups without patents and licences.

4.5 Analysis of Maturity of Startups Findings

The analysis synthesises how early-stage financing and strategic actions such as securing public funding, engaging in technological validation, and managing IP significantly impact positive investment decisions based on investment criteria.

The majority of startups (79 of 102) receiving public grants demonstrates that obtaining such funding is a positive signal for investors. As Giardino et al. (2014), and Islam, Fremeth and Marcus (2018) note, these grants are strategically used to mitigate early-stage risks and validate technological innovations. For Pre-Seed startups, this funding is vital for concept validation and preliminary research (Chapters 2.1, 2.2 and 2.4), enabling them to establish a robust foundation for further technological development without diluting equity, while ownership remains a challenge for Deep Tech hardware founders (Chapters 4.2.4 and 4.3). As startups demonstrate matured market traction, they become eligible for higher amounts of public funding, which can be instrumental in advancing product development to commercial readiness and scaling operations throughout their startup development, as discussed in Chapter 2.1.

Despite raising funds, most startups are actively involved in technology demonstrations and customer interviews, focusing on validating their technological assumptions. This ongoing validation occurs regardless of the startups' developmental stage and is contradictory to Botella-Carrubi, Maqueda-Llongo and Valero-Moya (2022) definition of Series A startups, but aligns with Blank and Dorf's (2012) definition of early-stage startups in Chapter 2.1, underlining the findings of this study that Deep Tech hardware startups have significant development cycles, even at Series A. Moreover, the authors' findings indicate that investors are willing to inject capital into startups that have not yet fully commercialised their technologies (Appendix 12), contradictory to non-Deep Tech startups at Series A (Botella-Carrubi, Maqueda-Llongo & Valero-Moya, 2022). The progression from theoretical to practical technology phases highlights the intensive development cycles Deep Tech startups face, as discussed in Chapter 2.2. The formation of strategic partnerships is commonly observed and is perceived as a crucial signal of potential market success. Echoing the findings of Mason and Harrison (2000), these alliances play a central role in reducing investment risks and securing additional capital, thereby enhancing a startup's market readiness and maturity. This can be observed by analysing the median round sizes for each traction phase (Appendix 13).

Further, the emphasis on IP protection from an early stage, with most startups initiating measures to secure their innovations, highlights a proactive approach to IP management over successful market traction, and aligns with research by Hall and Hofer (1993), but is contrary to findings by Douglas and Shepherd (2002), who emphasised that startups are usually more marketing than technology ready. At the Seed stage, the fact that ten startups have secured patents signals a significant maturation of their IP strategies at this stage and should be marked by Deep Tech founders. Interestingly, the lack of licensing agreements or negotiations with third parties suggests a strategic preference of investors that startups should retain control over their innovations, contrary to the findings of Greenberg (2013), but might be the consequence of a smaller data set in this thesis. Some startups engage in setting up demonstrator facilities with partners to prove technological processes on a commercial scale, further validating their technologies and securing investor confidence, which is a strong indicator for VCs to invest according to the authors' findings, and adds to the existing body of knowledge. Overall, IP protection measures, market traction measures, and progress in technology scale simultaneously, but to different extent across round stages.

4.6 Findings on Industry

The industries, defined through a combination of literature review, feedback from VCs, and survey pre-test feedback (Appendix 3 and 4), will be analysed in the following.

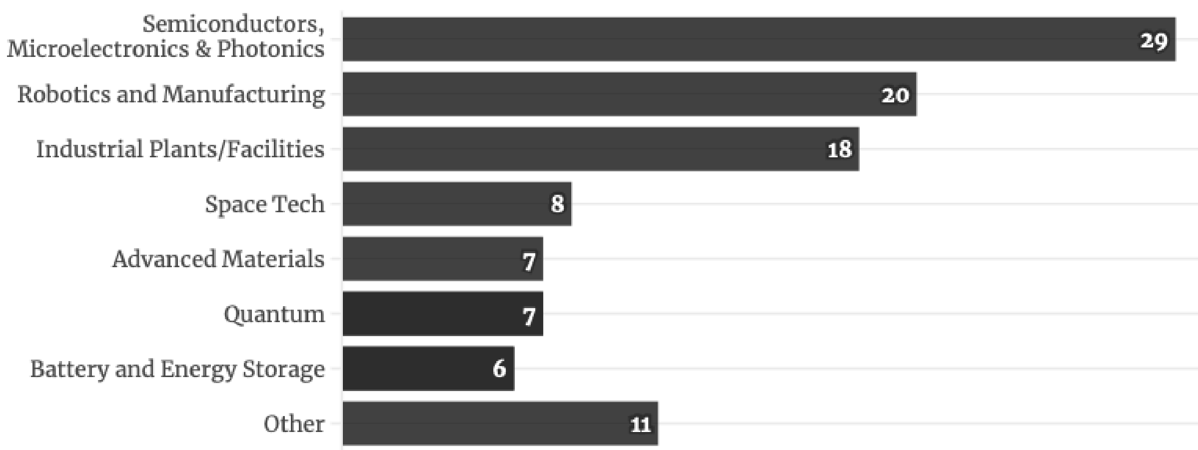

Figure 8. Industry Distribution of 102 Analysed Startup Investments

Regarding industry classification, the dataset contained 29 financings within the semiconductors, microelectronics and photonics sector, 20 in robotics and manufacturing, 18 in industrial plants or facilities, eight in space tech, seven each in quantum and advanced materials, and six in battery and energy storage. Additionally, 11 investment rounds were categorised under "Other", which were not exactly matching any of the suggested categories.

4.7 Analysis of Industry Findings

This section synthesises existing literature with new findings to outline the industry preferences of VCs in Europe.

The study reveals a concentrated investment pattern in three primary sectors: microelectronics and photonics, robotics and manufacturing, and industrial facilities. Each of these sectors represents a distinct area of technological advancement that promises substantial economic returns and societal benefits, aligning with Hall Hofer's (1993) observations. Representing the largest share of investments, the semiconductor, microelectronics, and photonics sector focuses on developing next-generation chips, essential in today's technology-driven economy. Further, the VC interests underscore a broader industry trend towards the automation of manufacturing processes, which can lead to significant improvements in cost efficiencies and production capabilities, which aligns with the findings of Popov and Roosenboom (2013), who suggest that industries poised for substantial process improvements tend to attract more investment. Investments in the industrial facilities sector typically involve startups that are engaged in energy production, recycling, and other sustainable practices, indicative of the current market shift towards green and sustainable industrial solutions, which aligns with findings of Dionisio et al. (2023). In contrast to the numerous investments in the aforementioned sectors, there is a notably lower level of funding in emerging technologies such as space tech, quantum computing, battery and energy storage, and advanced materials. This discrepancy could be due to the higher risks associated with these technologies or their longer timelines to commercialisation, which might deter immediate investment. The transformative potential of these fields is contrary to Tyebjee and Bruno's (1984) discussion on the VC preference for industries with high-growth potential, even if they are currently niche.

Overall, the attractiveness of an industry to investors is not solely determined by its current market position, but by its potential for future growth, the strategic timing of market entry, and the current potential of the industry. The analysis reveals that while VCs are keen on sectors that are primed for rapid development and commercialisation, there is a cautious, but considered interest in niche areas with long-term transformative potential.

4.8 Findings on Revenue and Business Model

4.8.1 Findings on Revenue

In the following, the analysis on revenue is conducted. Moreover, the revenue amount, which was a conditional field in the survey, presents insights into the financial performance, as a clear upward trend is evident. However, it may not reflect the revenue profile of the whole Deep Tech ecosystem.

Table 9. Distribution of Revenue Check Mark Across Stages

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
Yes	3	14	13
No	23	41	8
Total	**26**	**55**	**21**

Overall, 30 of 102 startups generating revenue were reported. The data from the survey indicated that startups generating revenue at the Pre-Seed stage are in the minority, with 3 of 26 startups (11.54%) reaching this milestone. This trend sees a notable increase at the Seed stage, where 14 out of 55 startups (25.45%) reported revenue generation. The progression continued to the Series A stage, where the proportion of startups generating revenue jumped significantly, with 13 out of 21 startups (61.90%) reaching this mark.

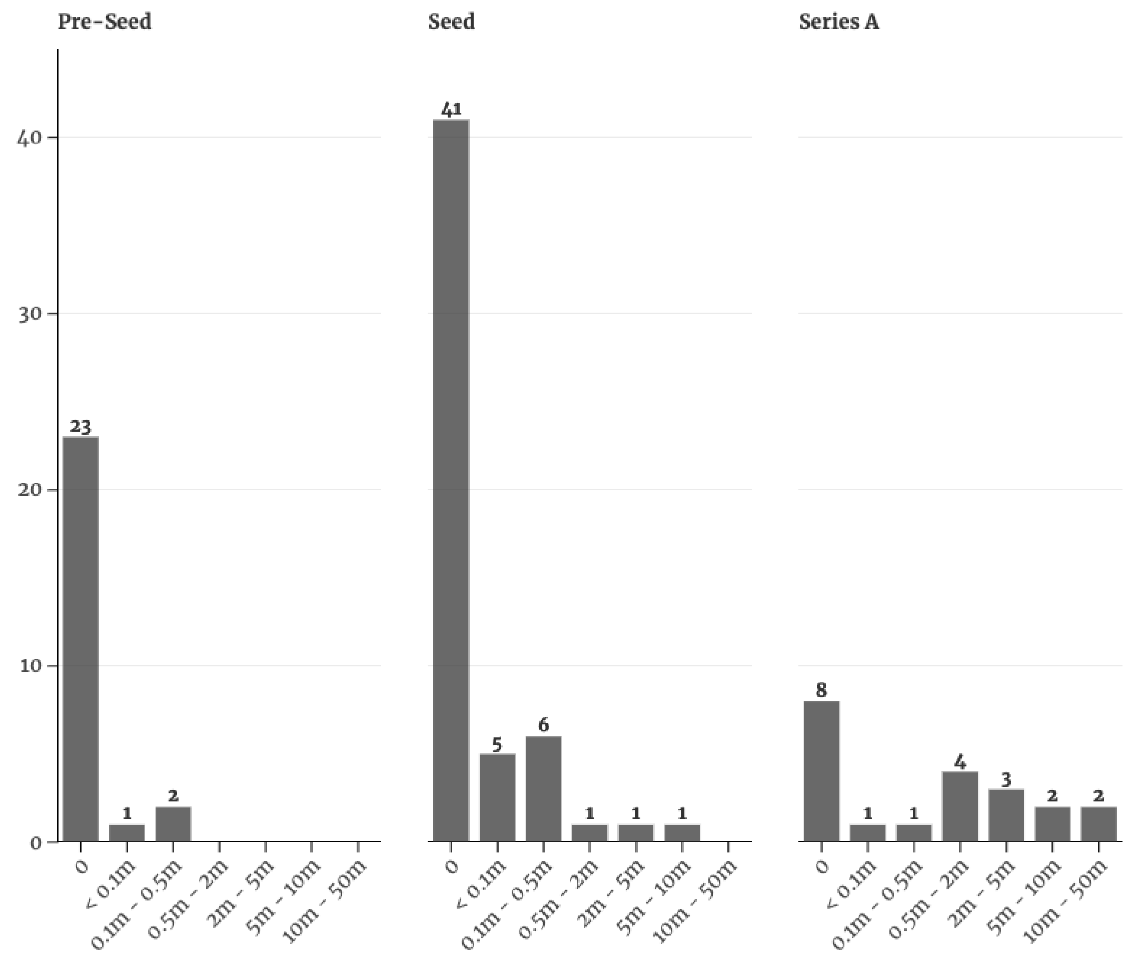

Figure 9. Distribution of Revenue Ranges Across Stages

The revenue amount was answered for 22 startups, where the most common answer was the €0.1 million to €0.5 million bracket, and a median at €0.5 million to €2 million. For both Pre-Seed and Seed stages, the most common revenue range reported is between €0.1 million to €0.5 million. Seed startups had the highest number of startups (six) generating revenue in the €0.1 million and €0.5 million range. However, the revenue jumped substantially at the Series A stage, where the most commonly reported range is from €0.5 million to €2 million. Also, the median revenue further soared to between €2 million to €5 million. Moving up the revenue scale, it was observable that Series A startups begin to show more significant revenue generation, with two companies each in the €5 million to €10 million and €10 million to €50 million ranges.

4.8.2 Findings on Growth Rate

The growth rate analysis for startups based on self-reported data of 24 startups, which was optional in the survey, illustrates the varying expansion trajectories across different funding stages.

Table 10. Distribution of Growth Rates Across Stages

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
Less than 50%	0	0	0
50% to 100%	2	2	2
101% to 200%	0	3	1
More than 200%	0	0	0
Unknown	1	6	7
Total	**3**	**11**	**10**

None of the startups at the Pre-Seed, Seed, or Series A stages had a reported growth rate below 50%. For the growth rate category of 50% to 100%, two startups were observed consistently across all stages. The 101% to 200% growth rate was reported for three Seed startups and one Series A startup, while there was no report on a growth rate of more than 200%. For most reported startups (14), the growth rate remained unknown.

4.8.3 Findings on Time to Revenue

The “Time to Revenue” analysis, an optional survey question with 69 responses, offers insights into the anticipated time frames for startups at the analysed funding stages to start generating revenue.

Table 11. Distribution of Time-To-Revenue Time Frames Across Stages

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
Less than 1 year	3	7	0
1 to 2 years	9	11	2
2 to 5 years	7	20	5
5 to 8 years	2	2	0
More than 8 years	1	0	0
Total	**22**	**40**	**7**

Overall, the two to five years bracket was the most common and the median for the analysed sample size. At the Pre-Seed stage, three startups expected to earn revenue in less than a year. In contrast, 20 Pre-Seed startups projected a two to five year time frame to revenue. Furthermore, for the five to eight-year time frame, two startups at both the Pre-Seed and Seed stages were reported. Notably, a single Pre-Seed startup anticipated more than eight years until revenue. Seven Seed-stage startups aimed for less than a year to revenue, while eleven Seed startups predicted a one- to two-year period. At the Series A stage, none projected revenue in less than a year, or longer time frames than five years, while the most common answer lied at two to five years.

4.8.4 Findings on Business Model

The business model analysis across different investment stages offers insights into how startups plan to generate revenue and provide value to customers. Most startups employ various business models, hence, the total figures differ from the total of analysed startups.

Table 12. Distribution of Business Models Across Stages

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
IP Licensing	8	15	5
Selling Materials (e.g. Methanol)	4	8	5
Hardware as a Service	8	17	7
Unit Sales	13	37	11
Software on Top of Hardware	6	15	6
Service Fees or Operational Licensing	9	14	6
Other	1	7	0
Total	**49**	**113**	**40**

Across all stages, the most common revenue model was unit sales, with 51 startups planning to directly sell their products, of which 13 were Pre-Seed startups, 37 were at Seed-stage, while 11 were Series A startups. The variation was higher across the other business models, where between 27 and 32 of startups each adopted IP licensing, Hardware as a Service, software on top of hardware, and service fees or operational licensing. Selling materials had 17 occurrences, being the least favourable business model across stages, while eight startups in total applied other business models.

4.9 Analysis of Revenue and Business Model Findings

In the analysis of revenue and business model findings within the Deep Tech sector, it becomes evident that the journey to revenue generation and the selection of business models are critical indicators of startup maturity and market acceptance. However, only 30 out of 102 surveyed startups generate revenue, which highlights that immediate revenue generation may not be as crucial in Deep Tech hardware investments, while it indicates that Pre-Seed startups begin to monetise their products or services, despite a smaller scale. Compared to Pre-Seed, more Seed and Series A startups are generating revenue, suggesting these stages involve significant validation of business models, aligning with findings by Botella-Carrubi, Maqueda-Llongo Valero-Moya (2022). This trend underscores the critical growth and development phase, where startups solidify their market presence and show potential for scaling.

The limited disclosure regarding revenue amounts and growth rates might reflect a communication gap between VCs and their funded startups, a strategic lack of transparency, or a de-emphasis on these metrics at early-stages. According to this thesis, startups, particularly at later stages, may be more conservative or uncertain in reporting projected growth rates. The urgency for early revenue generation noted among some startups is likely driven by the need to demonstrate viable business models to secure further funding to reduce risk, and avoid failure (Cantamessa et al., 2018). Conversely, the presence of longer-term views among startups across stages could be attributed to the complexities of their products or market environments, underlining a more strategic approach to achieving market fit and scalability. However, this highlights that Deep Tech VCs do not shy away from long time to revenue timeframes, regardless of revenue figures. Interestingly, no Series A startups expected to generate revenue in less than a year, indicating a realistic acknowledgment of the challenges and timelines associated with scaling sophisticated technologies. This contrasts with the advanced development stage of these startups as defined by Kollmann (2019), and underscores the ongoing development and market establishment efforts, but is surprising compared to Pre-Seed and Seed startups with shorter time frames according to this thesis, as described in Chapter 4.8.3.

The findings of this thesis imply that variation in round sizes is minimal across business models (Appendix 14). Hence, the distribution of business models reveals that numerous models can be successful when implemented correctly, which aligns with findings of Bednar, Tariskova and Zagorsek (2018). It indicates that VCs in Deep Tech do not exhibit the same strong preference for recurring revenue models that is prevalent in software startups (Zubakina & Koliasov, 2023). Moreover, the findings suggest that regardless of growth rates, unit sales is the most favourable business model for Deep Tech hardware startups, regardless of its complex nature, and the intensive capital as well as operational demands it entails. IP licensing emerges as a common early-stage business model, enabling startups to monetise their intellectual property without the immediate need to establish extensive sales or production capabilities, potentially as a derisk measure of Deep Tech hardware startups. However, the practical challenges of IP licensing, including typically lower than expected upfront fees and delayed revenue contingent on client production volumes, complicate this model. Nonetheless, it seems to be a viable business model according to the findings of this thesis. Founders in the hardware industry must carefully assess volume expectations and gross margins, with investors keenly evaluating pricing power and potential competitive pressure, which aligns and adds detail to findings from Hall and Hofer (1993). Moreover, Hardware as a Service models are popular according to this thesis, particularly in industries like robotics and manufacturing, where they offer a means to circumvent the pitfalls of unit sales by providing recurring revenue streams and reducing customers' upfront costs. This model also presents similar sales and production challenges as unit sales, and offers a strategic advantage in easing early user adoption, aligning with constraints presented by Heirman and Clarysse (2004), Blank and Dorf (2012), and O'Reilly and Binns (2019).

Overall, this analysis reveals that Deep Tech hardware founders are diverse in their approaches to generating revenue and selecting business models, shaped by the unique demands and opportunities within the sector, without clear indications on time to revenue. The varied strategies underscore the adaptability required to deal with this innovative yet challenging area of expertise, and the diversity in business models and revenue figures suggests that there is no one-fits-all solution.

4.10 Findings on Human Capital

4.10.1 Findings on Leadership Team

This section examines the distribution of characteristics, qualifications, and experiences of the leadership team, according to the survey responses.

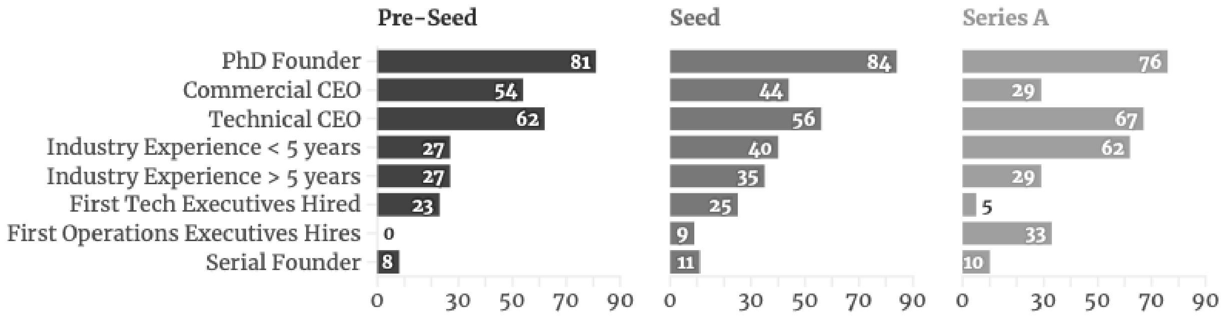

Figure 10. Distribution of Team Characteristics Across Stages (Share in % of startups)

Overall, having a PhD on the leadership team was the most common team characteristic, followed by a technical CEO over a commercial CEO, while the least common was a serial founder. At the Pre-Seed stage, the teams predominantly featured founders with strong academic credentials, where 81% of startups had a PhD founder. 62% of startups had a technical CEO, while 54% of startups included a commercial co-founder. Experience at this stage was not common, with only 27% of founders possessing over five years of industry experience, and no operations executives hired. During the Seed stage, the trend continued, with 84% having at least one PhD founder. The proportion of technical CEOs and commercial co-founders remained comparable, with 56% and 44% respectively. There was a slight increase in founders with over five years of experience, comprising 35% of the teams. 76% of Series A teams had a PhD, while only 29% had a commercial CEO, compared to 67% with a technical CEO. Further, 62% of the teams had founders with less than 5 years of experience, and 33% hired first operations executives.

4.10.2 Findings on Headcount

The following section examines the headcount data gathered through an optional question, focusing on six pre-defined answers. The distribution of employee numbers is a key indicator of organisational growth and scaling capacity, reflecting the human capital as they scale.

Table 13. Distribution of Headcount Across Stages

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
1 to 5	22	18	1
6 to 10	2	15	3
11 to 20	1	9	4
21 to 50	0	2	5
51 to 100	0	0	4
More than 100	0	0	0
Total	**25**	**44**	**17**

The most common answer was a headcount of one to five employees, followed by six to ten employees. The data revealed no startups with more than 100 employees at any of the stages were reported. In the Pre-Seed stage, the majority of startups (22 out of 25) employed between one and five full-time employees. Moving into the Seed stage, the number of startups with a headcount between 1 and 5 decreased to 18 out of 44. The most significant increase in human capital was observed in the six to ten employee range with 15 startups, and the 11 to 20 employee range with nine startups. At the Series A stage, the trend towards larger teams continued. Notably, by Series A, four startups had a workforce of 51 to 100 employees.

4.11 Analysis of Human Capital Findings

In the analysis of human capital within the Deep Tech hardware sector, several key patterns in investment criteria emerge, revealing what VCs prioritise when assessing the potential of startups. PhDs are the most dominant characteristic within Deep Tech teams, suggesting a high value placed on advanced technical knowledge and research expertise by VCs. This academic credential appears to be a prerequisite, underscoring the complexity and innovative nature of the sector. A thorough understanding of the underlying technology, its timeline, and challenges are crucial, adding a layer of understanding and detail to the findings of Roure Maidique (1986) and Skawińska Zalewski (2020), who state that startups with founders who have a clear understanding of the target market are more likely to succeed. Interestingly, there is a marked preference for technical CEOs over those with a primarily commercial background. This preference highlights the importance placed on in-depth technical knowledge at the leadership level, reinforcing the idea that effective leadership in Deep Tech goes beyond a business mindset to include strong technical expertise, possibly to better navigate the intricacies and technical challenges of the sector. The presence of serial founders and industry expertise does not show a significant trend across different funding stages, underlining that neither prior entrepreneurial nor practical experience are major factors for VCs when investing in Deep Tech hardware startups. This could be interpreted as confidence in the ability of technically proficient teams to overcome practical challenges through innovation and strategic management. This goes hand in hand with the strategic development in team composition from Pre-Seed to Series A, as startups tend to focus on augmenting their technical capabilities early-on, reflecting the initial need to develop a viable product or technology, as described by Kollmann (2019), and Botella-Carrubi, Maqueda-Llongo and Valero-Moya (2022). As startups progress from Seed to Series A, there is a noticeable increase in the number of operational and commercial executives, aligned with research by Hall Hofer (1993). This shift is aligned with the need to scale the business and manage more complex operations that go beyond product development to include market penetration and revenue generation.

Regarding team size, the findings reveal that no startups reported having more than 100 employees at any stage, which might suggest a focus on maintaining lean operations in the early phases of growth, potentially due to strict expenditure demands of investors or great management of human capital. However, by the Series A stage, some startups grow to between 51 and 100 employees, demonstrating a transition to more established operations and a scaling phase where the startup begins to mature by increasing human capital and solidifying its market presence. Also, it can be noted that especially Series A startups tend to increase headcount by hiring executives across tech, operations, and commercial. Overall, the human capital analysis in Deep Tech hardware startups illustrates a clear trajectory of growth in team dynamics, from technically dense, small teams to larger, more diverse groups, which differ significantly from teams of non-Deep Tech startups, as they do not require technical expertise.

5. Conclusion

5.1 Concluding Remarks

In the context of Deep Tech hardware startups, understanding the investment criteria applied by VCs and how these criteria vary across different funding stages is crucial. This chapter intends to conclude the research question: "What investment criteria do VCs apply for early-stage Deep Tech hardware startups in Europe, and how do their characteristics vary across Pre-Seed, Seed, and Series A funding rounds", drawing from a dataset of 102 relevant investment rounds spanning from 2022 to 2024.

This research found that VCs primarily focus on technological innovation and early IP protection measures at the Pre-Seed stage. Startups in this stage are often engaged in semiconductors and sustainable industrial technologies, emphasising unit sales as their predominant business model. Pre-Seed startups are typically in the concept validation and initial prototype development phase, with most not generating revenue. The teams usually include PhD holders and technical CEOs, highlighting the importance of advanced technical knowledge. Given the high risk, extensive time to revenue timeframes apply to startups, and equity dilution of around 30% is the standard at this stage, reflecting the larger round sizes required to bring hardware products to market.

It was also found that during the Seed stage the dominant criteria shift towards further market validation and early customer traction. Predominant industries remain similar, such as semiconductors and industrial facilities, and unit sales remains the primary business model. Startups at this stage are involved in developing and refining their products, IP protection, gaining initial market entry, and early customer acquisition. While there remains a gap in knowledge on growth rates, revenue generation starts to appear in the Seed stage, typically ranging from €0.1 million to €0.5 million, but findings are limited to a few startups. The teams grow to include a mix of technical and commercial expertise, reflecting the need for operational capabilities alongside technical development.

According to the data, VCs prioritise scalability and proven market fit by the Series A stage, and still do not apply growth rate benchmarks. Investment continues to concentrate on established sectors like semiconductors. However, interest in emerging areas such as quantum computing and advanced materials is more prevalent. Unit sales persist as the dominant business model, with some startups adopting Hardware as a Service models, due to more reliable cash flow. At this stage, startups achieve significant market traction, exceeding theoretical stages to rather practical stages, partnerships, and pilot projects. They are still involved in advanced product and IP development as well as the initial scaling of production, with revenue generation typically between €0.5 million and €2 million. The teams expand further in human capital, balancing technical, operational, and commercial executives to support the scaling process, with stronger emphasis on operations compared to Pre-Seed and Seed.

This study builds on the framework by Hall and Hofer (1993), which explores VC assessment criteria in depth. Their work emphasises understanding these criteria to enhance startup success rates and support founders in securing necessary funds. Hall and Hofer's (1993) insights into evaluating potential investments guide this thesis in defining and selecting the relevant criteria crucial for assessing the potential of early-stage Deep Tech hardware startups. This is achieved in combination with practical insights from VCs.

The thesis contributes to the existing literature by providing a detailed analysis of VC investment criteria specifically for Deep Tech hardware startups, a sector less explored in prior research. It reveals that VCs investing in this sector demand higher equity stakes across all funding rounds compared to other sectors, reflecting the higher perceived risks and capital requirements. Those increased capital requirements are reflected in larger round sizes compared to existing literature on startups. Additionally, it highlights the significant role of public funding and strategic partnerships in improving investor confidence and securing further investments. The findings show that technological advancement is prevalent at all analysed stages, offering valuable insights for both investors and startup founders in approaching funding. Further, this study indicates that VCs adjust their investment criteria based on a startup's development stage, with an early focus on technological potential and scientific expertise, but less on commercial aspects, shifting towards market validation and scalability indicators in later stages. This evolution highlights the strategic milestones Deep Tech hardware startups specifically must achieve to secure funding and succeed.

5.2 Limitations of This Study

The methodology employed has aspects to it that limit the robustness and applicability of the findings. This study focuses exclusively on early-stage investment criteria as outlined in academic research, without extending beyond Series A. Also, few insights, which were based on preliminary feedback by two VCs and the survey pre-test with six VCs, might limit practical insights from the VC industry. Such a focus might imply potential disparities between theoretical frameworks and real-world applications in VC. The data, derived from 102 relevant investment rounds, may not sufficiently represent the broad spectrum of the VC environment across Europe. Also, findings from 2022 to 2024 were generalised and not dissected. Utilising a survey distributed among VCs introduces the possibility of self-reporting biases, fostered by their agreement to cooperate. The accuracy of the responses is contingent upon the respondents' willingness and ability to provide precise and honest information, which can vary significantly among participants. The study's reliance on subjective measures in the survey, particularly those assessing market traction, introduces additional variability. These measures depend on the personal experiences, biases, or preferences of the investors, which can affect the consistency and reliability of the data across different respondents. Due to its cross-sectional design, the study's data encompasses the years 2022 and 2024, restricting the ability to observe long-term trends and fluctuations in VC funding. Such a narrow focus does not account for the broader economic conditions, market dynamics, and technological advancements that can significantly impact venture funding over more extended periods. The research design also implies that cause-and-effect relationships might not be discovered. Furthermore, by concentrating only on Europe, the study may not fully capture how global or regional factors outside of Europe influence VC practices and startup success.

5.3 Future Research

This study's exploration of early-stage investment criteria in the European VC landscape offers several insights, yet it also opens the way for further research to enhance understanding and applicability. Recognising the limitations of the applied method, future studies could expand in numerous areas to deepen the analysis and broaden the findings.

Firstly, future studies could benefit from increasing the sample size. A larger dataset would enable a more representative analysis of the VC environment, potentially leading to more generalisable findings. Secondly, it would be beneficial to explore the impact of non-traditional funding sources and investment structures, such as crowdfunding and loans. Investigating these alternative financing models could offer insights into their role and effectiveness in supporting early-stage startups compared to VC. Expanding the temporal and geographical scope would be invaluable. Incorporating data from outside Europe could provide a more global perspective on VC practices, enabling a comparative analysis across different regulatory and economic environments. Including data from a wider range of years would allow researchers to capture long-term trends and the cyclic nature of VC funding, which are central to understanding shifts in investment patterns influenced by economic fluctuations and market dynamics. Moreover, future research could enhance the reliability of data by mitigating subjective survey responses to reduce variability and bias in the responses. Implementing a mixed-methods approach that combines quantitative data with qualitative interviews or case studies could also provide a richer, more thorough understanding of investor decisions and startup development. Lastly, changing the analytical tools used in data processing and analysis could further refine the outcomes. Transitioning from Microsoft Excel to statistical software such as Stata could facilitate complex analyses, predictive modelling, and machine learning techniques. These advanced methods could uncover deeper insights and more robust correlations between investment criteria and concluded investments.

Ultimately, future research into this thesis' topic is strongly encouraged due to its relevance, economic and social impact, and lack of insights. Research into investment criteria and according characteristics will provide both entrepreneurs and VCs with tools for success to bring forward societies by enabling disruptive innovations.

5.4 Practical Implications

This study provides critical insights into the investment criteria used by VCs for early-stage Deep Tech hardware startups in Europe. These insights have significant practical implications for both VCs and startup founders, guiding strategic decisions and investment approaches.

For startup founders, understanding that VCs prioritise technological innovation and IP protection at the Pre-Seed stage, market validation and customer traction at the Seed stage, and scalability at the Series A stage, can help strategically plan milestones and development phases. Furthermore, it is crucial to emphasise the importance of having a strong technical team in the early stages, including PhD holders and technical CEOs, and gradually expanding to include commercial and operational expertise as the startup grows. Considering the critical role of public funding and strategic partnerships in strengthening investor confidence, founders should actively integrate these resources to strengthen their funding position and reduce perceived risks. Additionally, founders should be prepared to adapt business models from unit sales to potentially incorporating Hardware as a Service models as they progress through funding stages to better align with market demands and financing opportunities.

For VCs, tailoring investment criteria in Deep Tech based on the startup's development stage, focusing on technological potential and scientific expertise in early stages, and shifting towards market validation and scalability in later stages, is essential. Continuing to invest in established sectors like semiconductors while exploring emerging areas such as quantum computing and advanced materials, which show promising future growth and innovation, can diversify and strengthen their portfolios. Improved due diligence, using the detailed investment criteria and stages outlined in this study, ensures that Deep Tech hardware startups meet the necessary benchmarks. Overall, it can be concluded that Deep Tech hardware startups have different benchmarks across various investment criteria that VCs should be aware of and apply in their decision-making process.

Overall, it is crucial for founders to align development strategies and derisking steps with identified investment criteria to attract and retain investment. Integrating the findings of this research should support long-term success and market impact. VCs should adapt their funds to account for the unique risks and capital requirements of Deep Tech hardware startups, regardless of the generated revenue, business model and industry, by understanding the specific characteristics applying to each funding stage. They should adapt their evaluation frameworks to better understand and benefit from the distinct characteristics and needs of Deep Tech hardware startups.

By integrating these practical implications, both founders and VCs can gain a better understanding of funding, fostering a more robust and strategic approach to early-stage financing in the Deep Tech sector.

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Appendix

Appendix 1

Table A1. Overview of Identified Deep Tech Venture Capitalists

No.	Investor	Role	Fund	HQ	Fund Size
1	Adrian Locher	General Partner	Merantix	Germany	€100M
2	Adriana Vitagliano	Principal	Firstminute Capital	UK	£80M
3	Alberto Cresto	General Partner	Lunar Ventures	Germany	$40M
4	Alessandro Zaccaria	Partner	360 Capital	France	€200M
5	Alex Rohregger	Investor (n/a)	Picus Capital	Germany	n/a
6	Alex Wilson	Partner	IQ Capital	UK	$200M
7	Alexandra Beckstein	General Partner	QAI Ventures	Switzerland	€50M
8	Alexandre Mordacq	Partner	360 Capital	France	€200M
9	Alexis Houssou	Managing Partner	HCVC	France	$75M
10	Ambrose Thwaites	Analyst	DeepTech Labs	UK	n/a
11	Amelia Armour	Partner	Amadeus Capital Partners	UK	£110M
12	Andre Retterath	Partner	Earlybird Venture Capital	Germany	€350M
13	Andreas Fischer	General Partner	First Momentum Ventures	Germany	€50M
14	Andreas Riegler	Partner	APEX Ventures	Austria	€80M
15	Andreas Winter-Extra	Partner	KOMPAS VC	Denmark	€135M
16	Andrew J Scott	General Partner	7percent Ventures	UK	$39.3M
17	Angelika Vlachou	Partner	High-Tech Gründerfonds	Germany	€493.8M
18	Anke Gratz	Senior Associate	DeepTech & Climate Fonds	Germany	€1,000M

No.	Investor	Role	Fund	HQ	Fund Size
19	Anne-Sophie Carrese	Partner	Elaia	France	€77M
20	Beata Enwall	Associate	Norrsken VC	Sweden	€100M
21	Beau-Anne Chilla	Partner	FORWARD.one	Netherlands	€145M
22	Benedikt Kronberger	Partner	Matterwave Ventures	Germany	€120M
23	Benedikt von Schoeler	General Partner	VSquared Ventures	Germany	€165M
24	Benjamin Erhart	General Partner	UVC Partners	Germany	€260M
25	Bulent Altan	Partner	Alpine Space Ventures	Germany	€100M
26	Carlos Gonzalez-Cadenas	Partner	Index Ventures	UK	€290M
27	Cesare Maifredi	Partner	360 Capital	France	€200M
28	Charlotte Baumhauer	Investment Manager	SquareOne	Germany	€80M
29	Chris Hitchen	General Partner	Possible Ventures	Germany	€60M
30	Chris Sonnenberg	Partner	Innovation Industries	Netherlands	€200M
31	Christian Gonzalez	Investor (n/a)	Planet A Ventures	Germany	€160M
32	Christian Reitberger	Partner	Matterwave Ventures	Germany	€120M
33	Christian Schütz	Partner	b2venture	Germany	€135M
34	Christian zu Jeddeloh	Associate	Norrsken VC	Sweden	€100M
35	Christoph Baumeister	Principal	Possible Ventures	Germany	€60M
36	Christoph Gras	General Partner	Planet A Ventures	Germany	€160M
37	Christophe Jurczak	Partner	Quantonation	France	€91M
38	Christopher Magazzeni	Associate	IQ Capital	UK	$200M

No.	Investor	Role	Fund	HQ	Fund Size
39	Clément vanden Driessche	Investment Director	Elaia	France	€77M
40	Daniel Weiss	General Partner	Spacewalk	Germany	€35M
41	Daria Saharova	General Partner	World Fund	Germany	€350M
42	David Byrd	General Partner	BlueYard Capital	Germany	$175M
43	David Delfassy	Investor (n/a)	Ahren Innovation Capital	UK	£200M
44	David Meiborg	General Partner	First Momentum Ventures	Germany	€50M
45	Diana Röttger	Principal	APEX Ventures	Austria	€80M
46	Edward van der Hout	Analyst	Rubio Impact Ventures	Netherlands	€110M
47	Romeo Bütler	Principal	Verve Ventures	Switzerland	n/a
48	Estelle Godard	Associate	Promus Ventures	Luxembourg	€120M
49	Evgenia Macpherson	Principal	2xN	UK	$120M
50	Evgeny Slavin	Senior Associate	Speedinvest	Austria	€500M
51	Fabian Gruner	Principal	HV Capital	Germany	€780M
52	Fadwa Ouardani	Senior Associate	XAnge	France	€200M
53	Ferdinand Vermersch	Associate	VSquared Ventures	Germany	€165M
54	Flavia Levi	Principal	Octopus Ventures	UK	$280M
55	Francesco Fontana	Investor (n/a)	Neva SGR	Italy	€250M
56	Francesco Ricciuti	Associate	Runa Capital	Luxembourg	$157M
57	Frederick Michna	Principal	MIG Capital	Germany	€160M
58	Gabriel Matuschka	Associate	Fly Ventures	Germany	€53M

No.	Investor	Role	Fund	HQ	Fund Size
59	Gareth Keane	Partner	Promus Ventures	Luxembourg	€120M
60	Georg Stockinger	General Partner	SquareOne	Germany	€80M
61	Gregorio Gaspari	Associate	CDP Venture Capital	Italy	€150M
62	Guerric de Crombrugghe	General Partner	Nuketech	Belgium	€50M
63	Guilhem de Vregille	Partner	XAnge	France	€200M
64	Hampus Jakobsson	General Partner	Pale Blue Dot	Sweden	$100M
65	Helen Gerharz	Investment Manager	Freigeist Capital	Germany	n/a
66	Herbert Magnesius	Partner	VSquared Ventures	Germany	€165M
67	Hugo Hubert	Associate	Omnes Capital	France	€200M
68	Hussein Kanji	Partner	Hoxton Ventures	UK	$215M
69	Ines Kolmsee	Partner	Matterwave Ventures	Germany	€120M
70	Inka Mero	Managing Partner	Voima Ventures	Finland	€90M
71	Ion Hauer	Principal	APEX Ventures	Austria	€80M
72	Irina Haivas	Partner	Atomico	UK	$800M
73	Isabela Chick	Partner	DeepTech Labs	UK	n/a
74	James Wise	Partner	Balderton Capital	UK	$600M
75	Jasmin Güngör	General Partner	Onsight Ventures	Austria	€20M
76	Jason Whitmire	General Partner	BlueYard Captial	Germany	$175M
77	Jessica Burley	Investor (n/a)	Planet A Ventures	Germany	€160M
78	Jonas Sommer	Investment Manager	DeepTech & Climate Fonds	Germany	€1,000M

No.	Investor	Role	Fund	HQ	Fund Size
79	Jonno Evans	Principal	IQ Capital	UK	$200M
80	Jussi Sainiemi	Partner	Voima Ventures	Finland	€90M
81	Karol Lasota	Principal	Inovo	Poland	€107M
82	Karol Szubstarski	Partner	OTB Ventures	Poland	€150M
83	Katharina Neisinger	Associate	Pace Ventures	Germany	n/a
84	Kerry Baldwin	Managing Partner	IQ Capital	UK	$200M
85	Kris Kaczmarek	Associate	2xN	UK	$120M
86	Larissa Skarke	Investment Manager	World Fund	Germany	€350M
87	Lars Fjeldsoe-Nielsen	General Partner	2xN	UK	$120M
88	Lawrence Lundy-Bryan	Partner	Lunar Ventures	Germany	$40M
89	Lina Wenner	Partner	Firstminute Capital	UK	£80M
90	Lise Rechsteiner	General Partner	VSquared Ventures	Germany	€165M
91	Luca Saldì	Associate	Neva SGR	Italy	€250M
92	Luca Salerno	Analyst	LIFTT	Italy	€104M
93	Lukas Leitner	Associate	Lakestar	Switzerland	€252M
94	Mala Valroy	Investment Manager	Industrifonden	Sweden	n/a
95	Manjari Chandran-Ramesh	Partner	Amadeus Capital Partners	UK	£110M
96	Marc Alexander Kühn	Associate	UVC Partners	Germany	€260M
97	Margherita Marchetti	Investment Manager	Innovation Industries	Netherlands	€200M
98	Marie Tai	Principal	Possible Ventures	Germany	€60M

No.	Investor	Role	Fund	HQ	Fund Size
99	Mark Windeknecht	Principal	World Fund	Germany	€350M
100	Martin Fiennes	Partner	Oxford Science E	UK	£250M
101	Mason Sinclair	Principal	IQ Capital	UK	$200M
102	Mat Munro	Partner	Octopus Ventures	UK	$280M
103	Matti Kanninen	Managing Partner	Butterfly Ventures	Finland	€47M
104	Maureen Haverty	Principal	Seraphim Space	UK	$585M
105	Max Bautin	Managing Partner	IQ Capital	UK	$200M
106	Maxi Pethö-Schramm	Investment Manager	HV Capital	Germany	€780M
107	Maxime Lhoustau	Associate	Elaia	France	€77M
108	Maximilian Ochs	Investor (n/a)	First Momentum Ventures	Germany	€50M
109	Michael Lütolf	Principal	Verve Ventures	Switzerland	n/a
110	Moritz von Klot	Associate	Earlybird-X	Germany	€75M
111	Nader Sabbaghian	Partner	360 Capital	France	€200M
112	Nadine Geiser	Principal	World Fund	Germany	€350M
113	Nadja Reischel	Investor (n/a)	Cherry Ventures	Germany	€330M
114	Nathan Benaich	General Partner	Air Street Capital	UK	$121M
115	Nick de la Forge	General Partner	Planet A Ventures	Germany	€160M
116	Nils Lang	Investment Manager	High-Tech Gründerfonds	Germany	€493.8M
117	Nirmesh Patel	Principal	The Venture Collective	UK	$50M
118	Olaf Jacobi	Managing Partner	Capnamic Ventures	Germany	€190M

No.	Investor	Role	Fund	HQ	Fund Size
119	Olaf Joeressen	Investment Manager	High-Tech Gründerfonds	Germany	€493.8M
120	Oliver Hedaux	Associate	Ahren Innovation Capital	UK	£200M
121	Oliver Schoppe	Principal	UVC Partners	Germany	€260M
122	Olivia Ash	Investor (n/a)	Conception X	UK	n/a
123	Omar Hedeya	Associate	10x Founders	Germany	€160M
124	Pablo Karnbaum	Associate	SquareOne	Germany	€80M
125	Patrick Herrmann	Investor (n/a)	Picus Capital	Germany	n/a
126	Paul Eisenberg	Investor (n/a)	Kiko Ventures	UK	£450M
127	Paul Klemm	Partner	Earlybird Venture Capital	Germany	€350M
128	Peter Crane	Partner	Lunar Ventures	Germany	$40M
129	Philipp Semmer	Partner	Earlybird-X	Germany	€75M
130	Quentin Calleja	Senior Associate	Atlantic Labs	Germany	€80M
131	Rasmus Rothe	General Partner	Merantix	Germany	€100M
132	Rawan Farwana	Senior Associate	Oxford Science E	UK	£250M
133	Rick Hao	Partner	Speedinvest	Austria	€500M
134	Riku Seppälä	General Partner	Icebreaker.vc	Finland	€100M
135	Rob Desborough	Managing Partner	Seraphim Space	UK	$585M
136	Rob Kniaz	Partner	Hoxton Ventures	UK	$215M
137	Robert Gallenberger	Partner	Matterwave Ventures	Germany	€120M
138	Robina von Stein	Investor (n/a)	Contrarian Ventures	Lithuania	€100M

No.	Investor	Role	Fund	HQ	Fund Size
139	Roméo Walter	Associate	Fly Ventures	Germany	€53M
140	Ruben Schultz	Principal	Atlantic Labs	Germany	€80M
141	Sali Solmaz	Associate	Value Creation Capital	Netherlands	€30M
142	Sami Moughrabie	Partner	Atmos Ventures	USA	n/a
143	Sasha Vidiborskiy	Partner	Atomico	UK	$800M
144	Sebastian Peck	Partner	KOMPAS VC	Denmark	€135M
145	Sebastian Pollok	General Partner	Visionaries TOMORROW	Germany	€50M
146	Simon King	Partner	Octopus Ventures	UK	$280M
147	Sivesh Sukumar	Principal	Balderton Capital	UK	$600M
148	Stefan Haubner	General Partner	Amadeus APEX	UK	€80M
149	Stefano Bernardi	General Partner	Unruly Capital	UK	€24M
150	Stephan Rauscher	Partner	Earlybird-X	Germany	€75M
151	Stephen Nundy	Partner	Lakestar	Switzerland	€252M
152	Steven Jacobs	Partner	Lakestar	Switzerland	€252M
153	Thijs Gitmans	Partner	SHIFT Invest	Netherlands	€110M
154	Thomas Oehl	General Partner	VSquared Ventures	Germany	€165M
155	Thong Le Hoang	Principal	Visionaries TOMORROW	Germany	€50M
156	Tobias Faupel	General Partner	DeepTech & Climate Fonds	Germany	€1,000M
157	Torben Schreiter	Partner	Extantia Capital	Germany	€150M
158	Torsten Löffler	Investment Director	DeepTech & Climate Fonds	Germany	€1,000M

No.	Investor	Role	Fund	HQ	Fund Size
159	Tove Larsson	General Partner	Norrsken VC	Sweden	€100M
160	Uzma Choudry	Investor (n/a)	Octopus Ventures	UK	$280M
161	Vincent Kamphorst	Investment Director	Innovation Industries	Netherlands	€200M
162	Will Anderson	Associate	Possible Ventures	Germany	€60M
163	Will Bennett	Associate	Seedcamp	UK	$180M
164	Will Zeng	Partner	Quantonation	France	€91M
165	Wojtek Smolinski	Managing Partner	VIGO Ventures	Poland	n/a
166	Wojtek Walniczek	Partner	OTB Ventures	Poland	€150M
167	Wolfgang Neubert	Partner	APEX Ventures	Austria	€80M

Appendix 2

Table A2. Overview of Identified VC Funds Based on Identified Venture Capitalists

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
1	Merantix	x	x	x	Europe
2	Firstminute Capital	x	x	x	Europe
3	Lunar Ventures	x	x		Europe
4	360 Capital	x	x		Italy
5	Picus Capital		x	x	Global
6	IQ Capital		x	x	Europe
7	QAI Ventures		x	x	Europe
8	HCVC	x	x		US
9	DeepTech Labs	x	x		Europe
10	Amadeus Capital Partners		x	x	Europe
11	Earlybird Venture Capital		x	x	Europe
12	First Momentum Ventures	x			Europe
13	APEX Ventures		x	x	Europe
14	KOMPAS VC		x	x	US; Israel
15	7percent Ventures	x	x		US
16	High-Tech Gründerfonds	x	x		Germany; Europe
17	Elaia	x	x		Europe

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
18	Norrsken VC	x	x	x	Europe
19	FORWARD.one	x	x	x	Europe
20	Matterwave Ventures		x	x	Europe
21	VSquared Ventures		x	x	Europe; US
22	Alpine Space Ventures		x	x	Europe
23	Index Ventures		x	x	Europe
24	SquareOne	x	x	x	Europe
25	Possible Ventures	x	x		Europe; US; Australia
26	Innovation Industries	x	x	x	Europe
27	b2venture	x	x	x	Europe
28	Planet A Ventures	x	x	x	Europe
29	Quantonation	x	x	x	US; Canada
30	Spacewalk	x	x		Europe
31	World Fund		x	x	Europe
32	BlueYard Capital	x	x	x	Europe
33	Ahren Innovation Capital	x	x	x	US
34	Rubio Impact Ventures		x	x	Europe
35	Verve Ventures		x	x	Europe

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
36	Promus Ventures	x	x	x	US
37	2xN	x	x	x	US
38	Speedinvest	x	x		Europe
39	HV Capital			x	Europe
40	XAnge		x	x	Europe
41	Octopus Ventures		x	x	US
42	Neva SGR		x	x	Italy; Europe
43	Runa Capital		x	x	Europe; US
44	MIG Capital	x	x	x	Europe
45	Fly Ventures	x	x		Europe
46	CDP Venture Capital		x	x	Italy; Europe
47	Nuketech	x	x	x	US
48	Pale Blue Dot	x	x		Europe
49	Freigeist Capital		x		Europe
50	Omnes Capital		x	x	Europe
51	Hoxton Ventures	x	x		Europe
52	Voima Ventures	x	x	x	Finland; Europe
53	Atomico		x	x	Europe

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
54	Balderton Capital		x	x	Europe
55	Onsight Ventures	x	x	x	Europe
56	DeepTech & Climate Fonds		x	x	Germany
57	Inovo	x	x	x	CEE
58	OTB Ventures		x	x	Europe
59	Pace Ventures	x	x		US
60	LIFTT	x	x	x	Italy; Europe
61	Lakestar		x	x	Europe; US
62	Industrifonden	x	x	x	Nordics
63	UVC Partners	x	x	x	Europe
64	Oxford Science Enterprises	x	x		UK
65	Butterfly Ventures		x		Finland; Nordics; Baltics
66	Seraphim Space		x	x	Europe
67	Earlybird-X	x	x		Europe
68	Cherry Ventures	x	x	x	Europe
69	Air Street Capital	x	x	x	US
70	The Venture Collective	x	x		US
71	Capnamic Ventures	x	x	x	DACH

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
72	Conception X	x	x		Europe
73	10x Founders	x	x	x	Europe
74	Kiko Ventures	x	x	x	UK; Europe
75	Atlantic Labs	x			Europe
76	Icebreaker.vc	x			Finland; Sweden; Estonia
77	Contrarian Ventures	x	x	x	Europe
78	Value Creation Capital		x	x	Netherlands; Europe
79	Atmos Ventures		x	x	Europe
80	Visionaries TOMORROW	x	x		Europe
81	Amadeus APEX		x	x	Europe
82	Unruly Capital	x	x		Europe; US; Africa
83	SHIFT Invest	x	x	x	Netherlands; Europe
84	Seedcamp	x	x		Europe
85	VIGO Ventures		x		Europe

Appendix 3

Table A3. List of Contacted VCs and VCs Which Gave Initial Feedback on Survey

No.	Names of VC Funds	Provided Feedback
1	APEX Ventures	
2	DeepTech Labs	
3	Extantia	
4	First Momentum Ventures	Yes
5	Fly Ventures	
6	IQ Capital	
7	Matterwave Ventures	
8	Merantix	
9	Onsight Ventures	
10	Planet A Ventures	
11	Possible Ventures	
12	Speedinvest	
13	Uebermorgen VC	
14	Unruly Capital	
15	Verve Ventures	Yes

Appendix 4

Table A4. List of Contacted VCs and VCs Who Conducted Survey Pre-Test

No.	Names of VC Funds	Provided Feedback
1	APEX Ventures	
2	Atomico	
3	Balderton Capital	
4	BlueYard Capital	Yes
5	DeepTech & Climate Fonds	
6	DeepTech Labs	
7	Extantia	
8	First Momentum Ventures	Yes
9	Fly Ventures	Yes
10	Hoxton Ventures	
11	IQ Capital	Yes
12	Matterwave Ventures	
13	Merantix	
14	Onsight Ventures	
15	Planet A Ventures	Yes
16	Possible Ventures	
17	Speedinvest	
18	Uebermorgen VC	
19	Unruly Capital	
20	Verve Ventures	Yes
21	Voima Ventures	

Appendix 5

Possible Answers for Industry-related Survey Question

1. **Semiconductors, Microelectronics, and Photonics:** In this industry, startups develop the foundational components essential for modern electronics and communication systems.
2. **Robotics and Manufacturing:** Startups in this space are redefining production processes through automation, smart machinery, and advanced software integration, targeting efficiency and innovation in manufacturing.
3. **Industrial Plants/Facilities:** Startups in this sector focus on enhancing industrial efficiency and sustainability, often through novel processes like green chemistry and power-to-gas technologies.
4. **Advanced Materials:** This category includes startups pioneering the development of new materials, such as bio-based plastics, which offer environmental benefits and advanced functional properties.
5. **Battery and Energy Storage:** Startups here are addressing the need for energy storage solutions, a cornerstone for the broader adoption of renewable energy technologies.
6. **Quantum:** Quantum technology startups work at the cutting edge of computing and information processing, offering the potential for significant breakthroughs in various applications.
7. **Space Tech:** In this sector, startups offer products for space exploration and satellite technology, aiming to open new frontiers in communication, earth observation, and beyond.
8. **Other:** This category encompasses startups with innovations that do not neatly fit into the main categories, but offer unique value propositions and technological advancements in niche markets or emerging fields.

Appendix 6

Possible Answers for Leader Team-related Survey Question

1. **PhD**: Founders with a Doctor of Philosophy degree, typically indicating advanced expertise in a specific field relevant to the startup's technology.
2. **Industrial Experience less than five years**: Founders who have been involved in the relevant industry for less than five years, bringing recent experience and current industry knowledge.
3. **Industrial Experience more than five years**: Founders with more than five years of industry experience, offering a depth of knowledge and possibly a well-established professional network.
4. **Technological CEO**: A CEO with a strong technical or engineering background, leading the company's technological vision and product development.
5. **Non-Technical / Commercial CEO**: A CEO who brings expertise in business development, sales, and marketing to the team, focusing on the commercialisation and growth aspects of the startup.
6. **Serial Founder**: A founder who has previously set up one or more startups, suggesting a background in entrepreneurship.
7. **First Commercial Executives Hired**: The early recruitment of executives who focus on the commercial strategy and activities of the startup, such as sales, marketing, and business development.
8. **First Technology Executives Hired**: The initial technology leaders recruited to oversee and guide the development of the startup's core technologies.
9. **First Operational Executives Hired**: The first executives responsible for the day-to-day operational management and administrative functions of the startup.

Appendix 7

Possible Answers for Technology Phase-related Survey Question

1. **Whitepaper Stage**: Startups at this phase are typically in the conceptual stage, with their core technology outlined in whitepapers but not yet developed or tested.
2. **Laboratory (Lab) Demonstrator**: At this stage, the technology has progressed beyond theory, with prototypes or proofs of concept being developed and tested in a laboratory setting.
3. **Industrial Proof of Concept (PoC) Stage**: Technology that has moved beyond the lab, demonstrating feasibility in an industrial or real-world environment, yet not at full scale.
4. **Commercial Pilot Stage**: Startups have developed their technology to the extent that it can be piloted with potential users or customers, indicating a closer step towards market readiness.
5. **Full Commercialisation and Further Improvements**: At this stage, the technology is fully developed, commercially available, and the company may be focused on scaling and improving the product.

Appendix 8

Table A5. Overview of VC Funds that Received Survey Meeting Inclusion Criteria

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
1	Merantix	x	x	x	Europe
2	Firstminute Capital	x	x	x	Europe
3	Lunar Ventures	x	x		Europe
4	360 Capital	x	x		Italy
5	Picus Capital		x	x	Global
6	IQ Capital		x	x	Europe
7	QAI Ventures		x	x	Europe
8	DeepTech Labs	x	x		Europe
9	Amadeus Capital Partners		x	x	Europe
10	Earlybird Venture Capital		x	x	Europe
11	First Momentum Ventures	x			Europe
12	APEX Ventures		x	x	Europe
13	High-Tech Gründerfonds	x	x		Germany; Europe
14	Elaia	x	x		Europe
15	Norrsken VC	x	x	x	Europe
16	FORWARD.one	x	x	x	Europe
17	Matterwave Ventures		x	x	Europe

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
18	VSquared		x	x	Europe; US
19	Alpine Space Ventures		x	x	Europe
20	Index Ventures		x	x	Europe
21	SquareOne	x	x	x	Europe
22	Possible Ventures	x	x		Europe; US; Australia
23	Innovation Industries	x	x	x	Europe
24	b2venture	x	x	x	Europe
25	Planet A Ventures	x	x	x	Europe
26	Spacewalk	x	x		Europe
27	World Fund		x	x	Europe
28	BlueYard Capital	x	x	x	Europe
29	Rubio Impact Ventures		x	x	Europe
30	Verve Ventures		x	x	Europe
31	Speedinvest	x	x		Europe
32	HV Capital			x	Europe
33	XAnge		x	x	Europe
34	Neva SGR		x	x	Italy; Europe
35	Runa Capital		x	x	Europe; US

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
36	MIG Capital	x	x	x	Europe
37	Fly Ventures	x	x		Europe
38	CDP Venture Capital		x	x	Italy; Europe
39	Pale Blue Dot	x	x		Europe
40	Freigeist Capital		x		Europe
41	Omnes Capital		x	x	Europe
42	Hoxton Ventures	x	x		Europe
43	Voima Ventures	x	x	x	Finland; Europe
44	Atomico		x	x	Europe
45	Balderton Capital		x	x	Europe
46	Onsight Ventures	x	x	x	Europe
47	DeepTech & Climate Fonds		x	x	Germany
48	Inovo	x	x	x	CEE
49	OTB Ventures		x	x	Europe
50	LIFTT	x	x	x	Italy; Europe
51	Lakestar		x	x	Europe; US
52	Industrifonden	x	x	x	Nordics
53	UVC Partners	x	x	x	Europe

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
54	Oxford Science Enterprises	x	x		UK
55	Butterfly Ventures		x		Finland; Nordics; Baltics
56	Seraphim Space		x	x	Europe
57	Earlybird-X	x	x		Europe
58	Cherry Ventures	x	x	x	Europe
59	Capnamic Ventures	x	x	x	DACH
60	Conception X	x	x		Europe
61	10x Founders	x	x	x	Europe
62	Kiko Ventures	x	x	x	UK; Europe
63	Atlantic Labs	x			Europe
64	Icebreaker.vc	x			Finland; Swede;, Estonia
65	Contrarian Ventures	x	x	x	Europe
66	Value Creation Capital		x	x	Netherlands; Europe
67	Atmos Ventures		x	x	Europe
68	Visionaries TOMORROW	x	x		Europe
69	Amadeus APEX		x	x	Europe
70	Unruly Capital	x	x		Europe; US; Africa
71	SHIFT Invest	x	x	x	Netherlands; Europe

No.	Fund	Pre-Seed	Seed	Series A	Geographical Focus
72	Seedcamp	x	x		Europe
73	VIGO Ventures		x		Europe

Appendix 9

Table A6. Overview of the VC Funds that Completed Survey and Provided Data Points

No.	Names of VC Funds	No.	Names of Funds
1	7pc VC	17	APEX Ventures
2	Atomico	18	Earlybird
3	Elaia	19	Extania
4	First Momentum Ventures	20	Founderful
5	Intel	21	IQ Capital
6	Kindred Capital	22	Lea Partners
7	Matterwave VC	23	Nucleus Capital
8	Onsight VC	24	Possible Ventures
9	Project A Ventures	25	Runa Capital
10	Saxovent	26	Seedcamp
11	Seraphim	27	Speedinvest
12	Supernova Invest	28	The Creator Fund
13	Übermorgen VC	29	Unruly Capital
14	Verve Ventures	30	Vigo Ventures
15	Vsquared	31	Worldfund
16	XAnge	-	-

Appendix 10

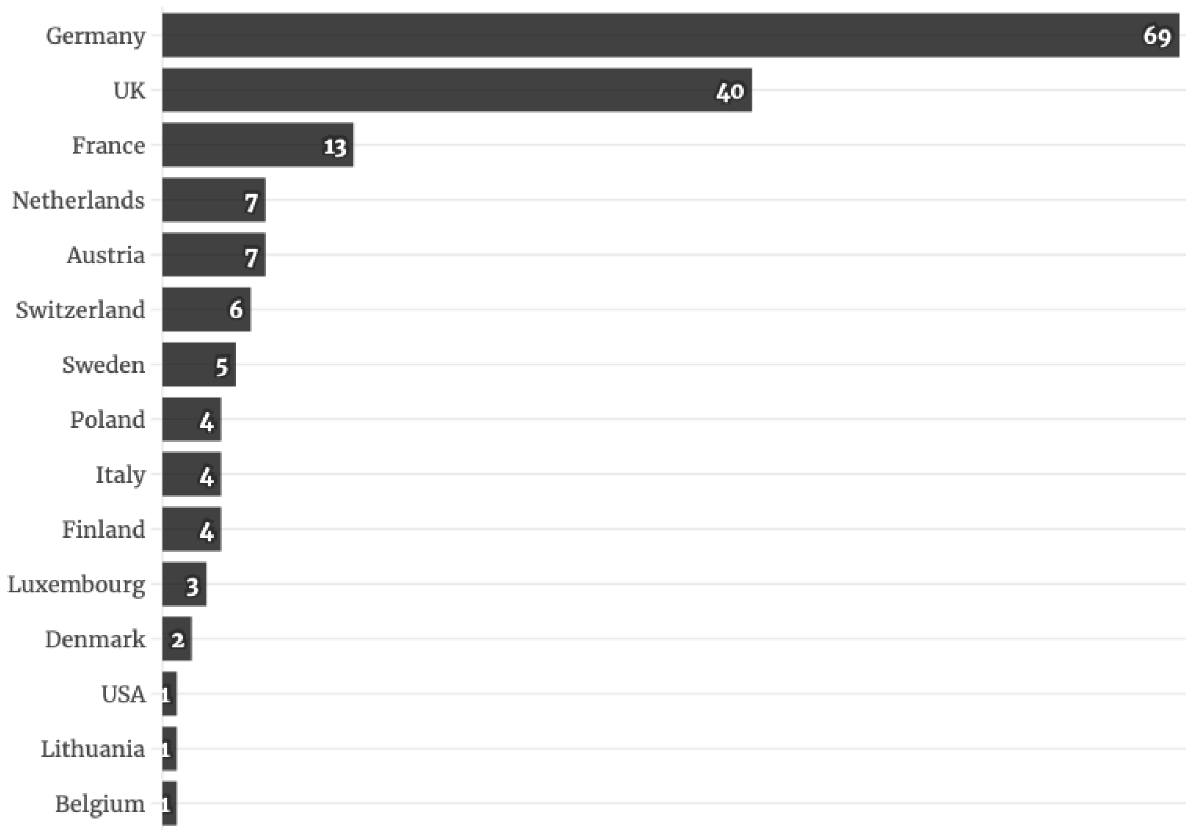

Figure A1. Country Allocation of Targeted VCs with Survey

Appendix 11

Table A7. Correlation between Combined Ownership (in %) and Median Round Size (in million €)

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
100%	2.00	3.75	n/a
90% to 99%	2.95	4.00	n/a
80% to 89%	1.73	2.30	n/a
70% to 79%	1.30	3.30	9.50
60% to 69%	n/a	6.25	22.50
50% to 59%	n/a	5.70	15.00
40% to 49%	n/a	7.00	20.00
30% to 39%	n/a	n/a	60.00
20% to 29%	n/a	n/a	n/a
10% to 19%	n/a	n/a	n/a
0% to 9%	n/a	n/a	n/a
Unknown	n/a	n/a	n/a

Appendix 12

Table A8. Correlation between Technology Stage and Median Round Sizes (in million €)

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
Whitepaper Stage	3.50	5.00	n/a
Lab Demonstrator Stage	1.90	3.80	10.00
Commercial Pilot Stage	1.50	1.70	14.00
Industrial PoC Stage	3.10	4.30	11.00
Full Commercialisation	n/a	n/a	18.50

Appendix 13

Table A9. Correlation between Market Traction and Median Round Size (in million €)

	Stage		
Possible Input	**Pre-Seed**	**Seed**	**Series A**
Tech/Feasibility Demo	2.65	3.20	15.50
Customer Interviews	2.90	3.20	9.00
Customer Interest Formalised	3.00	3.35	20.00
Secured Partnerships	3.00	3.60	20.00
Project Sales	3.00	3.60	17.50
Pilot Projects	3.00	4.65	19.00
Off-take Agreements	n/a	5.00	19.00
Full Commercialisation	n/a	5.00	21.50
Other	n/a	n/a	n/a

Appendix 14

Table A10. Correlation between Business Model and Median Round Sizes (in million €)

	Stage		
Business Model	**Pre-Seed**	**Seed**	**Series A**
IP Licensing	2.00	5.00	11.00
Selling Materials	3.25	4.34	11.00
Hardware as a Service	2.50	4.00	18.00
Unit Sales	2.40	3.85	9.00
Software on top of Hardware	1.50	3.00	18.50
Service Fees or Operational Licensing	2.90	4.34	16.50
Other	8.00	7.00	n/a