EMBA Innovation, Digitalization & Entrepreneurship

Beyond organizational ambidexterity: The multidextrous deep-tech startup

A Master's Thesis submitted for the degree of
"Executive Master of Business Administration"

supervised by
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Vienna, 01.08.2023

Affidavit

I, **JOSIANE P. LAFLEUR**, hereby declare

1. that I am the sole author of the present Master's Thesis, "BEYOND ORGANIZATIONAL AMBIDEXTERITY: THE MULTIDEXTROUS DEEP-TECH STARTUP", 68 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
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ABSTRACT

Subject: Collaborative ecosystems can be a crucial element in overcoming technological, business development, scaling, and commercialization risks. Deep-tech startups may therefore look to collaboration partners to increase their ambidexterity and fulfill their exploration and exploitation needs.

Main issue and objective: While the literature exploring the impact of collaborations on ambidexterity in large corporates is abundant, there is a manifest literature gap in how and if deep-tech startups use collaborations to achieve the same. This explorative inductive study aimed to investigate if deep-tech startups use collaborations to achieve ambidexterity and if these collaborations focus more on exploration or exploitation activities. We also sought to gain a deeper understanding of the deep-tech start-up collaboration process with a focus on the motivation, the partnership type, and the practical implementation of the collaboration to evaluate the impact of the collaboration on startup performance (access to resources, innovation, learning, access to market, etc.). Finally, we aimed to identify key factors and best practices that contribute to successful deep-tech startup collaboration.

Central research question: The central research question at the heart of the thesis is formulated as follows: Do deep-tech startups use collaborations to achieve ambidexterity and enhanced performance?

Research design and methodology: This inductive exploratory study was based on seven semi-structured interviews with deep-tech startup founders who had a physical product offering. The interview contents were analyzed qualitatively using Thematic Analysis by reducing the interview data to its core elements, identifying and coding recurring themes, summarizing the results graphically, interpreting the main findings and supporting these interpretations with direct quotations from the interviews.

Findings: We found that deep-tech startups rely heavily on collaborations for both exploration and exploitation. The deep-tech startups interviewed juggled a multitude of collaborations, at all technology readiness levels, for both

exploration and exploitation purposes, and with a wide variety of collaboration partner types, in an approach that we termed multidextrous. Adapting the seldom-used concept of multidexterity to the collaboration ecosystem of deep-tech startups, we defined the multidexterity concept as “the capacity to concurrently foster and manage multiple unique collaborations that span various partner types (startups, SMEs, Universities, corporates), technology readiness levels, industries, and objectives (from exploration to exploitation).”

Conclusions and outlook: Very little work currently exists on how deep-tech startups approach collaborations. The findings of this study show that collaborations are an essential tool used extensively by deep-tech startups to overcome their unique challenges. A deductive study with a larger sample is required to validate the generalization made in this explorative inductive study. More detailed case studies and observation studies are required to highlight critical strategies, lessons learned, and success factors to effectively navigate this intensive, unique, multidextrous collaboration environment.

Keywords: Collaboration, Ambidexterity, Deep-tech, Startups, Spinoffs

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CHAPTER 1. INTRODUCTION

Deep-tech startups and spinoffs are central to translating new scientific results into commercially available products. In this endeavor, deep-tech entrepreneurs must often balance the challenge of developing new markets in addition to their R&D and technological development activities. This balancing of innovation and exploitation is referred to as organizational ambidexterity. While ambidexterity is crucial for deep-tech startups pursuing higher performance levels, there has yet to be a widely applicable theoretical model of ambidexterity that deep-tech startups can use to achieve better performance (Khursheed and Mustafa, 2021).

Collaborative ecosystems and open innovation can be crucial elements in overcoming technological, business development, scaling, and commercialization risks. Deep-tech startups may therefore look to collaboration partners to increase their ambidexterity and fulfill their exploration and exploitation needs. While the literature is abundant in exploring the impact of collaborations on ambidexterity in large corporates, there is a manifest literature gap in how and if deep-tech startups do use collaborations to achieve the same. While startups do collaborate with established firms, they face severe dissatisfaction in the process. According to a joint research study conducted by Imaginatik and MassChallenge, 50% of startups ranked their experience interacting with corporates as mediocre or worse (Imaginatik and MassChallenge, 2016), while in a study by Becker et al. (2018), 38% of startups reported being dissatisfied and an additional 8% reported being very dissatisfied by their cooperation with SMEs.

Research question and objectives

This explorative inductive study focuses specifically on deep-tech startups with a physical/hardware product as they face different challenges compared to standard high-technology software startups. We wish to explore and understand if and how deep-tech startups collaborate to achieve ambidexterity.
The research question is formulated as follows:

> Do deep-tech startups use collaborations to achieve ambidexterity and enhanced performance?

The objectives are:

- To investigate if deep-tech startups use collaborations to achieve ambidexterity and if these collaborations focus more on exploration or exploitation activities.
- To gain a deeper understanding of the collaboration process with a focus on
    - the motivation,
    - the partnership type,
    - the practical implementation of the collaboration
- To evaluate the impact of the collaboration on startup performance (access to resources, innovation, learning, access to market, etc.)
- To identify the key factors and best practices that contribute to successful deep-tech startup collaboration.

Research methodology

An inductive approach to theory development was used in this study. Our primary data sources consisted of semi-structured interviews with seven deep-tech startup founders. The sample set was limited to hardware deep-tech startups that need to manufacture a physical product as they face unique risks, research & development costs, and time to market compared to traditional software and app-based tech startups. The semi-structured interviews were conducted in the summer of 2023 via video conference. This format allowed the participants to provide detailed answers while allowing the author to encourage elaboration and ask follow-up questions to gain additional insights about the startups' collaboration experience. The empirical data was analyzed qualitatively from the semi-structured interviews to explore the phenomenon of collaborations in deep-tech startups, the challenges and benefits of collaboration, the impact of collaborations on startup performance, and the strategies and best practices for successful collaborations. Using an inductive approach, recurrent key themes were identified from the interview notes and transcriptions. The results were coded and summarized graphically. The findings were validated by checking them against the original interview notes and by comparison with existing literature.

Contribution to the field

There is a literature gap focusing on the specific challenges of deep-tech startups and if and how they achieve ambidexterity through collaborations. From the explorative semi-structured interviews conducted, we established that deep-tech start-ups with a physical product offering rely heavily on collaborations to achieve ambidexterity in both exploration and exploitation activities due to their extensive needs and challenges. Our explorative work also revealed that deep-tech startups used collaborations heavily in a multidextrous fashion to keep a full pipeline of products at different technological readiness levels rather than focusing on a single product or application to bring to market. While it may not be possible to establish a framework to govern all collaborations, certain key factors and guidelines were identified to guide deep-tech startup management teams in their quest for ambidexterity and multidexterity through collaborations. We hope this new explorative knowledge on the modus operandi of deep-tech hardware startups will lead to better frameworks and tools to support deep-tech hardware startups in managing their collaborative network, as it is a primordial tool for achieving organizational ambidexterity and improved performance.

Structure of the thesis

This thesis is organized into five chapters. Chapter 1 motivates selecting the topic of achieving ambidexterity in deep-tech startups through collaboration, defines the research question and objectives, and provides an overview of the methodological approach. Chapter 2 provides a theoretical framework for the thesis, focusing on the themes of ambidexterity, collaborations as a tool to achieve ambidexterity, and the specific challenges of deep-tech startups wishing to achieve ambidexterity through collaboration. Chapter 3 provides detailed information on the methodological approach used to answer our research question, including research design, data collection methods, and data analysis techniques. Chapter 4 provides an analysis of the data collected and a discussion of the study's key findings. Finally, Chapter 5 relates the study's key findings to the initial research question and objectives and formulates recommendations for deep-tech startups wishing to leverage collaborations to achieve ambidexterity as well as an outlook for future research on the topic.

CHAPTER 2. THEORY

Ambidexterity

Even though exploration and exploitation can be viewed as two conflicting activities, they are both key elements of long-term organizational success. The concept of organizational ambidexterity was first introduced by Duncan (1976) to highlight the conflicts between the demands for change and flexibility versus stability and control. The concept was further defined by March in a 1991 landmark publication that stipulated that "activities to improve corporate performance in terms of organizational learning can be divided into exploitation and exploration" (March, 1991). It can also be further defined as "the ability to simultaneously pursue both incremental and discontinuous innovation and change" (Tushman and O'Reilly, 1996). Explorative learning refers to the process of searching for new knowledge, experimenting with novel ideas and new opportunities (March, 1991; Tushman and O'Reilly, 1996). It is inherently risky as it involves venturing into uncharted territory. Exploitative learning, on the other hand, focuses on refining and optimizing this pre-existing knowledge, practices, and capabilities. Exploitative learning emphasizes efficiency and productivity and focuses on incremental improvements rather than innovation and risk-taking (March, 1991; Tushman and O'Reilly, 1996). However, the difference between the two types of learnings is not always clear and an activity which may pass as "exploratory and experimental" for one organization or individual may be viewed as "exploitative and incremental" by another (Gupta, Smith and Shalley, 2006). March (1991) argues that the two activities are fundamentally incompatible and that organizations struggle to balance exploitation and exploration due to the scarcity of resources forcing them to make explicit and implicit choices between the two. For example, these implicit choices are reflected in organizational procedures, practices, and incentive systems. March (1991) emphasizes that exploitation tends to generate positive, proximate, and predictable returns, while the returns of exploration are uncertain, distant, and possibly negative. Organizations that focus solely on exploitation at the expense of exploration risk becoming trapped in suboptimal stable equilibria (March, 1991). Conversely, organizations that overly emphasize exploration over exploitation may find

themselves with too many underdeveloped ideas which are not yielding their full benefits (March, 1991).

Exploration and exploitation differ diametrically on several dimensions but are both necessary for success. The opposition between the two activities, as highlighted by (Mattes and Ohr, 2013b), is further summarized in Table 1, making it clear that balancing both exploration and exploitation is a challenge for any company, be it a deep-tech startup, an established SME, or a large corporate.

Table 1. Characteristics of exploration vs. exploitation (modified from Mattes and Ohr (2013b)).

	Exploration	Exploitation
Innovation type	Radical	Incremental
Risk	High	Low
Horizon	Mid- to long-term	Short- to mid-term
Focus	Fundamental technological advances, new business models	Minor improvements, costs reductions/efficiency, optimization
Strategic goals	Transform/create markets	Improve competitiveness
Activities	Broadly defined	Strictly defined
Culture	Open, flexible, agile, experimentation, collaboration, teamwork	Procedures and control
Structure	Decentralized, low hierarchy	Centralized, high hierarchy
Performance criteria	Success of the innovation/unit	Success of the task/individual units
Reward systems	Supports teamwork	Supports individual performance
Focus	Learning	Financial measures

In the case of startups, exploration and exploitation activities involve very specific tasks, according to Volery, Mueller and Von Siemens (2015) as listed in Table 2.

Table 2. Nature of exploration and exploitation activities, according to Volery, Mueller and Von Siemens (2015).

Exploration activities	Exploitation activities
Performing experiments to achieve a product/market fit	Performance of daily operations
Engaging with users to explore new revenue streams	Administration
Searching for capital and funding	Accounting
Acquiring knowledge of new technologies	System maintenance
Innovating products and business processes	Repeated sales to existing customers
	Incremental product developments
	Overall efficiency improvements

The three horizons model developed by Baghai, Coley, and White in their 1999 book, The Alchemy of Growth, is a helpful representation of how larger companies can manage their innovation portfolio to achieve ambidexterity and ensure long-term growth. The model uses three different time horizons (Figure 1), with the first horizon focused on the short-term exploitation of mature products (the cash cow), the second mid-term horizon focused on incremental improvements to mature products and as an onboarding stage for new products from the third horizon which are now seen as a viable business and the third, long-term horizon which serves as a playground for innovation and exploration by focusing on research and development (R&D). Companies should strive to perform the exploration and exploitation activities illustrated in Figure 1 in a balanced fashion rather than in a linear sequence.

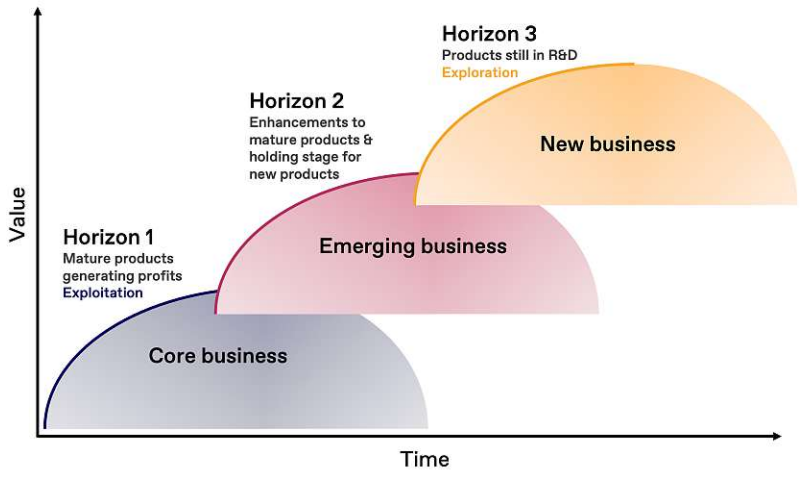


Figure 1. The three horizons model (adapted from Baghai, Coley and White (1999)).

There are several ways for an organization to balance exploration and exploitation internally. The primary strategy to balance exploration and exploitation is to separate these activities physically within the organization in a concept referred to as structural ambidexterity (Duncan, 1976; Tushman and O'Reilly, 1996). This approach involves creating separate structural units within the organization, each dedicated solely to explorative or exploitative activities. The explorative unit is allowed to operate with more autonomy, fostering innovation, experimentation, and risk-taking. Meanwhile, the exploitation unit focuses on efficiency, optimization, and incremental improvements. By structuring the organization in this way, both types of learning can coexist without interfering. However, deep-tech startups generally don't have the resources to implement an innovation centre separate from their exploitation activities like large corporates do, making structural ambidexterity an unrealistic option.

Recognizing the role of processes and systems in balancing exploration and exploitation, Gibson and Birkinshaw (2004) introduced the concept of contextual ambidexterity. In contextual ambidexterity, exploration and exploitation are embedded in day-to-day business. More specifically, it is defined as "the capacity to simultaneously achieve alignment and adaptability at a business-unit level" (Gibson and Birkinshaw, 2004). This strategy requires the creation of an environment where employees feel empowered to both explore and exploit. Leadership is determinant in promoting a culture that encourages exploitation and exploration behaviors (Alghamdi, 2018). This concept of permanent contextual ambidexterity was pioneered by 3M already in 1948 and has been adopted by modern companies such as Google, where employees can use 20% of their time to explore (Mattes and Ohr, 2013b). However, implementing ambidexterity within a single organization is complex and challenging due to the limited resources available (Gupta, Smith and Shalley, 2006). Contextual ambidexterity can also be implemented temporally. Here, a change from exploration to exploitation occurs over time. However, managing the continual alternance between exploration and exploitation is complex and impractical in real life (Mattes and Ohr, 2013b).

Collaborations as a tool to achieve ambidexterity

An alternative to the complex internal balancing of exploration and exploitation activities is to extend the concept of ambidexterity to a broader, external system. While innovation used to be a closed process where firms drew almost exclusively on internal sources to develop and commercialize innovations, open innovation has received much attention in past years. Open innovation refers to seeking and using external ideas, knowledge, and resources to complement and enhance a firm's internal innovation capabilities and expand the markets for external innovation exploitation (Chesbrough, 2003). Open Innovation finds its incentive in the fact that competitive advantages can be leveraged both from inbound and outbound open innovation. In his 2003 book on Open Innovation, Chesbrough defines inbound open innovation as "the practice of leveraging the discoveries of others," implying not only that companies can rely on external R&D if they wish, but in fact, that they should gain competitive advantage (Chesbrough, 2003). Furthermore, Chesbrough (2003) suggests that companies could gain significantly by seeking external business models rather than relying solely on internal paths to market in a process called outbound open innovation. In this context, some organizations can specialize in exploration, while others in exploitation and a form of collaboration between the two becomes necessary. Open innovation can therefore enable a firm to develop its capacity for organizational ambidexterity, improving its performance and efficiency (Hwang, Lai and Wang, 2021). Nobakht et al. (2021)'s observation of 214 knowledge-intensive firms did confirm that open innovation activities significantly enhanced organizational ambidexterity.

Collaboration refers to two or more entities working together to achieve a common goal or objective (Schuh, Studerus and Schmidt, 2022). This can take many forms, including partnerships, joint ventures, co-creation, or co-development agreements. The purpose of collaboration is often to combine the resources, expertise, and capabilities of the participating parties to achieve a greater outcome than they could individually (Schuh, Studerus and Schmidt, 2022). The complementarity between startups, established SMEs, and large corporates is evident when seen through the ambidexterity lens. Collaboration between startups and corporates or established SMEs can benefit both parties

by, for example providing them with access to new technologies, markets, and customers. As a corollary, the two cooperating partners may reduce their individual autonomy, flexibility, or agility.

The strategic orientation of businesses concerning exploration and exploitation can be illustrated graphically as shown in Figure 2 (Gedajlovic, Cao and Zhang, (2012), Mattes and Ohr (2013a) and Kim, Lee and Shim (2022)). Startups are firmly in the exploration stage (Figure 2, Quadrant IV), while large corporates focus largely on exploitation and incremental improvements to their existing product portfolio (Figure 2, Quadrant II). Rather than progressing chronologically from exploration at the R&D and startup stage to exploitation at the later corporate stage or alternating back and forth between both, exploration and exploitation can be executed simultaneously and in a balanced manner through collaboration between startups and larger corporates. This collaboration can enable corporates and startups to achieve ambidexterity (Figure 2, Quadrant I) and operate in the best competitive position possible (Schuh and Studerus, 2022). Therefore, a small company that wishes to achieve an equilibrium between exploration and exploitation can enter into partnerships with other companies to perform one of these two functions (Schreuders, J. and Legesse, A., 2012). Nobakht et al. (2021) have observed that open innovation activities significantly enhance organizational ambidexterity in knowledge-intensive firms, potentially enhancing both exploration and exploitation.

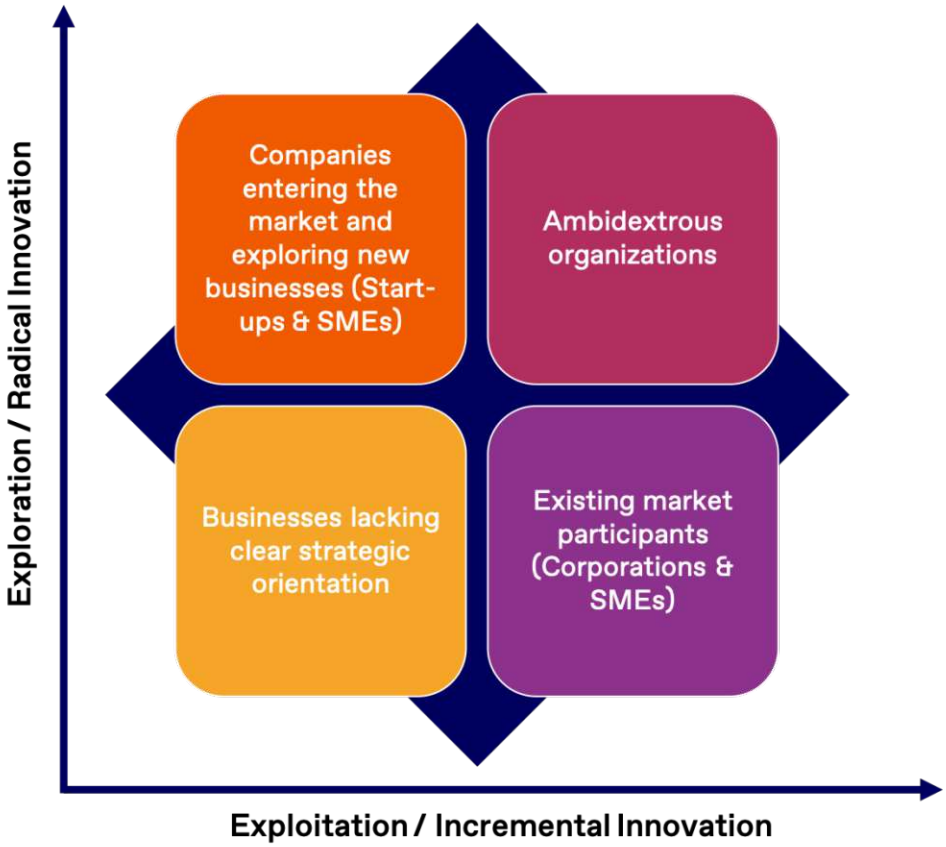


Figure 2. Strategic orientation of businesses concerning exploration and exploitation (adapted from the works of Gedajlovic, Cao and Zhang (2012), Mattes and Ohr, (2013a) and Kim, Lee and Shim, (2022).

The specific challenges of deep-tech startups relating to ambidexterity and collaborations

A technology startup, or "tech startup," is a company that uses technology to create a new product or service. These types of startups can include software companies, mobile application developers, and e-commerce businesses, among others. Deep-tech startups lie at the crossroads between fundamental research and industrial applications. According to Schuh, Studerus and Hämmerle (2022), deep-tech startups are defined as "startups with a key physical offering to be manufactured that is based on deep technology, originate in a high-tech or medium-high-tech industry and are driven by the founding team's self-developed knowledge edge in a deep technology". With their "intense focus on science and technology, deep-tech startups seek to develop unique, proprietary, and hard-to-reproduce technological or scientific advances that have the power to create their own markets or disrupt existing industries" (Harlé, Soussan and de la Tour,

2017). A strong research capability is essential for deep-tech startups since their innovations rely primarily on "fundamental and advanced R&D supported by highly developed skills, knowledge, and infrastructure" (Harlé, Soussan and de la Tour, 2017).

Startups go through a succession of technology readiness levels (TRLs) and market readiness levels (MRLs) as they progress from idea to scale-up, as shown in Figure 3. While the TRL reflects the degree of maturity of a technology, from research to development and deployment (European Commission, 2014), the market readiness reflects how close a product or technology is to commercial application, from ideation, through testing, traction, and scaling (Drescher, Sullivan and Bennett, 2016).

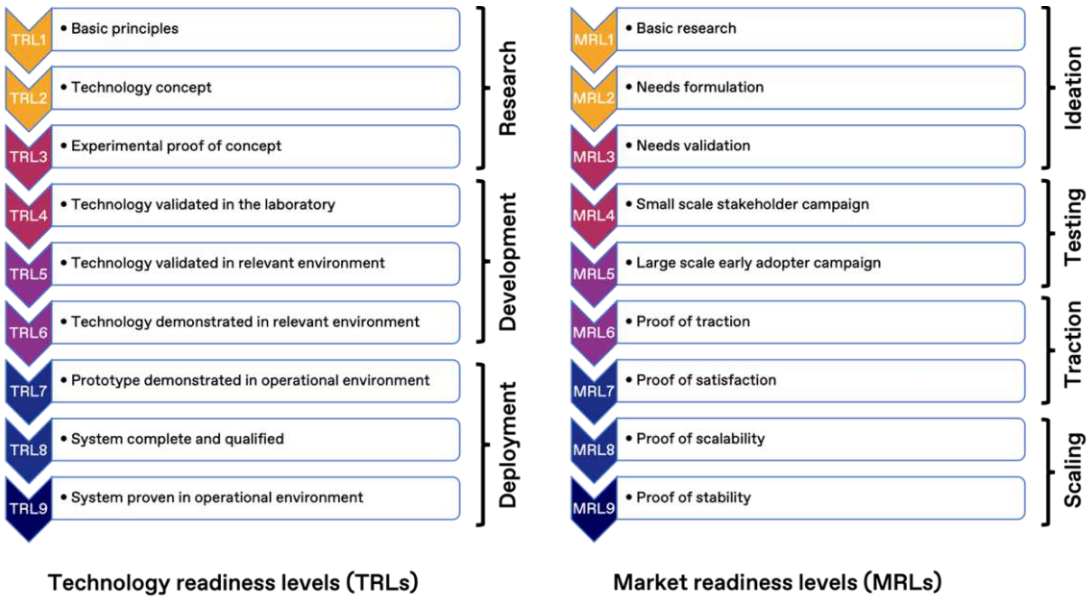


Figure 3. The different technology readiness levels (TRLs) and market readiness levels (MRLs) of a startup. Adapted from the Horizon 2020 Work Programme 2014-2015 (European Commission, 2014) for the TRLs and Drescher, Sullivan and Bennett (2016) for the MRLs.

Due to their nature, deep-tech startups spend considerably more time in the lower TRLs than software or app-based startups. Additionally, deep-tech entrepreneurs must often face the challenge of developing new markets in addition to R&D and technological development, making the MRL progression challenging. The main challenges faced by technology startups are summarized in Table 3. In addition to facing a large technological uncertainty due to the innovative nature of the product, deep-tech startups must face a high business

development uncertainty as they try to scale and commercialize their product with limited financial resources and production capacity.

Table 3. Main challenges and risks faced by deep-tech startups (summarized from Schuh, Studerus and Schmidt (2022)).

Challenges and risks to overcome	
Technological uncertainty	There is a risk that the new technology will not lead to a marketable product.
Business development uncertainty	There is uncertainty about the possibility of developing the market and establishing the business successfully is risky due to the novelty of the technology and lack of resources.
Scaling and commercialization uncertainty	The lack of financial resources and production capacity threaten the scaling and commercialization success.

These challenges are echoed in the answers given to a survey conducted by Hello Tomorrow and the Boston Consulting Group by 400 deep-tech startups. The survey revealed that deep-tech startups perceived their main challenges to be the lengthy time to market, high capital intensity, considerable technological risk, and yet-unknown commercial applications of their innovation, as illustrated in Figure 4.

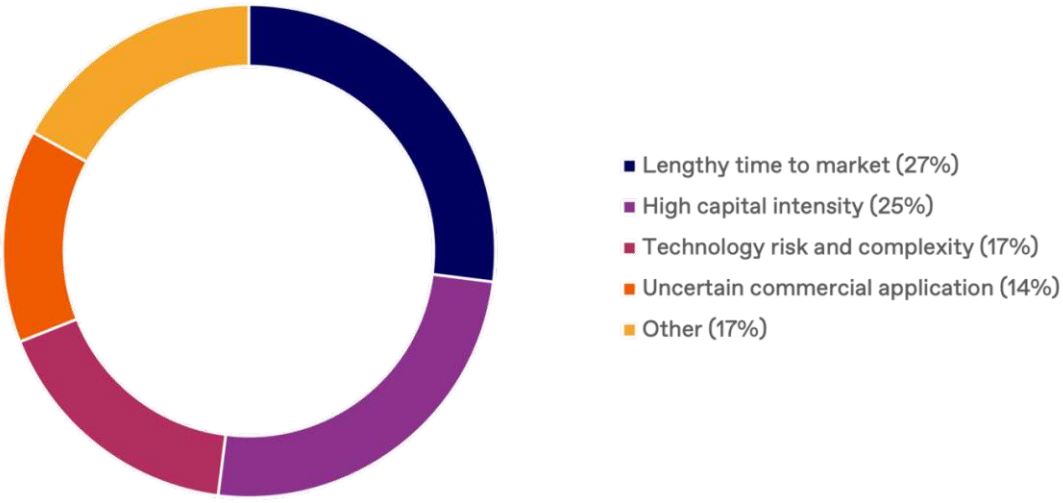


Figure 4. Challenges faced by deep-tech startups according to a survey conducted by Hello Tomorrow and BCG and answered by more than 400 deep-tech startups (adapted from de la Tour et al. (2017)).

Collaborative ecosystems and open innovation can be crucial to overcoming the specific challenges deep-tech startups face. As illustrated in Figure 5, while

startups spend their early stages focusing on research and development and building their team, it is expected that by TRL 5-6, they will focus on building tactical alliances with other organizations and that they will maintain relationships with key market players throughout the rest of their development (European Innovation Council, 2022). These tactical alliances and collaborations can be leveraged to gain access to customers and their feedback, pursue new market opportunities, establish a marketing strategy, and scale up.

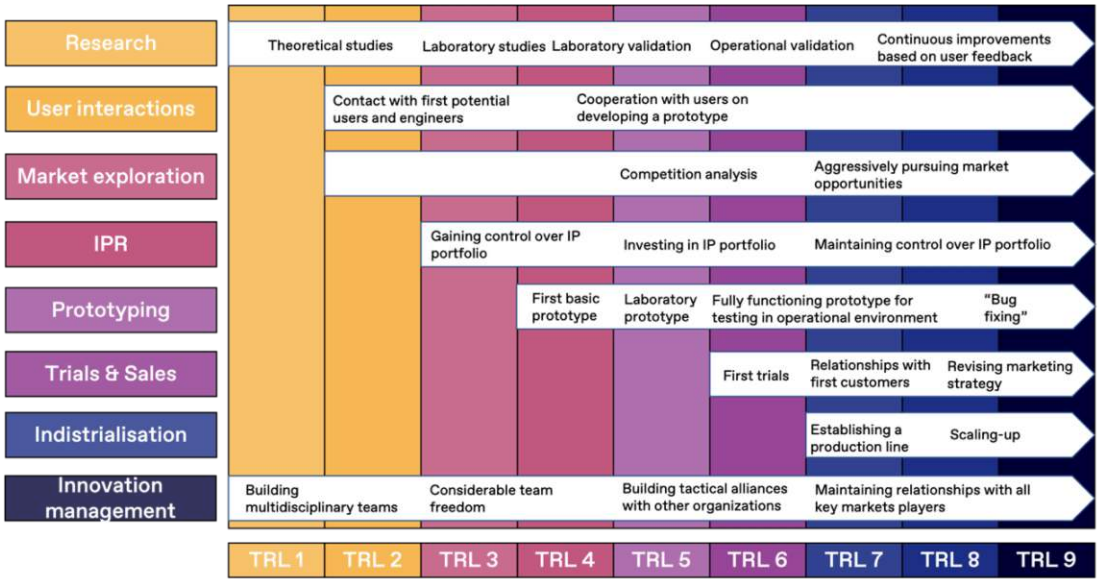


Figure 5. The different technology readiness levels for a startup (modified from the EIC Transition Guide (European Innovation Council, 2022).

As illustrated in Figure 3 and Figure 5, startup needs evolve significantly as they and their products move closer to market. As a corollary, the attractiveness of various types of collaborating partners shifts over time as well (Harlé, Soussan and de la Tour, 2017). From a survey conducted by Hello Tomorrow and BCG, and answered by more than 400 deep-tech startups, de la Tour et al. (2017) identified four deep-tech startup archetypes. Each deep-tech startup archetype features its challenges, needs, and preferred collaboration partners based on its level of technological maturity and market readiness, as shown in Figure 6. According to this model, at low TRLs and MRLs, product development partnerships should be preferred, and universities are best at fulfilling these needs. Corporates, on the other hand, form ideal partners in product development partnerships where the deep-tech startup has a low TRL with a high MRL, or in go-to-market partnerships where the deep-tech startup has a high TRL but low MRL. However,

venture capital investment firms become the preferred partners when a deep-tech startup has achieved a high MRL and TRL (de la Tour et al., 2017).

Figure 6. Challenges, needs, and preferred partners for deep-tech startups depending on their Market Readiness Level (MRL) and Technology Readiness Level (TRL) as well as the most frequently used partnership model for each archetype (summarized and modified from de la Tour et al., (2017)).

As seen above, deep-tech startups with either low TRL or MRL favour corporate collaborations. Since corporates can offer access to the market as well as technical and business expertise, collaboration is an oft-explored avenue for deep-tech startups to overcome their challenges and minimize their risks at this stage. However, according to de la Tour et al. (2017), the standard formula corporates use to collaborate with digital and app startups cannot simply be applied to the world of deep-tech. As a result, many deep-tech startups fail to establish corporate partnerships. According to their survey, 97% of deep-tech startups are interested in corporate partnerships. However, 25% of these could not establish such a collaboration due to a lack of confidence in the technology, misunderstanding between the parties, or a complex and slow decision process, as shown in Figure 7 (de la Tour et al., 2017).

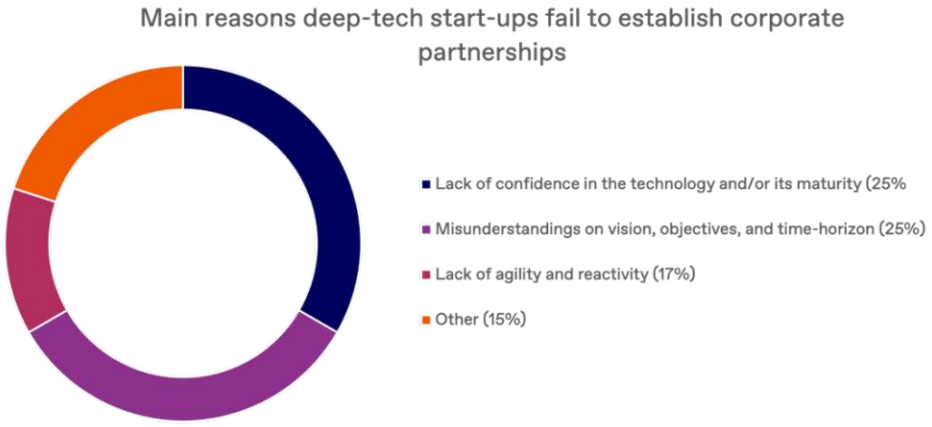


Figure 7. Main reasons deep-tech startups failed to establish corporate partnerships according to a survey conducted by Hello Tomorrow and BCG and answered by more than 400 deep-tech startups (adapted from de La Tour et al., (2017).

COLLABORATION WITH CORPORATES

Corporates are established firms operating in mature markets. They focus mainly on incremental innovations, such as increasing efficiency and reducing the costs of existing processes. As seen in Figure 6, aside from startups that are both technologically mature and market ready, most startups would rather collaborate with corporates to fulfill their needs and surmount their challenges (de la Tour et al., 2017). The type of collaboration ranges from product development to go-to-market and commercial partnerships. According to de la Tour et al. (2017) "collaborations with low-TRL (immature) startups with innovations far from the core business might be in a dedicated function such as R&D or open innovation, while collaborations with high-TRL (almost market-ready) startups close to the core business should be integrated within the business units". Corporates are the "preferred partners for companies looking to gain access to the market through, for example, access to market and customer data, an existing customer base, or a distribution network" (Harlé, Soussan and de la Tour, 2017).

On the flip side, corporates also pursue collaborations with startups. While in the past, corporates tended to ignore young startups and preferred waiting until they had ripened into acquisition targets, they nowadays actively seek relationships with startups (Imaginatik and MassChallenge, 2016). In fact, 82% of large organizations now consider collaborations with startups as important (Imaginatik and MassChallenge, 2016). The motives, according to a research study

conducted by Imaginatik and MassChallenge include exploring new technologies and/or business models (60% of respondents) and exploring nascent industries (26% of respondents) while only 25% of respondents were looking to develop potential acquisition targets (Imaginatik and MassChallenge, 2016).

Despite this firm yearning on both sides to collaborate, the endeavour's success is far from guaranteed. According to a joint research study conducted by Imaginatik and MassChallenge (2016), 50% of startups ranked their experience interacting with corporates as mediocre or worse while in a study by Becker et al. (2018)., 38% of startups were quite dissatisfied and an additional 8% were very dissatisfied with their cooperation with SMEs. We summarize the advantages and pitfalls that can hinder the collaboration's success from the deep-tech startup perspective in Table 4. Advantages include leveraging the corporate's knowledge of strategy, marketing, and communication (de la Tour et al., 2017). The startup can benefit from rapid improvements to their value proposition (de la Tour et al., 2017) and gain momentum through powerful growth hacks (de la Tour et al., 2017). Financial resources become more accessible (de la Tour et al., 2017), and the possibility of investments through corporate venture capital (CVC) is opened (de la Tour et al., 2017). Collaborations can also provide commercial partnerships to help sell products (de la Tour et al., 2017), procurement partnerships for accessing products and services (de la Tour et al., 2017), and distribution partnerships to leverage the corporate's marketing abilities and customer base (de la Tour et al., 2017). Licensing agreements (de la Tour et al., 2017) and mentorship opportunities (Imaginatik and MassChallenge, 2016) further enhance the startup's growth. Overall, collaborations with corporates offer market access, technical knowledge, and business expertise, facilitating the development of a robust business plan. On the other hand, several non-negligible disadvantages and pitfalls should be considered. Slow corporate decision-making can hinder progress (Harlé, Soussan and de la Tour, 2017), and slow procurement may lead to cash flow issues (de la Tour et al., 2017) for the startup while legal technicalities (de la Tour et al., 2017), bureaucracy (Imaginatik and MassChallenge, 2016), and cultural differences (Imaginatik and MassChallenge, 2016; de la Tour et al., 2017; Röhl and Engels, 2022) can create burdensome challenges. Lack of transparency and alignment can result in lengthy and challenging negotiations (de la Tour et al., 2017). Failure to agree on vision, objectives, and intellectual property rights

can also strain collaborations (de la Tour et al., 2017). Exclusivity-based relationships can limit a startup's prospects and impact their chances of success (de la Tour et al., 2017). Other challenges include the lack of agility (de la Tour et al., 2017), difficulties in finding the right contact person (Imaginatik and MassChallenge, 2016), lack of buy-in from the corporate side (Harlé, Soussan and de la Tour, 2017), and divergent interpretation of terms (Imaginatik and MassChallenge, 2016).

Table 4. Advantages and pitfalls for deep-tech startups wishing to collaborate with corporates.

Advantages & Benefits	Disadvantages & Pitfalls
Market	Administrative challenges
The corporate's skills and knowledge in marketing, communication, strategy (de la Tour et al., 2017) as well as its business expertise (Harlé, Soussan and de la Tour, 2017) can benefit the start-up. Collaboration with the corporate can lead to rapid improvements to the value proposition (de la Tour et al., 2017), momentum build (de la Tour et al., 2017) and enhance growth (Imaginatik and MassChallenge, 2016). The corporate can provide financial resources (de la Tour et al., 2017) and may invest in the startup through corporate venture capital (CVC) (de la Tour et al., 2017) Commercial partnership with corporates may help sell the products (de la Tour et al., 2017) and provide access to new markets (Harlé, Soussan and de la Tour, 2017). Corporates can help startups develop a healthy business plan (de la Tour et al., 2017).	Slow procurement can lead to critical cash flow issues (de la Tour et al., 2017). . Hard to find the right contact partner within the collaborating organization and (Imaginatik and MassChallenge, 2016) this partner may not be able to provide the necessary sponsorship for the project within the organization (Harlé, Soussan and de la Tour, 2017).
Distribution	Cultural challenges
Leveraging of corporate resources (Imaginatik and MassChallenge, 2016; de la Tour et al., 2017). Procurement partnership to help the startup procure products and services within the corporate (de la Tour et al., 2017). Distribution partnership to leverage the corporate's marketing abilities,	Lack of agility (de la Tour et al., 2017). Slow corporate decision-making. (Harlé, Soussan and de la Tour, 2017). Lack of transparency and alignment can lead to long and painful negotiations (de la Tour et al., 2017). Divergent interpretation of terms (Imaginatik and MassChallenge, 2016).

customer base, and marketing power abilities (de la Tour et al., 2017). Licensing agreements (de la Tour et al., 2017).	Cultural gap, (de la Tour et al., 2017) cultural issues (Imaginatik and MassChallenge, 2016), and differences in innovation culture and speed (Röhl and Engels, 2022). Financial and strategic KPIs may not reflect the maturity of the startup (de la Tour et al., 2017)
Technical Expertise	Contractual challenges
Technical knowledge (Harlé, Soussan and de la Tour, 2017). Product and process know-how (Röhl and Engels, 2022). Mentorship (Imaginatik and MassChallenge, 2016).	Legal technicalities burden (de la Tour et al., 2017) and bureaucracy (Imaginatik and MassChallenge, 2016). Exclusivity contracts and IP rights can be hard to negotiate for an inexperienced start up facing a corporate giant (de la Tour et al., 2017). Exclusivity-based relationships can severely limit a startup's prospects and impact their chances of success (de la Tour et al., 2017). Design of a suitable and fair contract for the startup (de la Tour et al., 2017).

Both the advantages and pitfalls listed in Table 4 can be attributable to the intrinsic differences between startups and corporates. (Das and He, 2006) summarize very well the difference between entrepreneurial firms, such as deep-tech startups, and established partners such as corporates and SMEs and how these differences come into play in the context of collaborations as shown in Table 5.

Table 5. Differences between entrepreneurial and established forms (adapted from Das and He (2006)).

	Entrepreneurial firms	Established firms
Intrinsic differences		
1. Resources	Short of financial, manufacturing, and marketing resources	Affluent in financial, manufacturing, and marketing resources
2. Innovativeness	More innovative	Less innovative
3. Status in competition	Challengers in competition	Defenders, vulnerable to competition from newcomers
4. Legitimacy	Less	More
5. History/track record	Scarce	Sufficient
6. Economic/political power	Little influence over the environment	More economic and political power
7. Organizational characteristics	Structure: clan, informal Communication: fewer levels, frequent, informal, more horizontal Decision making: speedy, flexible, informal, centralized from the top, keeping options open, opportunist	Structure: bureaucratic, formal, fragmented Communication: more levels, slower, infrequent, open to distortion, barely horizontal Decision making: slow, consensual, decentralized at the intermediate levels, long-term strategies
8. Business focus	Products and services	Expansion in scale and scope
9. Planning horizon Speedy development Not in a hurry	Speedy development	Not in a hurry
Differences in expectations/requirements from the collaboration		
1. Control over technology	Retain control over its technology	Capture the technology
2. Confidence in technology	Confident	overly committed Skeptical
3. Interorganizational interfacing	Decisions makers are the executors	Decision makers are not the executors
4. Criticality of alliancing	The alliance is a matter of survival	The alliance is not a matter of survival
5. Strategic objective	Survival, growth	Sometimes the collaboration is used only as a blocking strategy against major competitors
6. Consistency of commitment	Subject to change	Consistent

In light of the stark differences listed in Table 5, it's hardly surprising that many collaborations fail. Minshall et al. (2008) published practitioner guidelines aimed at overcoming the challenges of knowledge transfer in asymmetric partnerships between startups and large corporates. Das and He (2006) proposed a set of partner selection criteria to help small entrepreneurial firms collaborate with established firms. They suggest that the collaborating firms should have compatible motivations, the established firm should be prepared to support manufacturing and marketing with their facilities to improve the entrepreneurial firms' chances of growing into a stable organization, the middle managers of the established firm who will be the ones carrying out the operation should be involved from the very beginning, a dedicated task force should be created, and the established firm should be committed to act speedily (Das and He, 2006).

In addition, the intrinsic differences between startups and corporates, the type of collaboration chosen also provides an additional risk factor. According to (Schuh, Studerus and Schmidt, 2022), the majority of corporate – technology startup collaboration fail due to the following two reasons:

1- the choice of collaboration type was made opportunistically, and
2- the established collaboration types are unsuitable for technology startups.

Schuh, Studerus and Schmidt (2022) identify the following four deficits in the existing literature regarding the typification of collaborations between corporates and technology startups as summarized in Table 6. According to their analysis, when the choice of collaboration type is made opportunistically, the specific requirements of technology startups as well as the expectations of the corporates are not being met. This inadequate collaboration choice is not only due to a lack of knowledge on collaboration types, but also to the fact that current models, such as strategic alliances, virtual companies, and joint ventures, are simply inadequate to yield beneficial collaborations between corporates and technology star-ups.

Table 6. Deficits and requirements for collaboration between corporates and startups (summarized from Schuh, Studerus and Schmidt (2022)).

Deficits	Consequences	Requirements
The asymmetry in size, available resources, and business experience of the collaboration partners is not sufficiently considered.	Unmet needs as well as a one-sided dependency for the technology startup.	Combining the different strengths of the corporates and technology startups.
Existing collaboration types are oriented towards the longer term, failing to meet the needs of startups ongoing organizational changes.	The goals of the deep-tech startup change with time, heavily impacting the collaboration.	The collaboration should be flexible and allow for goal redesign.
Existing collaboration types do not take a joint objective as the basis for collaboration.	Goals may not be considered in a balance manner due to the asymmetry between the partners.	A formal common goal can be established, but individual company-specific goals can also be pursued as long as they don't contradict each other.
The goals and motives of the startup are underrepresented.	The challenges of the startup with respect to resources, capital, and exploitation represent major needs for the startup.	Substantial consideration of the startup needs is necessary for the collaboration.

We must however note that there exist successful collaborations between deep-tech startups and corporates where one partner takes care solely of exploration while the second solely of exploitation. Gupta, Smith and Shalley (2006) provide an example of the successful market exchange between "fabless" semiconductor companies (often deep-tech startups) which focus on R&D and semiconductor foundries (large corporates with extensive assets) which specialize exclusively on manufacturing. They however argue that such ambidextrous collaborations are only possible if the following conditions are met:

1- The two organizations control mutually complementary resources so that the output of the explorer does not remain fully unused and that the most likely to be successful ideas can be handed over to the collaborating partner for exploitation.
2- The sphere in which the explorer operates is very dynamic, whereas the sphere in which the exploiter operates is steadier.

3- Mutual co-specialization is minimized.

COLLABORATION WITH SMES

Deep-tech startups can also collaborate with established SMEs. Thanks to collaboration with startups, SMEs can acquire competences which they could not acquire on their own due to their size (Röhl and Engels, 2022). However, although the differences between startups and SMEs seem to be smaller at first glance compared to larger corporations, differences and issues still exist as shown in Table 7. Just like with corporates, the different planning horizons and targets cause challenges in the implementation and success of the collaboration. Corporates and SMEs tend to pursue longer-term targets and often possess a bigger weight and influence than startups who are focusing on scaling and possess very limited resources (Schuh and Studerus, 2022).

Table 7. Cultural differences between startups and SMEs which can create obstacles to cooperation (summarized from Röhl and Engels (2022).

	SMEs	Startups	Impact
Continuity	High degree of prudence	High-speed decisions and disruptive implementations	Difficulty in defining cooperation goals
Equity	High retained earnings and equity ratios	Dependence on external financing	
Environment	Often rural	Often urban	Hindering effect due to divergent spatial distribution
Longevity	Long-term existence is expected	Failure is considered as a possible early exit	The uncertainty about the longevity of the collaboration partner can be an obstacle for SMEs
Age of decision-makers	Majority >50 years old	Average 35 years old	Different views and behavioural patterns
Innovation	Incremental	Disruptive	Complementarity

According to Röhl and Engels (2022), analogous to the situation with larger corporations, established SMEs and startups have mutually complementary competence profiles. Startups can test new ideas with the help of SMEs while they, just like larger corporations, also gain access to new innovative technologies by collaborating with startups. Due to the high cost of R&D, few

SMEs have their own R&D department. The most common form of cooperation between SME and startups is project related, followed by customer-supplier relationships, joint ventures, and minority shareholdings (Röhl and Engels, 2022). Larger companies (>1000 employees) are more active when it comes to holdings, joint ventures, takeovers, incubators, and accelerator programs (Röhl and Engels, 2022). Niever, Scholz and Hahn (2022) studied founding teams cooperating with SMEs in the early stages of startup development. This mutually beneficial collaboration allows SMEs to gain early access to innovations while providing early-stage startups with the SMEs resources and experience.

CHAPTER 3: METHODOLOGICAL APPROACH

Research design and data collection methods

THEORETICAL APPROACH

An inductive approach to theory development was used in this explorative study. This approach was selected because very little is known about if and how deep-tech start-ups use collaborations to achieve ambidexterity and enhance their performance. Thematic Analysis was used to identify recurring themes and produce a thematic description of participants' answers to interview questions. This methodology allowed us to develop a theory based on the apparent thematic patterns identified in the interview data and to draw conclusions from these.

DATA COLLECTION

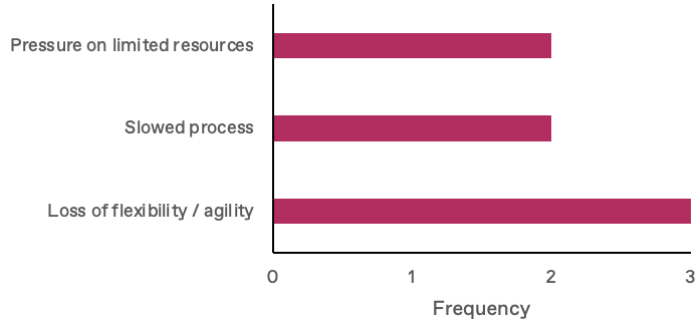
Semi-structured interviews were conducted with founding members of deep-tech startups to explore the phenomenon of collaborations in deep-tech startups and if this phenomenon contributed to ambidexterity and hence enhanced the performance. questions of the semi-structured interviews followed a pre-defined structure covering background information on the deep-tech startup, the motivation for past and existing collaborations, the practical implementation of past and existing collaborations, as well as the results of these collaborations. The last questions of the semi-structured interviews were dedicated to summarizing key factors and best practices for deep-tech startups wishing to collaborate to improve their performance. The interview questionnaire can be found in Appendix I – Interview Guideline. All interviews were conducted via videocall and were scheduled to last one hour.

DATA ANALYSIS AND PATTERN RECOGNITION

Interview data were analyzed qualitatively using Thematic Analysis as described by Saunders, Lewis and Thornhill (2019). Answers to the interview questions were reduced to their core elements, and recurring themes were identified, coded, and illustrated graphically to provide an ensemble picture of the interview answers and highlight similarities and differences across participants. An example of how this process was performed is shown for one of the interview

questions in Table 8. The interview answers were transcribed and units of data with similar meaning were identified and labeled with identical codes. The codes were derived from the collected data. Finally, the frequency of each code appearance in the interview answers was plotted in bar or pie chart to get an ensemble overview of the qualitative data collected. Bar graphs and pie charts are effective ways to represent qualitative data. They provide a rapid qualitative overview of the similarities and/or differences between the experiences of each participant for further interpretation. Interview quotes were selected to add context to the presented data.

Table 8. Demonstration of how recurring themes were identified, summarized, coded, and illustrated graphically to provide an ensemble picture of the participants' answers to interview questions.

Question: What were the drawbacks of the collaboration for your company?		
Participants answer with recurring themes highlighted	**Reduced answers**	**Theme**
Our design is frozen now	Loss of flexibility in modifying the design	Loss of flexibility and agility
The slow decision speed	Slowed decision speed	Slowed process
The loss of flexibility and agility	Loss of flexibility and agility	Loss of flexibility and agility
It was time consuming but the return was always positive	Pressure on time resources	Pressure on limited resources
The time frame	Long times	Slowed process
You can get stuck in tunnels, loose a market if you get a wrong distributor. Get married with big corporate who has its own agenda. They decide to stop, it's a blow for the company. Can be dangerous if you do not have an exit plan.	Can block you from other opportunities	Loss of flexibility and agility
Each new collaboration adds increased pressure on our limited resources.	Pressure on limited resources	Pressure on limited resources
Qualitative data representation of recurring themes using a bar chart: 		

THEORY BUILDING

Using an inductive approach, we identified recurring themes and patterns in the collected data to develop an enhanced perspective on the collaboration phenomenon that applies more specifically to little-studied deep-tech start-ups with a physical highly innovative product.

VALIDATION

The interpretation of the main findings of the explorative interviews was further checked against interview transcripts and the existing literature. Interview excerpts were selected to add context to the presented data and findings.

Description of the cases

Being a deep-tech startup founder with a physical product offering was the main criterion for selecting participants. No potential participants were pre-selected for the study based on the fact that they had not entered any collaborations during the course of their activities. All startups had an R&D-intensive product that was a completely new offering and were EU-based spin-offs from technical universities. Participants were all founders of the companies and had executive roles within their organizations. A brief description of the participants, with their product and role within their organizations is given in Table 9 and a more detailed description of each of the companies and their collaboration history is given below.

Table 9. Brief description of the participants

	Product	Participant role
Deep-tech startup # 1	Medical diagnostics	Co-founder and CTO
Deep-tech startup # 2	Spectroscopic accessory	Co-founder and CEO
Deep-tech startup # 3	Chemical product	Co-founder and COO
Deep-tech startup # 4	Sensor and software	Co-founder and CEO
Deep-tech startup # 5	Sensor and software	Co-founder and CEO
Deep-tech startup # 6	Medical diagnostics	Co-founder and CEO
Deep-tech startup # 7	Sensor	Co-founder and CTO

Participant ≠1

The first participant is a university spinoff with a novel technology for medical diagnostics. The limited liability (GmbH) company was founded in Austria in 2019. They produce a hardware device based on novel technology for their diagnostic tests and provide diagnostic services to doctors. They have a multitude of research and development collaborations with doctors and hospitals and collaborations with larger corporates for production.

Participant ≠2

The second participant is a university spinoff with a novel technology for spectroscopic analysis. The limited liability (ApS) company was founded in

Denmark in 2015. They produce a spectroscopy accessory based on novel technology as well as software and custom solutions for their customers. They have a multitude of research and development collaborations with startups, universities, and research institutes as well as collaborations at higher TRLs with instrument manufacturers and resellers.

Participant #3

The third participant is a university spinoff with a patented technology for the high-performance production of a chemical product. The limited liability (GmbH) company was founded in Austria in 2021. They have a multitude of research & development collaborations with SMEs and larger corporate players to accelerate the development of their product for specific commercial applications. Depending on how they are advanced in each specific application field, collaborations are either focused on exploration or exploitation activities.

Participant #4

The fourth participant is a university spinoff with a patented technology for the high-performance production of an innovative product for the transport industry. The limited liability (GmbH) company was founded in Austria in 2018. They have a multitude of research and development collaborations with researchers as well as collaborations at higher TRLs with startups, SMEs, and corporates which focus on applications and product development.

Participant #5

The fifth participant is a university spinoff with a patented sensor technology for the high-performance production of an innovative product for the transport and energy industry. The limited liability (GmbH) company was founded in Austria in 2021. They have a multitude of research and development collaborations with researchers, other startups, SMEs, and corporates.

Participant #6

The sixth participant is a university spinoff with a patented hardware technology for medical diagnostics. The limited liability (ApS) company was founded in Denmark in 2014. They have a multitude of research and development collaborations with researchers, hospitals, SMEs, as well as with a large

international corporate for development and production and with international corporates for distribution and access to new markets.

Participant #7

The final participant is a university spinoff with an innovative hardware technology which can be used in environmental, pharmaceutical, and industrial applications. The limited liability (GmbH) company was founded in Austria in 2019. They have a multitude of research and development collaborations with researchers, startups, and SMEs, as well as with a large international corporate for development and potential distribution.

Interview preparation

The key topics of the structured interview were selected to answer the research question whether deep-tech startups use collaborations to achieve ambidexterity and enhanced their performance. All interviews were conducted by the author and recorded in interview protocols. The interview questions were closely aligned with the research objectives and divided into the following themes:

THEME 1: USE OF COLLABORATIONS BY DEEP-TECH STARTUPS TO ACHIEVE AMBIDEXTERITY

In the first section of the interviews, our objective was to investigate if deep-tech startups use collaborations to achieve ambidexterity and if these collaborations focus more on exploration or exploitation activities. The very first question was to ask the participants how many collaborations they had. This was an exploratory question to which we could not find any answer in the existing literature. We then sought to learn at which development stage the participants were when they sought collaborations to confirm the description of the different technology readiness levels of a startup provided by the European Innovation Council (European Innovation Council, 2022) and which states that from TRL 5, startups should start building tactical alliances with other organizations and maintain these through the remainder of their technological development as shown in Figure 5 of Chapter 2. We also asked questions which sought to verify the results of the study conducted by de la Tour et al. (2017) describing the challenges, needs, and preferred partners of deep-tech start-ups as a function of their TRL level presented in Figure 6 of Chapter 2. Finally, since the major risk

factors identified for the failure of collaborations between technology start-ups and corporates is that the choice was made opportunistically and the collaboration type was unsuitable (Schuh, Studerus and Schmidt, 2022), we also designed questions to validate if these were also true for deep-tech start-ups and various types of collaboration partners.

THEME 2: MOTIVATION, PARTNERSHIP TYPE, AND PRACTICAL IMPLEMENTATION OF COLLABORATIONS

In the second section of our interview, the objective was to gain a deeper understanding of the collaboration process with a focus on the motivation, the partnership type, and the practical implementation of the collaboration. The questions in this section of the interview were selected to verify the observations made in the joint research study conducted by Imaginatik and MassChallenge (2016), reporting on the experience of startups interacting with corporates and the associated challenges. We sought to explore if the challenges observed in this study applied also to deep-tech start-ups and if they could be extended to other types of collaborations, such as collaborations with other startups, SMEs, and research institutes.

THEME 3: IMPACT OF THE COLLABORATION ON STARTUP PERFORMANCE

According to March, exploration and exploitation activities are undertaken by organizations to improve performance (March, 1991). In the third section of our interview, our main objective was to evaluate the perceived impact of the collaboration on startup performance. We focused our questions on the advantages and inconveniences listed in Table 4 of Chapter 2 which were collected from various literature sources (Imaginatik and MassChallenge, 2016; de la Tour et al., 2017; Harlé, Soussan and de la Tour, 2017; Röhl and Engels, 2022) such as access to resources, innovation, faster learning, and access to markets and customers, slower decision speed, and loss of flexibility to verify if these also applied in the specific case of deep-tech startups with a physical product offering.

THEME 4: KEY FACTORS AND BEST PRACTICES

In the final section of our interview, our main objective was to identify the key factors and best practices that contribute to successful deep-tech startup collaboration with various partner types. The literature currently available is largely skewed towards exploring best practices from the angle of large corporates wanting to collaborate with startups. This section was made up of several questions that were open and exploratory in nature.

CHAPTER 4: RESULTS AND DISCUSSION

Presentation of the results

Interview data were analyzed qualitatively using Thematic Analysis as described by Saunders, Lewis and Thornhill (2019). Answers to the interview questions were reduced to their core elements and coded to allow the identification of recurring themes. The resulting reduced and coded interview answers were illustrated graphically with qualitative bar charts and pie charts to provide an ensemble picture of the differences and commonalities of the answers of the interview participants and support the qualitative analysis. Supporting quotes to illustrate the most common answers to each question are provided along with the graphical summaries. Results are grouped by themes corresponding to the research objectives. A discussion of the key findings of the study follows the presentation of the results.

THEME 1: USE OF COLLABORATIONS BY DEEP-TECH STARTUPS TO ACHIEVE AMBIDEXTERITY

As illustrated in Figure 8, rather than focusing on single collaborations, the deep-tech startups interviewed had a minimum of 5 collaborations and the majority more than 10. None of the deep-tech start-ups interviewed had no collaborations. The general sentiment among the interview participants was that collaborations were essential to achieve their goals as illustrated by the following quote on the necessity and benefits of collaborations:

> "It is necessary to have collaborations. There is so much to learn from the others, everybody has a different picture. They are often sharing their knowledge even if the collaboration is not going to happen when they tell you their pains, needs, restrictions. Helps you save a lot of efforts."

And the following quote emphasizing the need to collaborate frequently to enhance one's cooperative skills:

> "Learned a lot from every collaborations and previous mistakes. The more you cooperate, the better you become at it."

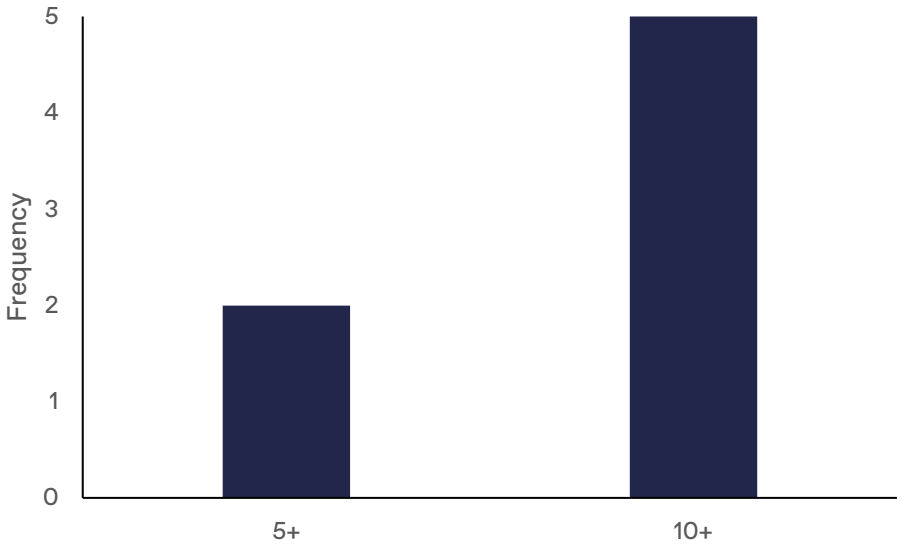


Figure 8. Most common number of collaboration partners per single deep-tech startup.

Similarly, rather than focusing on a single objective, all study participants had collaborations focusing on both exploration and exploitations activities simultaneously (Figure 9).

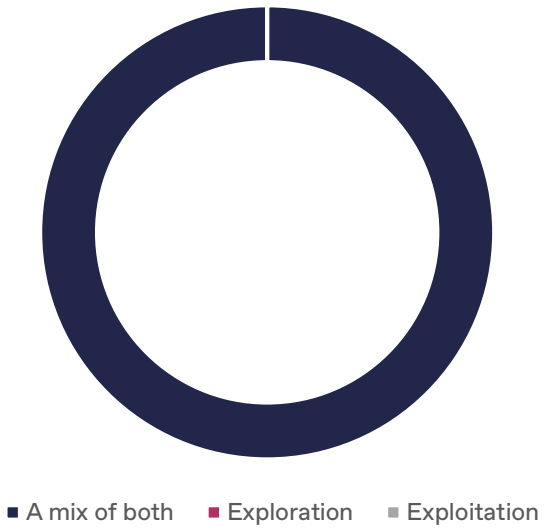


Figure 9. Most common need fulfilled by collaborations

To explore this theme further, we enquired about the nature of the collaboration partners and the technology readiness level of the innovations for which collaborations were in effect. Not only did collaborations overall span every TRL Level (Figure 10), but most interview participants also juggled collaborations at

two or three TRL levels simultaneously. Only two participants focused solely on research and development (TRL 4-6) collaborations. However, even though their product development was still at the research and development level, the collaborations still focused on both exploration and exploitation activities. All five other participants had collaborations spanning innovations at lower and higher technology readiness levels simultaneously. Collaborations included other startups, SMEs, corporates, and universities (Figure 11). However, other startups were the least common collaboration partners. One participant offered the following explanation for this phenomenon:

> "We have had very little collaborations with other startups, they have the same problems as you have yourself as a startup. SMEs are the sweet spot. With big corporate distributors, you are just a drop in the sea."

The same participant added that on top of preferring SMEs to startups and corporate distributors, they always aimed at representing 30% of the revenues of their distributors which would get them the right level of commitment, illustrating the delicate balance in finding an appropriately sized partner.

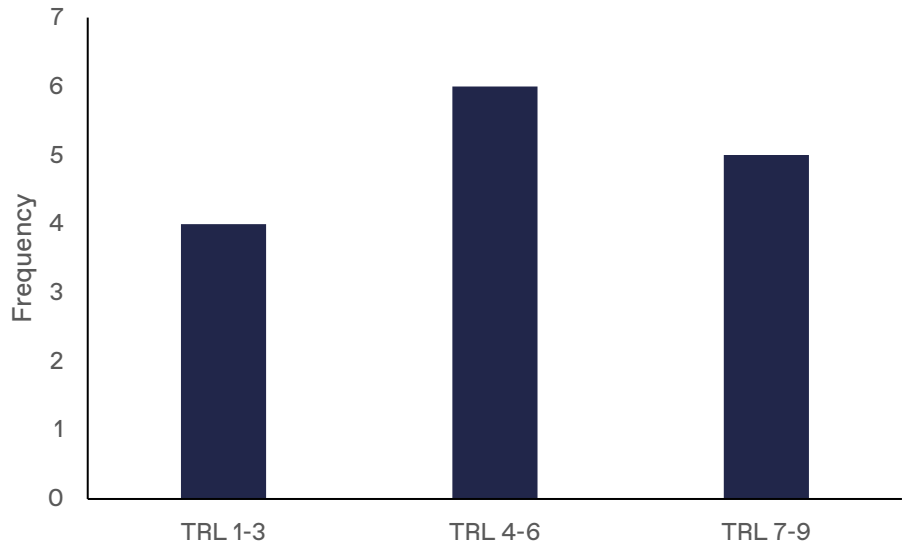


Figure 10. Most common technology readiness level (TRL) of the products for which participants sought collaborations.

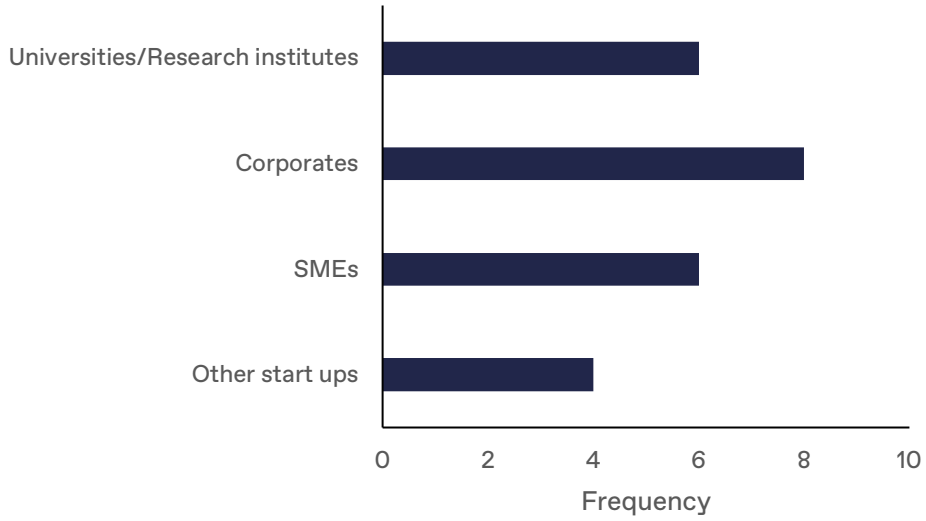


Figure 11. Most common types of collaboration partners for the participants.

THEME 2: MOTIVATION, PARTNERSHIP TYPE, AND PRACTICAL IMPLEMENTATION OF COLLABORATIONS

The two most pressing challenges that were faced by deep-tech startups entering collaborations were the long development times and knowledge/expertise gaps, followed by production/technological challenges, market resistance to change, and lack of distribution network (Figure 12). These challenges span both exploration and exploitation activities. These findings are perfectly illustrated by the following quote from a participant:

> "We have collaborations on all levels. We have different products in the pipeline. At higher TRL, collaborations are more commercial (instrument manufacturers and resellers). At low TRLs we collaborate with universities and research institutes."

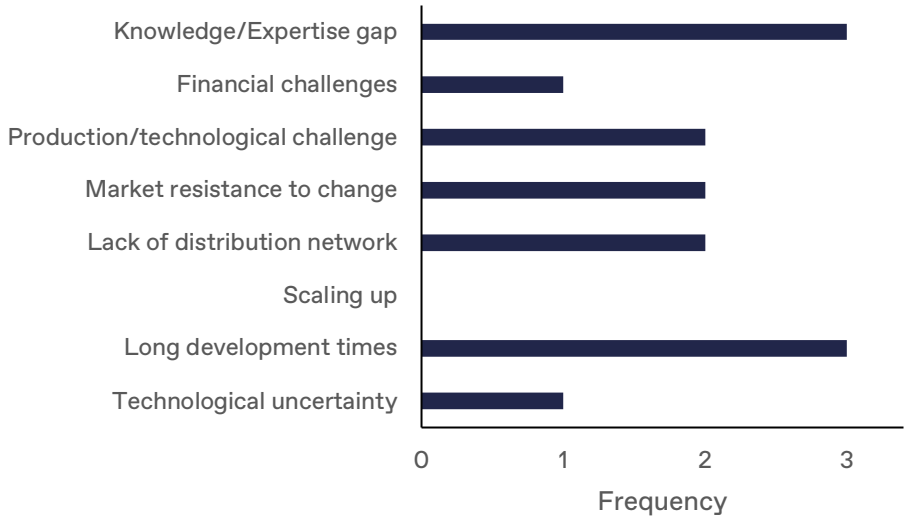


Figure 12. Most common motivations for deep-tech startups to seek-out a collaboration.

When expressing their expectations out of a collaboration relationship, most participants aimed at establishing strong collaborations with common goals (Figure 13). Despite the wish for well -defined collaborations, the implementation most often didn't reflect this desire and a lot of collaborations were deemed informal or at least started informally before becoming better defined. Looser collaborations were more common at lower TRLs.

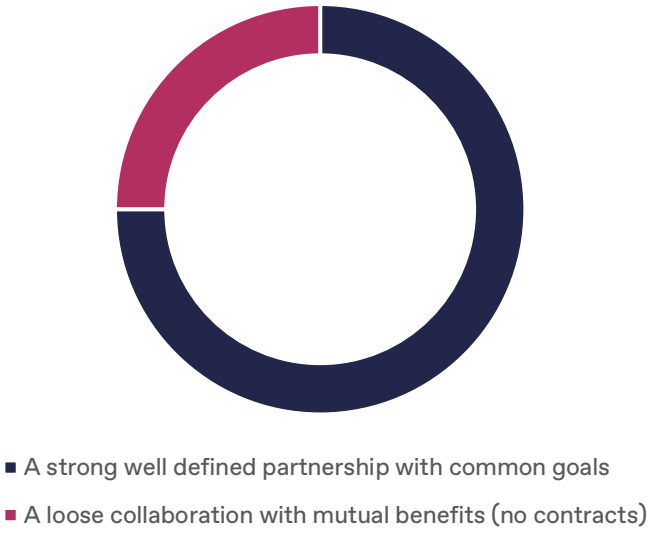


Figure 13. Deep tech startup expectations in terms of collaboration.

To achieve the objective of creating a strong collaboration, one deep-tech startup recommended starting easy with a loose collaboration before gradually evolving to a strong well-defined collaboration in the following words:

> "If you can start with a loose approach, it will go faster. Structure can scare some or can jam you in bureaucracy and delay the outcome. It's better to just get started informally. It will be easier to formalize once they know you and a relationship is established."

A second participant supported this strategy with the following quote:

> "It's important not to focus too much on bureaucracy at first. Relationship/Topic first. Checking out opportunities first. Like dating. "

Most startups were strategic in their partner selection, having themselves researched and contacted their collaboration partners (Figure 14) based on their current technological or commercial need rather than acting opportunistically.

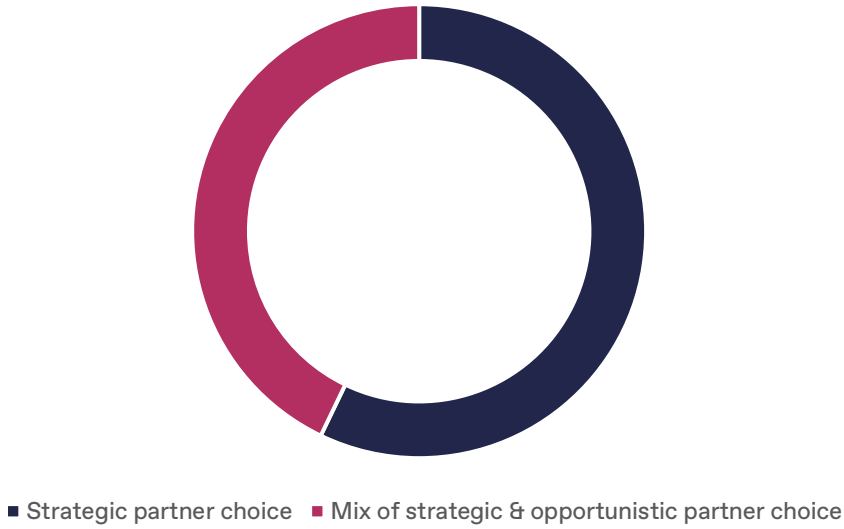


Figure 14. Most common way of selecting collaboration partners for deep-tech startups.

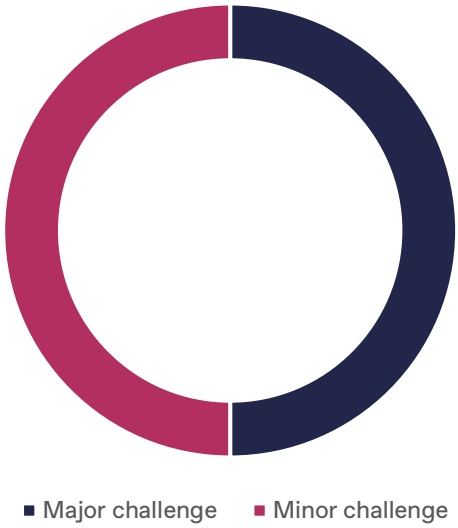


Figure 15. Difficulty level in finding the right person to talk to.

Although finding the right person to talk to was considered a major challenge only half of the time (Figure 15), the following interview statements indicate that this task was easier with smaller companies then with the big ones:

> "We contacted a lot of companies. In the end it was too much and we had to focus. It is easier with smaller companies to find the right person to talk to. The CEO or CTO always comes to talk. It's not the case with the big companies. The initial contact is with a salesperson. It takes 2-3 meetings before they send the right person."

> "It was long to get in contact with the right person in large corporates. And in the end, even if you get the right level of sponsorship, the project can easily be cancelled without explanation from above."

> "We have the green light from management for our collaboration project but the innovation manager is not that interested. It's bad luck. The innovation manager one year ago was way more motivated and pushing the project forward but he left."

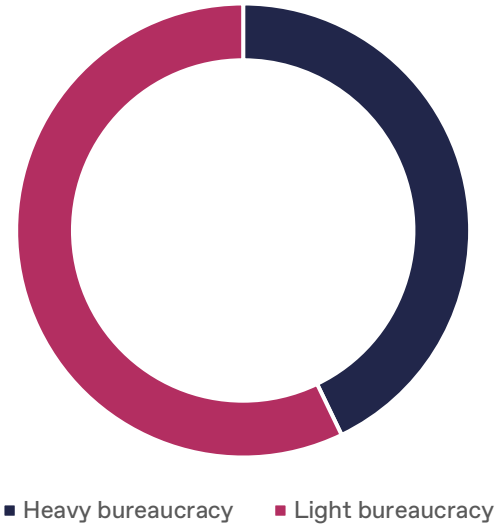


Figure 16. The bureaucratic load linked to collaborations for deep-tech startups.

While the bureaucracy was deemed light in most cases (Figure 16), it was a general sentiment that the bureaucratic load increases with the size of the collaboration partner, with large corporate partners and academic institutions imposing the heaviest bureaucratic load on the deep-tech startups interviewed. Despite this, most collaborations were simply secured via a non-disclosure agreement (Figure 17).

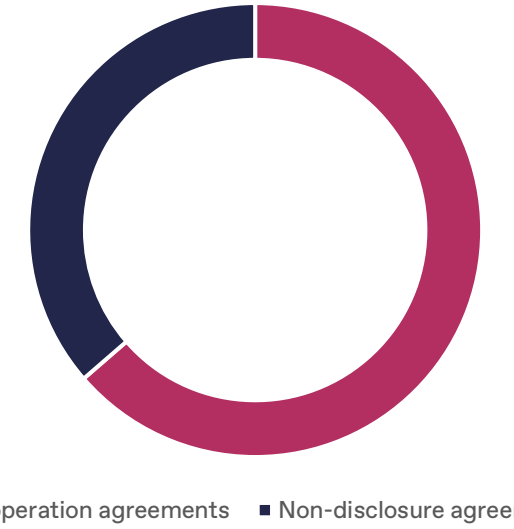


Figure 17. How deep-tech startups secure their collaboration agreements.

Overall, most deep-tech startups had positive opinions of the terms of the collaboration agreements that they reached (Figure 18). It is to note that the two negative opinions were related to collaboration agreements with large

corporates. Similarly, when asked if they felt both partners were equal in setting the terms of the collaborations, the only two cases where the deep-tech startups felt the partners were unequal were cases where the collaboration was with a large corporate. One participant offered the following quote:

"As the size of the partner increases, inequality increases"

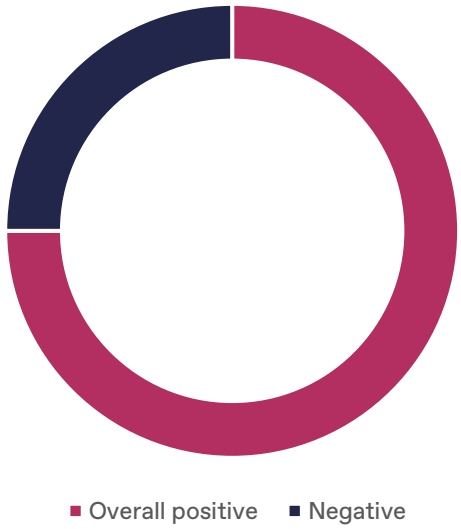


Figure 18. Deep-tech startups over all opinion on the agreement terms reached with their collaboration partners.

Finally, the main practical challenge faced by deep-tech startups during collaboration was the insufficient resource allocation from the partner followed by time delays (Figure 19).

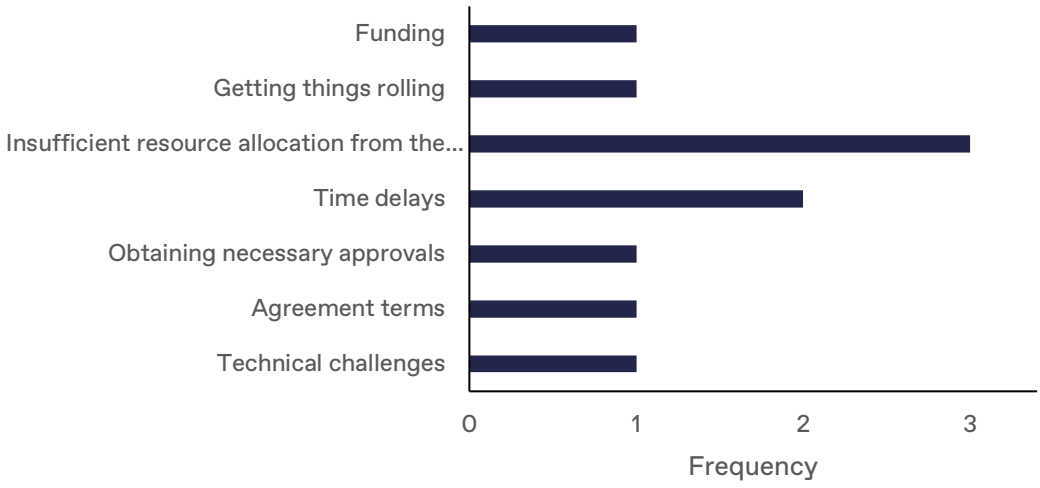


Figure 19. Practical challenges most commonly faced by deep-tech startups during collaborations.

THEME 3: IMPACT OF THE COLLABORATION ON STARTUP PERFORMANCE

All the startups interviewed deemed the impact of collaborations on their startup performance to be positive (Figure 20). It was considered crucial to startup progress and product improvement as illustrated by the two following quotes:

"Collaborations have a crucial impact. We could not be where we are without collaborations."

"Each time we collaborate we improve our product and learn tremendously"

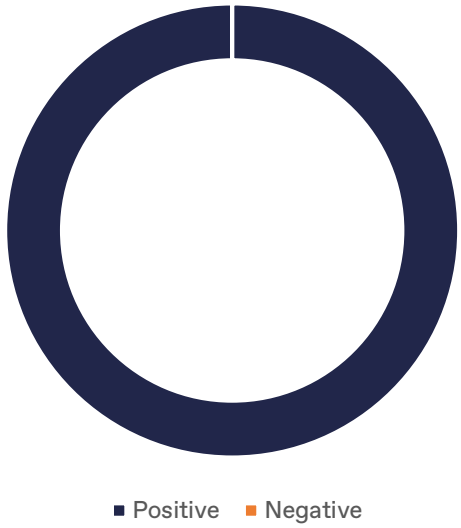


Figure 20. Impact of the collaborations on the deep-tech startup performance.

As shown in Figure 21, the most common benefits of collaborations for the startups encompassed both exploration and exploitation activities. The most common listed benefits were the improved competitiveness, the increased learning speed, the generation of innovative solutions and ideas, and the access to expertise or knowledge. Other commonly mentioned advantages were the shortened time to market and access to new customers and markets. In contrast the most reported drawbacks of collaborations were related to the efforts and resources required, the loss of flexibility, and the slowed decision speed and increased time frame of projects (Figure 22).

Figure 21. Most common benefits of collaboration for deep-tech startups.

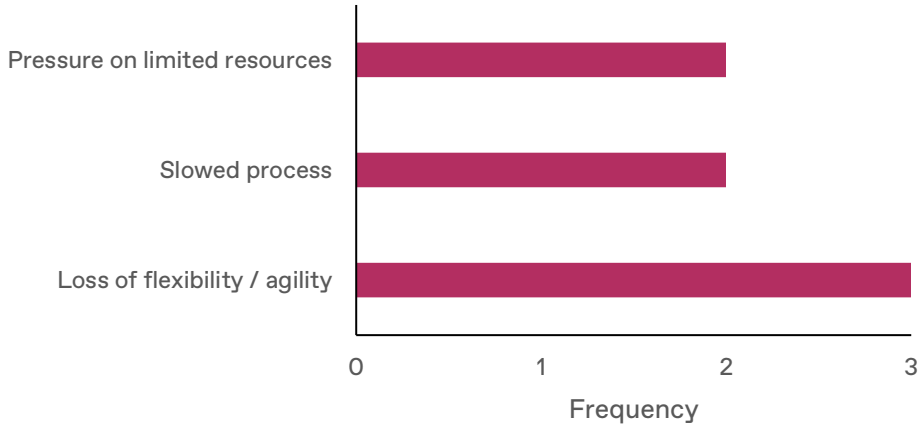


Figure 22. Most commonly reported drawbacks of collaborating for deep-tech startups.

THEME 4: KEY FACTORS AND BEST PRACTICES

The key factors identified as essential to a successful collaboration by interview participants are listed in Figure 23. One of the most frequently recurring themes was the importance of finding the right who is enthusiastic and willing to push the project as illustrated by the following quotes:

"The contact person in the other company should be the right one. For an engineering project, you should be in contact with the engineer performing the work, not the CEO, to avoid miscommunication."

"Big corporates say they are startup friendly, but it is more words than actions. We have had negotiations last for more than half a year despite a green light from management due to a change in innovation manager which was not as interested in the project as his predecessor."

The importance of creating a win-win situation where both partners benefit from the collaboration and have aligned interests was also frequently mentioned as illustrated by the following quotes:

"Think about the alignment of interest, their agenda, how you can contribute to their agenda/strategy. Be very clear about how you contribute."

In addition, startups felt it was important to be strategic on the collaboration partner choice to avoid wasting time and resources on dead-end projects as illustrated by the following quotes:

"Focus, don't take too many. Be strategic."

"Check that you have the bandwidth. Don't collaborate with 20 groups and startups just because you think you need to collaborate."

"Cut out your losses very fast if it is not working because collaborations take a lot of energy and resources for a small startup. Don't fall prey to the sunken cost fallacy."

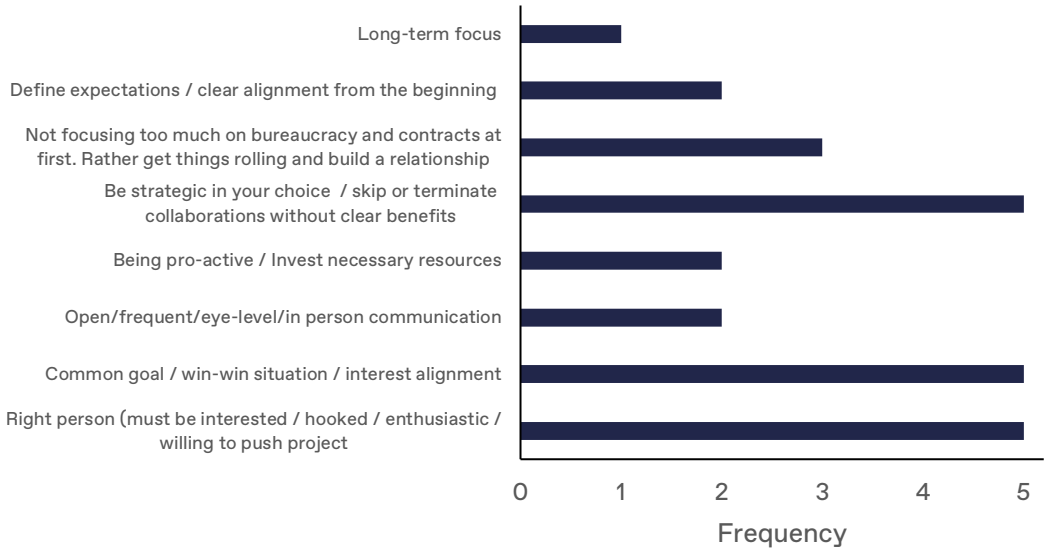


Figure 23. Key success factors and best practices identified by deep-tech startups.

Discussion of the key findings of the study

ROLE OF COLLABORATIONS IN ACHIEVING AMBIDEXTERITY: MOTIVATION, IMPLEMENTATION, AND IMPACT ON PERFORMANCE

A previous study by Parida, Lahti and Wincent (2016) posited that "young entrepreneurial firms should have a clear preference for either exploration or exploitation because such an approach to ambidexterity reduces variability in firm performance" due to the tension and necessary resources and capabilities necessary to handle these two competing activities. Volery, Mueller and Von Siemens (2015) identified six behavioral patterns that allowed entrepreneurial organizations (not exclusively deep-tech endeavors) to pursue ambidexterity. Among these, they recognized that entrepreneurs actively sought to avoid being trapped in exclusively exploitation-oriented activities by reserving 20% of their time for exploration (Volery, Mueller and Von Siemens, 2015). However, they found that although these activities did coexist, in two-thirds of the cases studied, entrepreneurs shifted the organization's focus from one activity to the other in a temporal approach rather than accomplishing both simultaneously through collaborations, as observed here. The key finding of this study reveals that there are alternatives for deep-tech startups wishing to achieve ambidexterity. The deep-tech startups who participated in this study did not focus on a single activity, nor did they switch between exploration and

exploitation in a temporal way. Interview participants focused on permanent contextual ambidexterity (Tushman and O'Reilly, 1996) and used a broad external collaboration system as shown in Figure 8 to implement their strategy through inbound and outbound open innovation (Chesbrough, 2003).

Studies focusing on the collaborative relationships of deep-tech startups tend to focus heavily on the corporate's perception and needs. Prior studies have shown that startups can greatly benefit from collaboration in an open innovation setting to overcome the liability brought about by their young age and small size (Usman and Vanhaverbeke, 2017). Studies have also shown that "startups with a strong intention to cooperate are more successful" (Garidis and Rossmann, 2019). Schuh, Studerus and Rohmann (2022) found that deep-tech startups benefit from collaborations with corporates to grow and prosper while the corporate partner benefits from access to deep technologies to innovate. From this, it could be assumed that startups already excel at explorations and would look to collaboration partners to fulfill their exploitation duties. This was also apparent in Figure 2 where we highlighted the strategic orientation of businesses concerning exploration and exploitation, placing startups firmly on the exploration corner and corporates on the opposite end (Gedajlovic, Cao and Zhang, 2012, Mattes and Ohr, 2013a, and Kim, Lee and Shim, 2022). However, our key finding in this explorative study is that deep-tech startups rely heavily on collaborations both for exploration and exploitation as shown in Figure 8 and Figure 9 and the associated quotes. This need for multiple collaborations is attributable to the fact that deep-tech startups face long development times, market resistance, and technological uncertainty while also experiencing a lack of the necessary resources, knowledge, technology, and distribution network (Figure 12). These challenges incite deep-tech start-ups to seek collaborations to bring their product to technological and commercial maturity. In essence, we found that deep-tech startups not only use collaborations actively to achieve ambidexterity, but they juggle a multitude of collaborations (Figure 8), at all TRL levels (Figure 10), for both exploration and exploitation purposes (Figure 9), and with a wide variety of collaboration partner types (Figure 11), in a truly *multidextrous* approach.

Although not widely used in management literature, the term has recently been used to frame challenges in customer relationship management (Ritter and Geersbro, 2018), to describe multifaceted strategic capabilities that harness various types of growth (Edwards, 2021), and to describe the ability to "develop, nurture, and execute several distinctive business model strategies simultaneously across different levels and function" (Demir and Angwin, 2021). Robbins et al. (2021) proposed multidexterity as a new metaphor for open innovation, defining organizational multidexterity as "the ability to simultaneously carry out multiple activities based on diverse strategic logics and levels of knowledge to generate and select a portfolio of innovative outcomes". Startups interviewed did pursue multiple open innovation activities and proceeded to a selection of each idea to pursue further as outlined by Robbins et al. (2021). However, in their pursuit of ambidexterity, they did not limit themselves to explorative collaborations, but actively sought to form collaborations to exploit their products as well. In the current economical context, deep-tech startups are expected to be asset-light by venture capital investors and therefore are likely to seek collaborations for production and distribution.

Adapting the concept to deep-tech startups, we define multidexterity in the context of deep-tech startup collaborative ecosystems as follows:

> The capacity to concurrently foster and manage multiple unique collaborations that span various partner types (startups, SMEs, Universities, corporates), technology readiness levels, industries, and objectives (from exploration to exploitation).

This propensity of deep-tech startups to balance and integrate multiple strategic approaches and collaborations simultaneously is, of course, driven by necessity. Deep-tech startups evolve in a rapidly changing and developing world. To succeed in this unpredictable market, startups must pursue multiple simultaneous strategies. The deep-tech startups interviewed were all university spinoffs. In contrast to traditional high-technology startups, which are driven by a technology pull-type situation, deep-tech spinoffs with a physical innovation face the very particular challenge of having to face a "technology push" situation. They have come up with groundbreaking scientific results in the laboratory and need to find the correct application. This situation is challenging as the market is

either non-existent or perhaps refractory to changes. In the words of one deep-tech startup owner:

> “ We are throwing as much spaghetti at the wall as possible and seeing what sticks.”

Deep-tech startups intrinsically possess qualities that allow them to pursue this multidextrous approach. They are flexible, dynamic, and agile. This will enable them to navigate the complexity of the multidextrous approach and seize diverse opportunities and capitalize on various growth avenues.

Multidextrous deep-tech startups actively collaborate with external entities such as universities and research institutions, other startups, SMEs, and large corporates (Figure 11) to improve their competitiveness, increase their learning speed, generate innovative solutions and ideas, and access expertise and knowledge (Figure 21). This extensive collaboration network allows deep-tech startups to deploy their cutting-edge technology in different industry sectors and markets at increased speeds. It also puts pressure on already scarce resources, resulting in lost flexibility and lengthier timeframes (Figure 22). While maintaining such a large collaborative network is challenging, participants overwhelmingly deemed the impact of collaborations on their performance to be positive (Figure 20) despite the occasional heavy bureaucracy (Figure 16) and challenges in finding the right person to talk to (Figure 15).

The main advantages of the multidextrous collaboration approach for deep-tech startups include the following (Figure 21):

1. Improved competitiveness: Deep-tech startups can more readily identify new applications or niches for their technologies by exploring multiple markets or industry segments. At the same time, the synergistic combination with other technological offerings can enhance competitiveness significantly.
2. Increased learning speed: Learning speed is greatly enhanced in collaboration through knowledge and expertise exchange, by the opportunity to validate ideas and prototypes, and by gaining valuable feedback by engaging with stakeholders.

3. The generation of innovative solutions and ideas: Engaging in a multitude of collaborations at varied TRL levels and with various types of collaboration partners allows deep-tech startups to explore a broader range of opportunities and potentially develop breakthrough solutions that span multiple industries or applications.
4. Access to expertise and knowledge: Collaboration and partnerships with external entities, such as universities, other startups, SMEs, and corporates provide deep-tech startups with access to specialized knowledge and expertise.
5. Shortened time to market: The access to new knowledge, technology, and expertise that deep-tech startups gain from collaborating with external entities can enhance not only their technology development but also their commercialization and market understanding, shortening their time to market.
6. Access to new customers and markets: Partnering with established companies allows deep-tech startups to leverage their market presence, distribution channels, and customer base. Collaborations with established market players can also help establish the reputation and legitimacy of the deep-tech startup in a specific market.

The main disadvantages of the multidextrous collaboration approach for deep-tech startups include the following (Figure 22):

1. Resource allocation: Pursuing multiple collaborations exerts enormous pressure on a deep-tech startup's limited financial and human resources.
2. Loss of flexibility: The increased resources put into the collaboration can prevent a startup from achieving other goals or hinder its decision capacity.
3. Slowed decision speed and resulting increased time frame of projects: Collaboration, especially with larger corporate partners, can significantly slow down decision speed and result in unnecessary time delays due to the collaborating partner's high bureaucracy or low engagement.

While a multidextrous approach to collaborations offers advantages, these are weighted significantly by the increased pressure on resources and possible time

delays. This point is paradoxical as startups enter collaborations in the first place due to their limited resources. Therefore, deep-tech startups must assess their capabilities, resources, and strategic goals to determine if a new collaboration should be initiated or even if an ongoing one should be let go as emphasized by the startups interrogated. This was reflected in the fact that participants in our study tended to select their collaboration partners strategically (Figure 14) and recommended to put an early end to ineffective collaborations (Figure 23).

KEY FACTORS AND BEST PRACTICES FOR DEEP-TECH COLLABORATIONS

While it may not be possible to establish a framework to govern all collaborations, we can derive from this study guidelines and best practices for deep-tech startups wishing to enhance their exploration and exploitation activities through external collaborations and open innovation. As highlighted in Figure 23 and the associated quotes, the key factors recognized as essential for a successful collaboration included ensuring alignment of interests between both partners, creating a win-win situation that benefits both parties and securing an enthusiastic project sponsor who can actively drive the project forward. Furthermore, participants emphasized the significance of making strategic choices when selecting collaboration partners to prevent wasting time and resources on unproductive endeavours. Favoring building a relationship over contracts, investing the necessary resources, open and frequent communications and clear alignment were also recurring recommendations.

These recommendations concord with the findings of Hora et al. (2018) who found that “factors that promote a good organization of cooperation include mutually developed objectives and milestones, and well-organized communication channels through which information and knowledge can be exchanged frequently”. Minshall et al. (2008) also found that a close contact with stakeholders was very important when developing their practitioner guidelines for partnerships between startups and large firms. Although startups and established firms may have different intrinsic motivations for entering a collaboration, these should be compatible (Das and He, 2006) and include a shared mindset, vision, trust, and honesty (Hora et al., 2018). This does not however mean that both collaboration partners should share identical goals, each

company can strive for their own goals as long as they are not in opposition with each other to prevent a win-win situation (Schuh, Studerus and Schmidt, 2022). But even with a shared vision and goals, finding a project partner that is enthusiastic and willing to push the project was deemed essential to ensure that the collaborating partner invests the necessary resources and to minimize long waiting times and delays. This sentiment is in agreement with the findings of Das and He (2006), who found that the middle managers of the established firm who will be the ones carrying out the operation should be involved from the very beginning, or a dedicated task force should be created, and the established firm should be committed to acting speedily. Das and He (2006) also recommended that the established firm should be ready to offer the use of its manufacturing and marketing facilities to improve the entrepreneurial firms' chances of growing into a stable organization. Indeed, the practical challenge most often cited by study participants was the insufficient resources allocated by the partner (Figure 19).

The strategy outlined by some participants to favor building a relationship with the cooperation partner rather than focusing on contracts and agreements can also be seen to support the findings of Niever, Scholz and Hahn (2022) on innovation driven by cooperation between startups and SMEs in which they divide the process in four phases: Learn-Match-Test-Partner. They describe the "Learn" phase as the stage where both parties familiarize themselves with each other with the primary objective of fostering mutual understanding. This phase is therefore characterized by short-term activities. During the "Match" phase, the two potential partners determine if they are compatible for collaboration in the context of, for example, a pilot project. In an ideal scenario, a successful match would then progresses to the "Partner" phase, where longer-term projects such as co-creation, joint ventures, and strategic alliances can be pursued. In our study, while participants initially sought strong, well-defined partnerships with common goals with their partners (Figure 13), they often ended up with looser collaborations secured with simple non-disclosure agreements (Figure 17). This allowed them to slowly build relationships with their partners and progress to more defined collaborations at a later stage.

In summary, the necessary conditions to enhance exploration and exploitation through collaboration according to our study participants were:

1. Alignment of interests between both partners
2. Mutually beneficial situation
3. Securing an enthusiastic project sponsor
4. Making strategic rather than opportunistic partner choices
5. Focusing on building a relationship with the partner
6. Both partners should invest the necessary resource for the collaboration
7. Open and frequent communications

Finally, we would like to add one entrepreneurial behaviour that was not mentioned by interview participants but could be inferred from the interview results: The ability to multitask is essential. This was also pointed out by Volery, Mueller and Von Siemens (2015) in their study of behavioural patterns that allowed entrepreneurial organizations (not exclusively deep-tech startups) to pursue ambidexterity. In sum, organizations aiming at a multidextrous approach to collaborations are expected to demonstrate multitasking capabilities.

CHAPTER 5: CONCLUSIONS

Relation between the key findings of the study and the initial research question and research objectives

In this study, we explored how deep-tech startups use collaborations extensively to achieve ambidexterity and enhance their performance. While previously available literature did explore the theme of collaborations in start-ups, they invariably focused on aspects of single collaborations. The results of this study show for the first time that deep-tech startups with a physical product offering do indeed collaborate, and that they do so extensively, juggling a multitude of collaborations on both exploration and exploitation activities simultaneously. Deep-tech startups face long development times, knowledge and expertise gaps, production and technical challenges, market resistance, and a lack of distribution networks. They overcome these challenges by actively seeking opportunities to collaborate. The multidextrous collaboration approach offers deep-tech startups several advantages. It enhances their competitiveness by enabling them to explore multiple markets and leverage synergies with other technologies. Multiple collaborations increase learning through knowledge exchange, idea validation, and valuable stakeholder feedback. By engaging in diverse collaborations, startups can generate innovative solutions across industries and applications. Partnerships with external entities also provide access to specialized expertise, accelerating technology development and market understanding. This, in turn, shortens their time to market and opens up new customer and market opportunities. Collaborating with established companies can also lend the startup credibility with users and suppliers while opening new markets.

However, pursuing multiple collaborations can strain the startup's limited resources, both financially and in terms of human capital. The focus on collaborations may restrict flexibility and decision-making capacity, potentially hindering other strategic goals. Collaboration, particularly with larger corporate or academic partners, may also introduce delays due to slow decision-making processes or bureaucratic hurdles.

In summary, while juggling multiple collaborations in a multidextrous fashion offers numerous benefits for deep-tech startups, careful resource management, flexibility, and efficient decision-making are crucial to mitigate the potential drawbacks of this approach. The study participants provided key insights and guidelines to navigate such an environment successfully. In addition to seeking a win-win situation where both partners benefit from the collaboration and finding a project sponsor who is enthusiastic and willing to push the project, deep-tech startup leaders emphasized the importance of strategically choosing collaboration partners to avoid wasting time and resources on less beneficial projects.

Outlook

The inductive findings of this study show that collaborations are an essential tool used extensively by deep-tech startups in an approach we characterized as *multidextrous* to overcome their many challenges and achieve better performance through organizational ambidexterity. However, our generalizations are based on a relatively small sample set of seven deep-tech startup founders, and all the data was self-reported in the context of semi-structured interviews. Further work is needed to explore how deep-tech startups approach collaborations and to validate our findings that deep-tech startups use collaborations extensively at all TRL levels for both explorative and exploitative activities in a multidextrous fashion. A follow-up deductive study is necessary to validate the key finding of this study. Observational data and more detailed case studies could also be used confirm these results and highlight key strategies, lessons learned, and success factors to effectively navigate this intensive collaboration environment. Further work could benefit deep-tech startups by providing additional education and training materials tailored to their needs and focusing on collaboration skills, project management, resource allocation, and decision-making in a collaborative setting.

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APPENDIX I - INTERVIEW GUIDELINE

INTRODUCTION

1. Introduction of myself and that the goal of the interview is to gain a deeper understanding of the collaboration process with a focus on motivation, general management approach, and practical implementation of the collaboration.
2. Thank the participant and emphasize that results will remain anonymous.
3. Confirm the time available for the interview (ca. one hour)
4. Emphasize that the participant can refuse to answer questions or stop the discussion at anytime.
5. Request to record the interview and assure them the recordings will be destroyed after transcription.

BACKGROUND

1. What is your deep-tech product and target market?
2. How many collaborations (technical and commercial) did you have to date?
3. At which development stage were you in when you sought to enter collaborations?
4. What was your immediate challenge at the moment?
5. Which type of collaboration partner did you seek?
6. How did you choose the collaboration partner?
7. How did you find the right person to talk to? Was it a major challenge?
8. Could that person offer you the required sponsorship level within the organization?
9. How much time passed between the initial contact and the project start?

THE MOTIVATION FOR THE COLLABORATION

1. What were the motives for entering a collaboration?
2. Were the motives the same for every collaboration if you had many collaborations?
3. What were the expectations of the cooperation?

THE PARTNERSHIP TYPE AND PRACTICAL IMPLEMENTATION

1. How did you legally secure the cooperation?
2. Did your collaboration partner request exclusivity?
    a. Did this prevent you from entering other collaborations or achieving specific goals?
3. Were the legal technicalities and bureaucracy a burden in terms of time or resources?
4. What is your opinion on the terms of the agreement that was reached?
5. Did you feel both partners were equal?
6. What were the most significant practical challenges in implementing the collaboration?

THE RESULT OF THE COLLABORATION

1. How did the collaboration impact your performance overall as a startup?
2. What were the benefits of the collaboration for your startup?
    a. Did you get access to resources that you may not have had otherwise (knowledge, expertise, technology, funding,...)?
    b. Did the collaboration lead to new, innovative ideas, solutions, or opportunities?
    c. Did the collaboration help you learn faster?
    d. Did the collaboration provide access to new markets and customers, expanding your reach and potential growth?
3. What were the drawbacks of the collaboration for your company?
    a. Was the decision-making speed of your collaboration partner an issue?
    b. Did you lose flexibility as a result of the collaboration?

Summary and best practices

1. What were the key factors that contributed to the success/failure of this collaboration?
    a. Were some actions crucial to ensure the success of the collaboration?

2. Have you identified best practices for collaboration from your experience? What are they?
3. What advice would you give to other small companies looking to achieve a balance between exploration and exploitation activities through collaboration?
4. Would you like to add some final thoughts?