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New Approach to Evaluating Startups: Technology-Focused Framework

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Abstract

This study proposes the development of a specialized framework for evaluating technology startups, focusing on the technological and technical aspects often overlooked in traditional evaluation methods. Using both theoretical and empirical approaches, this study identifies 13 critical components for assessing technological viability, including scalability, validation, technical team, compliance with legal requirements, maturity, sustainability, among others. These components were validated through expert consensus using the Delphi method, involving 11 experts from the fields of investment, entrepreneurship, mentoring and academia, each with experience in different technological areas.

The study underscores the need for an adaptable evaluation framework, as the relevance of each component varies depending on the specific technology being assessed. To address this, the House of Quality (HoQ) matrix was adapted to incorporate the priorities and perspectives of investors, enabling a flexible yet structured process to quantify and compare these components across different technological contexts.

This framework provides a valuable tool for investors and entrepreneurs, facilitating more informed decisions and reducing uncertainty associated with disruptive technologies. It also contributes to the innovation ecosystem by offering a structured approach that complements existing evaluation methods, particularly within the rapidly growing deep tech sector, where precise technology assessment is increasingly critical.

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1. Introduction

1.1 Presentation of the topic

As the world evolves, new challenges continually arise, requiring innovative solutions. In many cases, technology serves as a key tool in addressing the complex issues faced by both society and businesses. Often, the development of a novel technology or technical solution results in the formation of a new firm dedicated to bringing it to market; these companies are commonly known as startups. Startups are young companies founded to develop a unique product or service, bring it to market and make it irresistible and irreplaceable for customers (Baldridge, 2024). Startups, being innovative, often offer solutions that no one has previously developed, and if their product achieves good market acceptance, the returns can be huge. As a result, an increasing number of governments are offering support and programs that encourage the development of new technologies in their countries, creating innovation ecosystems and supporting scientific and technological research.

Investors, attracted by the potential success of new technologies, create a symbiotic relationship with the founders. Considering the recent birth of the company, entrepreneurs seek financing to be able to enter the market when it is in early stages or to scale if the startup is more developed. Investment is a fundamental engine for startups to emerge and achieve their objectives, since, without financing it is difficult for a startup with limited resources to prosper. On the other hand, more and more investors seek to invest in emerging companies, since if successful these have a high growth potential.

According to the definition of Ries (2013), a startup is a human institution designed to create a new product or service under conditions of extreme uncertainty. Considering this, the risk of failure becomes very high. The failure rate for new startups is currently 90% (Howarth, 2023). Therefore, although investors are very attracted to new technologies, they are constantly looking to ensure that their investments are successful. As a result, assessing the potential success of these new companies has become a major challenge.

Investing in a startup can mean multiplying the investment or it can turn into a loss. Estimating the future value of the company is a challenge that must consider both expectations and potential risks of failure. Today there are various methods and tools to evaluate startups, predicting their success and value. Depending on the stage in which the startup is, different startup valuation methods can be applied. There is no universally acknowledged approach for appraising startups. Instead, numerous viewpoints and theories on how to value startups have evolved, each having a unique approach to valuation (Olsen, 2019).

Valuation should capture every element of a startup, its business model, its market, its competitive environment, its technology, its founding team, as well as all the risks associated with the startup. A legitimate valuation is therefore a strong bridge between these elements and final value estimation (Damodaran, 2017). However, despite the variety of existing evaluation methods, most of them tend to focus solely on the financial or market aspects of the startup, leaving aside a deep analysis of other critical components and their associated risks. There are some methods used in early-stage investment that do incorporate the evaluation of the product or technology and the founding team as part of the company's valuation. However, these approaches usually address these elements superficially, without delving into key aspects such as technological maturity, scalability, degree of innovation, or alignment with emerging trends in the sector. This lack of detail can result in incomplete valuations that do not adequately capture the risk and potential associated with the technology, which consequently may increase uncertainty for investors.

Approximately 6% of startup failures are due to technological concerns, such as weak cybersecurity and out-of-date technology solutions (Vyshyvaniuk, 2024). This statistic is derived from a broad sample of startups, including those with minimal or no direct connection to technology. If we narrow down the focus to tech-driven startups, the percentage of failures attributed to technological issues would likely be significantly higher. This becomes even more pronounced in the context of Deep Tech Startups, where the core value proposition and innovation are deeply rooted in advanced technologies. A study conducted by Digital Catapult (2023), involving 1,257 deep-tech investors, revealed that 31% of respondents perceive significant risks in their investments due to a lack of understanding or knowledge of the underlying technology. This underscores the importance of thorough technological evaluation and expertise in mitigating investment risks in these highly specialized startups.

Technology, being the pillar on which many of these startups are built, not only determines the viability of the product or service, but also influences its ability to scale and adapt to changing market demands. Today, the TRL scale is the benchmark for measuring the development and maturity of a research, as well as its readiness for market acceptance and potential investments, especially since its reintroduction in EU-funded projects in 2012 (European Commission, n.d.). Despite being a good reference point to understand the development of technology, it remains an incomplete analysis. Evaluating maturity, innovation potential, scalability and the viability of the technology is crucial to predict the success of a startup. Without a detailed analysis of these aspects, evaluations can be incomplete, increasing the risk for investors.

The purpose of this research is centered around the introduction of this problem. This purpose is designed to fill the existing gap in the technological evaluation of startups, providing investors with a more precise and focused tool that allows them to make more informed investment decisions. The following sections further explore the objectives of this research and its significance within the scientific-technological innovation ecosystem.

1.2 Research objectives

The main objective of this research is the development of a framework for the evaluation of technological startups focused mainly on technological and technical aspects of the product. To achieve this, we will seek to: (1) Identify and analyze the key components that should be considered in the technological assessment, through a literature review and identify parameters in responses to experts (2) Develop a structured framework that integrates these components, and (3) Validate the proposed framework through assessing its feasibility and effectiveness with expert feedback gathered via surveys.

This research will be guided by the following key questions:

- What are the most critical technological components to assess when evaluating a technology startup?
- How can these components be effectively quantified and compared?

This research aims to contribute to the development of more effective evaluation methodologies for technological startups, offering both investors and entrepreneurs a robust tool for assessing technological viability.

1.3 Hypothesis

Based on the identified problem and the proposed objectives, this research will be guided by the following hypothesis:

"A framework that specifically focuses on the technological aspects of a startup will enable investors to make more informed and precise investment decisions, whilst also providing entrepreneurs with a clear understanding of the key requirements they must meet to attract investment, thereby reducing uncertainty and the risk associated with the intangible and innovative nature of new technologies."

This hypothesis is based on the following assumptions:

1. Relevance of technology: Technology is a crucial component that determines the success of a startup, especially in its early stages. Properly evaluating technology can provide a more accurate view of the startup's potential for success.
2. Need for a specialized approach: Current evaluation methodologies, which focus primarily on financial and commercial aspects, are insufficient to fully capture the value and risks associated with the underlying technology. A specialized approach to technology evaluation can fill this gap.
3. Benefit of the framework: A well-structured and specific framework for technology evaluation will provide a more detailed and accurate approach, helping investors make better-informed decisions. It will also help founders gain insight into the requirements for attracting investors. This will not only reduce uncertainty and risk, but also improve the efficiency and effectiveness of the investment process in technology startups.

4. Diversity of Technologies: Every technology is unique and requires a tailored approach to evaluation. The framework provides a foundational guideline that is adaptable to different types of technologies, ensuring that each one is assessed according to its specific characteristics and needs. This flexibility allows for a more accurate and context-sensitive evaluation.

This hypothesis will be tested by developing and validating the components of the new technology assessment framework, based on a theoretical framework that considers specific parameters for technology assessment. These components will be quantified using an existing and reliable methodology (House of Quality), adapted for the context of investment in technology startups. Validation through literature review, surveys and interviews with experts will confirm whether these components, integrated into the framework, provide an accurate and reliable method.

1.4 Importance of the study

This study is highly relevant for several key reasons. First, evaluating technology is critical to determining the success of a startup, especially those whose value proposition is based on technology or that belong to the deep tech sector. These startups directly rely on technological innovation as their main core, and their success or failure is intrinsically linked to the quality, viability, and scalability of their technologies.

Currently, there are no standardized methodologies that focus specifically on evaluating technology in startups. This gap represents a significant challenge in the scientific and technological innovation ecosystem, which this study seeks to fill by providing a structured and reliable framework to evaluate technology in a comprehensive manner. This approach is particularly critical for deep tech startups, where technology is not just a component, but also the heart of the company.

Furthermore, this approach will enable investors to mitigate risks by methodically examining the crucial technology components required to avoid startup failure owing to technological concerns. With a more exact and thorough tool, investors will be able to make better informed judgments, enhancing the probability of success for their investments.

On the other hand, startups, which depend largely on financing to survive and grow, will find in this study an essential tool to methodically identify the technological components that are valued by investors. This will not only improve their ability to attract investments, but will also increase their chances of success in a highly competitive environment, especially for those whose value proposition is directly linked to technology.

1.5 Order of the thesis

This thesis is divided into eight chapters, with each adding to a thorough grasp of the study issue. The first chapter introduces the subject by stating the research objectives, hypothesis, and importance of the study, laying the groundwork for the work that follows. It offers the appropriate backdrop for the study and explains the main topics that will be addressed.

The second chapter details the methodology, starting with the theoretical foundation and moving into the specifics of the Delphi Method used in the research. This chapter also justifies the integration of numerous perspectives and techniques, outlining the sequential process used and the reasons for the methodological decisions taken.

The third chapter focuses on the startup ecosystem, including essential concepts, the startup life cycle, and examples of technical failures. This context is critical for determining the research's significance.

Chapters four and five describe in detail how information is gathered using the chosen research approach. Chapter four explores the theoretical frameworks related to startup and technology assessment. It explores a variety of methodologies, including the Scorecard and Dave Berkus methods, as well as frameworks such as Technical Due Diligence and Technology Readiness Levels (TRL). The chapter also discusses Quality Function Deployment (House of Quality) and finishes with insights gained from these frameworks, which are critical for the creation of the suggested evaluation model. The fifth chapter presents the application of the Delphi Method, summarizing the results from interviews and questionnaires. It highlights key findings, patterns in themes, and their implications for the proposed framework.

Chapter six is dedicated to the creation of the evaluation framework. It identifies and groups essential components, translates investor requirements into technical specifications, and presents the final framework, which adapts the House of Quality for investors and startups.

The discussion in chapter seven connects the findings back to the research objectives, offering a critical examination of the results and considering the study’s broader implications and limitations. At the end, the thesis concludes with a summary of the key insights, reflecting on their practical significance and suggesting directions for future research.

2. Methodology employed

In order to effectively develop the thesis, two main approaches were defined to create the new evaluation framework: 1) Theoretical approach and 2) Empirical Research approach (Delphi method). The first approach involved a thorough literature review to gather key information and understand current practices in technology evaluation in startups. The second approach involved data collection through expert interviews, conversations, and questionnaires. After each stage of data collection, integration was performed through triangulation and thematic analysis, ensuring a solid synthesis of the information. The main objective of this stage is to identify the critical technological components that must be assessed when evaluating a technology startup, thereby addressing the first research question of this study.

In this section, each methodological approach will be explained in detail, describing the specific steps taken, the logic behind the chosen methods, and how they contributed to the development of the overall framework.

2.1 Theoretical approach

The first phase focuses on a thorough review of the academic literature and previous studies on technology evaluation in startups. "A Literature reviews allows to gain familiarity with the current knowledge in the chosen field, as well as the boundaries and limitations" (University of Illinois Springfield, 2022). In turn, the literature review allows to find gaps where in-depth research has not been carried out (Western Sydney University, 2024), which in turn allows to verify the importance of the study in this field. The theoretical approach process was developed in different stages that were based on the empirical literature review. The stages of the process were:

a. Search for relevant sources

A comprehensive search was conducted for relevant scientific articles, books, and case studies. These sources provide a variety of essential perspectives and data to understand current practices in technology assessment. In turn, this practice helped to better understand the startup and technology ecosystem.

b. Critical analysis of existing methodologies and frameworks

A critical analysis of established methodologies and frameworks for assessing technology, startups, or products was conducted. This included the Technology Readiness Level (TRL) for evaluating technological maturity, the Berkus method for the valuation of startups, or the House of Quality (HoQ) for product design and development alignment. This analysis provided insights into the strengths, weaknesses, and practical applications of each approach within the context of technology startups.

c. Synthesis of insights

The synthesis of insights obtained from the literature provides an up-to-date and informed understanding of current practices. This step is crucial to extract relevant components or parameters that will be used in the development of the assessment framework.

d. Identifying recurring patterns and parameters

By analyzing and synthesizing current methodologies, recurring patterns and common causes of failure in underlying technologies are identified. These patterns and parameters become essential components of the new framework, ensuring that it addresses both critical success factors and potential risk areas.

The literature review not only provides a solid theoretical foundation but also guides the structuring of the framework, ensuring that it is aligned with current best practices and knowledge in startup technology assessment.

2.2 Empirical Research approach – Delphi Method

The empirical research approach is grounded on obtaining real-world evidence of what is experienced in the startup ecosystem daily, with the aim of being able to contrast with what is found in the literature. This approach is very useful to raise relevant information that is very limited in the theory. To achieve this, a sample of experts familiar with technology, innovation, and product development was selected. The Delphi Method was chosen for this investigation to reach a consensus and validate the evolving requirements. Delphi is a structured methodology for systematically collecting expert judgments on a problem, processing the information, and building a general group agreement (García Valdés & Suárez Marín, 2013). The research was conducted in two rounds: the first involved interviews with the experts, and the second consisted of a questionnaire designed to validate the findings from the initial round and literature review.

1st round - Individual Interviews: Individual interviews is conducted between the researcher and each participant, marking the first round of data collection. This method is critical to gaining in-depth and detailed insight into each interviewee's personal experiences, opinions, and specific knowledge, especially on topics that require deep technical analysis or are sensitive in nature. Similar open-ended questions will be used for all participants, with minor adjustments depending on the study group, allowing the researcher to explore in depth and adapt the questions based on the responses. This approach fosters depth and nuance in the research outcomes, which purely quantitative methods may not provide (Dunwoodie, Macaulay, & Newman, 2023)

2nd round - questionnaire: In the second round of the study, a questionnaire was utilized to evaluate the findings from the first round of interviews and compare them to the literature review. This questionnaire was created to get expert feedback on the relevance and correctness of previously discovered components, allowing for a more solid consensus. The questions were designed such that participants could evaluate and prioritize the components, allowing for a quantitative analysis that supplemented the qualitative data gained previously.

Selected study groups

In-depth interview studies require careful selection and recruitment of participants, with the researcher first defining the characteristics of the individuals or social groups to be studied (Knott, Rao, Summers, & et al., 2022). For this research, experts with varied experiences and perspectives within the startup and assessment ecosystem were selected. Below, the four groups targeted for investigation are defined.

1. **Investors in technology startups:** Angel investors, venture capitalists or members of crowdfunding platform. They have practical experience in evaluating

technological value and can offer insights into the criteria they use and gaps in existing methods.

2. **Technological startup entrepreneurs:** They are essential to understand the challenges and needs from the perspective of those who develop the technology. They could provide insights into how they perceive the valuation of their technology and what aspects they consider most critical. Entrepreneurs must cover different areas of technology.

3. **Consultants or experts in innovation and technology:** Professionals who advise startups on innovation or technology development strategies, this may include mentors from incubators, accelerators or innovation programs. They can offer insight into how technology fits into the overall valuation of a startup.
4. **Academics with specialization in entrepreneurship and technology:** Researchers who have published works on technological entrepreneurship or startup valuation can offer a theoretical and analytical perspective.

2.3 Foundation in the integration of approaches and methodologies

The development of this thesis and the construction of the new framework benefited from the close integration of two research methodologies, namely theoretical and empirical, which were identified at the outset of the research process. The procedures used to compile the data gathered using these approaches are described in this part, with an emphasis on determining the most important needs that investors have prioritized. To show how each approach adds to the research's robustness, the reasoning behind its selection is also explained in detail.

2.3.1 Sequential Integration Process

The steps followed during the investigation for the collection and validation of information are detailed below:

1. Literature Review: This phase involved gathering information from existing literature, identifying current theories, synthesizing insights, and pinpointing parameters and patterns across various evaluation methodologies.

2. Preparation and research design: This phase included the development of interview guides and the careful selection of participants, ensuring representation from a broad range of perspectives within the technological startup ecosystem.

3. Conducting individual interviews: In the first round of Delphi Method individual interviews were conducted with entrepreneurs, investors, and other key stakeholders to gather detailed information and specific opinions on critical technological aspects in startup valuation.

4. Preliminary analysis: Data from individual interviews were analyzed to identify themes and patterns through thematic analysis. In parallel, comparisons were made with existing literature to identify differences or consensus between them.

5. Identification of critical components: Based on the information gathered from interviews and literature, critical components for evaluating technology in startups, as required by investors, were proposed.

6. Development of the questionnaire: A structured questionnaire was developed to validate the critical components identified. This tool was designed for experts to evaluate and prioritize these components, ensuring alignment with investor expectations in technological startups.

7. Presentation and validation of findings: The findings were presented to experts, who were then asked to complete the questionnaire to validate the results. This step was essential for refining the framework and confirming its relevance to investors' needs.

This combined approach ensures that the research covers issues related to technology assessment in startups in depth and variety of perspectives, thus providing a comprehensive and well-informed framework.

2.3.2 Justification for methodological choices

The combination of literature review and analysis of expert interviews provides a solid foundation for the framework, ensuring that the selected components are essential for a comprehensive and accurate technology assessment. According to Denzin (2009), “by combining methods and investigators in the same study, observers can partially overcome the deficiencies that flow from one investigator and/ or one method. In this respect triangulation of method, theory, and data remains the soundest strategy of theory construction" (p. 300).

The information obtained from both strategies was integrated to develop a technology assessment framework. This framework is designed to be:

Comprehensive: Considering both qualitative and quantitative aspects.

Practical: Adaptable to different types of technologies and stages of startup development.

Evidence-based: Grounded in current literature and the experiences of experts in the field.

By combining the literature review with the insights gained from expert interviews, the proposed framework offers a robust and well-grounded guide for the technological evaluation of startups. The choice of methodologies is justified by the following reasons:

Triangulation: Triangulation is a technique used to increase the validity and reliability of results by combining multiple methods, data sources, and perspectives. According to Denzin (2009), multiple triangulation is an effective strategy and exists by combining various methods, data sources, and theoretical perspectives within a single study. This approach helps to overcome the limitations that may arise from relying on one method or investigator, resulting in a research perspective that is more robust than any single-method approach.

In this thesis, multiple triangulations are used:

- Methodological triangulation: since both qualitative and quantitative data from the different existing methodologies are integrated to evaluate start-ups.
- Data triangulation: to corroborate the information obtained from different sources, which will strengthen the robustness of the proposed framework. Four study groups are involved, and in each case experts with different experiences.
- Theoretical triangulation: Various conceptual frameworks are used for the evaluation of technologies.

Thematic Analysis: Thematic analysis is a key qualitative data analysis approach that focuses on recognizing, examining, and interpreting recurring patterns or themes within the qualitative data. (ATLAS.ti, 2024). This approach allows to identify patterns in the most relevant insights obtained during interviews and found in the literature, providing a solid foundation for technology evaluation.

To carry out this analysis, the stages of familiarization with the data, generation of initial codes, search for patterns among the interviews, review of themes, definition and naming of themes, and proposals for components to incorporate into the framework in the final report will be followed. These steps ensure a systematic identification and organization of the most relevant themes, providing a solid basis for the evaluation of the technology.

Delphi method: It consists of an iterative information gathering technique, based on consulting experts in an area, in order to obtain feedback on what the group has expressed and that, starting from an open exploration, after more than one round, they produce an opinion that represents the group (Reguant-Álvarez & Torrado-Fonseca, 2016).

This methodology helps refine the opinions and ensure that the selected components are widely accepted by professionals in the field. In the case of this research, the second round of Delphi was used to validate and assign quantitative relevance to each of the components collected in the first round and in turn allow participants to counter-argue with respect to what is proposed.

3. Startup Ecosystem

3.1 Ecosystem definitions

The aim of this thesis is to evaluate startups and analyze their technology in relation to investors, mentors and the innovation ecosystem. This is why it is very relevant to understand: **what is a startup?**

According to the Cambridge Dictionary (Cambridge University Press, n.d.), a start-up company is a small business that has just been started, but this definition does not tell us much about it, as it does not differentiate it from a regular company. On the other hand, Paul Graham (2012), founder of YCombinator, tells us that a startup "is a company designed to grow fast". This rapid growth is one of the main characteristics of a startup. Eric Ries (2011) offers one of the most recognized definitions, which defines a startup as a human institution designed to create a new product or service under conditions of extreme uncertainty.

While there are many definitions of startups and each author may interpret them in different ways, all definitions agree that it is a small company that can achieve large and rapid growth in the short term. This rapid growth is usually achieved due to the innovative value proposition that the startup offers, which allows it to differentiate itself in the market. By operating differently from the competition, a startup often suffers risks related to its acquisition or low efficiency in projecting its success, which is why a large percentage of startups fail in the early stages.

As already mentioned in its definition, a startup is a business that is just starting out, which is why it usually needs to raise funds in order to reach the market. These funds are often provided by investors interested in supporting projects with high growth potential. The first funders of a startup may include family, friends, or angel investors, but as the company matures and demonstrates viability, it may also attract the interest of venture capital funds. This financing process is crucial for the startup to scale, develop its product or service, and establish itself in the market, which in turn allows it to compete and generate sustainable revenue.

Angel investors: Individuals who invest part of their personal capital in startups (usually smaller amounts than VCs). They generally invest at early stages and bring not only money but also expertise. Angels want to make a profit on their investments, but a significant component of angel investing is giving back to the community (Stagars, 2015, p. 128)

Venture Capital: Funds or firms that invest capital in startups with high growth potential. In exchange for their investment, venture capital funds usually require a significant stake in the company, seeking high returns.

On the other hand, incubators and accelerators provide another great support for entrepreneurs. They play a fundamental role in the startup ecosystem. Incubators provide support in the early stages of a startup's development, helping entrepreneurs refine their ideas, access resources, and form networks of contacts. Accelerators, on the other hand, usually focus on startups that already have a product or service, offering short-term intensive programs that include mentoring, financing, and exposure to investors. These programs accelerate the growth of startups and facilitate their entry into the market.

Every time a startup wants to seek investment or enter an incubation or acceleration program, it must present a pitch to demonstrate its main strengths, its value proposition, and a business model. In this way, interested parties can evaluate the startup before making decisions.

3.2 Startup Life Cycle

Like any company, a startup also has its life cycle. The literature shows that different stages of a startup have been identified. This allows the company to identify what stage of development it is in and also allows it to know what type of investors or support to turn to in order to continue moving forward.

There are 6 main stages of a startup: pre-seed stage, seed stage, early stage, growth stage, expansion stage, exit stage. Each of the stages has characteristic aspects that will be defined below.

Pre-seed stage: This stage is all for generating ideas. It's about testing and analyzing the startup's opportunities. The goal is to determine if the product or service can be a viable solution to a real market problem (BaselArea, 2023). At this stage, the creator seeks partners and an initial team to help create the product or service, such as a co-founder or partner to share duties, as well as an engineer or staff member allocated to product innovation (Baviera Díaz-Leante, 2020). Funding is unlikely to be available at this stage, although incubators or innovation programs for ideas may be available.

Seed Stage: At this stage, the founders already have an MVP and begin looking for investors. Potential investors for seed-stage startups include incubators, crowdfunding, and angel investors. Considering investors are taking a substantial risk by investing in your firm at this time, they will want an ownership interest in the company in exchange for their financial contribution (Embroker Team, 2023). Usually, the funds raised at this stage are used to improve the prototype and seek to reach the market.

Early stage: Securing a first round of venture capital funding is the typical definition of an early-stage startup, also known as Series A. Success at this stage is only possible once your company has built a minimum viable product (MVP) (BaselArea, 2023). Once it is proven that the product or service really interests the market, it is a matter of improving the product through the process of continuous innovation (Marchiotto, 2018).

Growth stage: The growth stage includes Series B and C startups. As the business model and customers are defined, both VC and Private Equities invest in this phase, since the investment risk is lower than in the early stages (Baviera Díaz-Leante, 2020).

Growth-stage startups have found product-market fit. They know who their customers are and are aiming to get as many of them as possible. Typically, the emphasis is on user growth and scalability, which includes rapidly expanding the team and physical assets needed to serve the startup's growing customer base (Y Combinator, 2024) .

Expansion Stage: By the time a startup reaches Series D, E, etc. They have grown into a sizable tech startup with hundreds or perhaps thousands of workers. At this point, the firm has established itself as a major player in its industry, thus the "startup risk" is quite minimal (Y Combinator, 2024). The company is already profitable and self-sufficient. Many people will no longer consider the business a startup (BaselArea, 2023).

Exit stage: Not all startups decide to take this action, but most of them are geared towards further growth. There are different forms of exit, and the choice will depend on the founders' objectives. The most typical forms of exit are merger or getting acquired by another company or Initial Public Offering (IPO).

3.3 Types of startups

Startups are a whole world and that is why there is a great variety of emerging companies. Their rapid growth is usually linked to innovation, and since many of them have technological characteristics, they also cause greater expansion. Considering that the objective of this thesis is to evaluate technology, we will focus on it. There are many ways to define or differentiate the types of startups, below we will explain the differentiation according to the innovation matrix, the differentiation according to the value proposition and the type of technology.

Budda (2020) presents a two-dimensional matrix (technology and market) to understand the 4 types of innovation. **Incremental innovation** improves existing products or processes without significantly altering the market or the underlying technology. **Disruptive innovation**, on the other hand, introduces products that may initially be inferior but eventually redefine the market. **Architectural innovation** reorganizes the existing components of a product to attack new markets without changing the underlying technology. Finally, **radical innovation** introduces both new technologies and new markets, revolutionizing entire industries, such as the invention of the Internet.

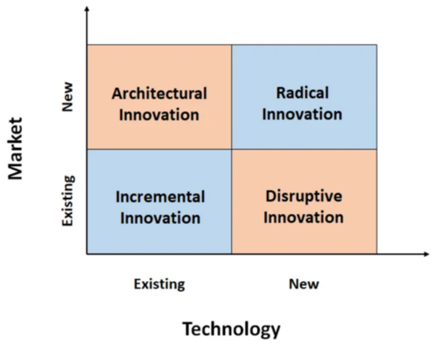

Figure 1. *Innovation Matrix with Technology and Market axes.*

Source: *Budda (2020), Innovation Matrix.*

Another way to differentiate startups is to understand where their value proposition lies. The two biggest value propositions can be in the business model, the product, or both.

Product/Service Value Proposition: This category encompasses startups that focus on offering a unique or significantly improved product or service. The innovation can be in the underlying technology, the user experience, or the ability of the product or service to meet a need more effectively than existing solutions.

Business Model Value Proposition: Startups in this category innovate in the way they generate value and capture revenue. This can include unique pricing structures, novel distribution models, or different ways of interacting with customers and partners.

When we approach the topic of technology startups, which develop their products or services based on technology, is possible to find two main scenarios. Firstly, the product may be the result of adapting existing technologies to offer a new alternative; in these cases, although the product may seem novel, the value proposition is mainly focused on the business model. On the other hand, when a startup develops a product completely from scratch, the value proposition is usually based precisely on this innovation. By offering something radically new and innovative, the fundamental value of the company is defined in the product.

When we talk about the type of technology, it is essential to highlight companies known as **deep tech**. These startups focus on deep and disruptive technological developments that have the potential to create significant changes in industries and society. Unlike other technology startups that might be based on applying existing technology in innovative ways, deep tech companies are dedicated to the creation of new technologies that often require lengthy research and significant development investments. Common areas include biotechnology, advanced artificial intelligence, quantum technology, aerospace technologies, sustainable energy, advanced materials, etc. (European Institute of Innovation and Technology, 2023). These companies are not only looking to meet market needs, but also aim to solve major global challenges, from climate change to personalized medicine and beyond.

It is important to highlight that this study takes on greater relevance in startups where the value proposition is in technology, that is, in radical and disruptive technologies such as deep tech technologies. These startups are at the forefront of innovation, setting the pace of technological progress and opening up new market opportunities. Therefore, understanding their technology in depth is crucial before making investment decisions. The objective of this thesis is in line with enabling investors and stakeholders to make more informed decisions, adequately assessing the risks and potential long-term benefits that these innovative technologies can offer.

3.4 Cases of failure due to technology

There are many cases where startups have failed due to their technology. The reasons for failure can mainly be due to scalability issues, overestimation of technological capacity, rapid technological obsolescence, insufficiently tested technology, etc.
In recent history, we have seen several examples of technologies that promised to transform industries but ultimately failed due to various factors. Below are 2 well-known failure cases:

- **Google Glass:** Google Glass is a wearable computer that resembles a pair of eyeglasses. It was created by Google and originally launched in 2013. Google Glass features a tiny display that displays information into the user's field of view. The gadget may be used to capture images, send messages, receive directions, and browse the internet (Price, 2023).

The main reasons for the failure were privacy concerns and technical issues. The device allowed recording videos and taking photos without clear consent of the people being recorded, raising fears about its use as an invasion of privacy. In addition, vulnerability to hacking increased the risk of compromising the user's personal data. (Price, 2023). These serious privacy and security issues were compounded by technical difficulties such as short battery life, slow charging times, inferior camera quality and voice control issues, which limited its usefulness and market acceptance (John, 2024).

- Theranos: Theranos was founded by Elizabeth Holmes in 2003 with the intention of revolutionizing health diagnostics by claiming it could perform a wide range of medical tests using just a drop of blood, in contrast to conventional tests that required significantly more blood (De Pablo García, 2023). The startup managed to raise a lot of investment and was valued at $9 billion before the fraud was exposed.

This scandalous fraud case turned out to be one of the most notorious in the tech startup space. Despite initial promises, Theranos' technologies never worked as advertised. The company's devices, designed to perform comprehensive medical tests with just a few drops of blood, failed to produce accurate or consistent results. The lack of technological feasibility was critical, as medical tests require high precision to be clinically useful.

These cases, like that of Google Glass and Theranos, highlight the importance of carefully evaluating technology in startups before making investments. In the case of Google Glass, promises of an innovative experience were thwarted by technical issues and privacy concerns, preventing the technology from becoming viable and widely accepted. On the other hand, Theranos, with its unproven and failed technology, misled both investors and the public, demonstrating how a lack of technological feasibility can lead to the collapse of even the most promising startups.

These failure cases also highlight the need for investors to conduct thorough due diligence before committing funds to startups that promise to revolutionize industries with unproven or flawed technologies. Underlining that an innovative idea or an attractive business model is not enough if the technology is not robust, scalable or able to meet expectations. This demonstrates the importance of the present study, validating the relevance of the research objectives.

4. Theoretical approach

Having understood the general notions and concepts related to startups and technology, the following section provides the theoretical framework that underpins the evaluation of technology startups. Evaluation frameworks for both startups in general and for technology-specific evaluation are described, and it concludes with an analysis of patterns and conclusions derived from them. The objective of this section is to understand existing evaluation frameworks and methodologies, and then to identify and propose essential components for the new framework.

4.1 Startup assessment frameworks

4.1.1 Dave Berkus Method

The Berkus method was developed by Californian angel investor Dave Berkus in the 1990s. The Berkus method offers a simple approach for founders and early-stage investors to evaluate a company by focusing on risk factors rather than financial projections, even before the company starts generating revenue (Eqvista, 2023).

To estimate a startup before it generates revenue, the Berkus method offers entrepreneurs and early-stage investors a simple framework that allows them to focus on risk factors rather than final projections. However, the effectiveness of this method does not replace the need for the startup to conduct extensive due diligence.

The Berkus Method employs qualitative and quantitative considerations to assess value, including the next five elements:

If Exists:	*Add to Company Value up to:*
Sound Idea *(basic value)*	\$1/2 million
Prototype *(reducing technology risk)*	\$1/2 million
Quality Management Team *(reducing execution risk)*	\$1/2 million
Strategic relationships *(reducing market risk)*	\$1/2 million
Product Rollout or Sales *(reducing production risk)*	\$1/2 million

Figure 2. *Valuation for each risk-reduction element.*

Source*: Berkus, D. (2016). After 20 years: Updating the Berkus method of valuation.*

According to Berkus (2016), each component should be worth up to $500,000. However, in 2016, some years after the approach was developed, Dave explained that the Angel Capital Association's HALO report, which includes typical pre-money values for angel investors, shows that the US average is greater than this amount. As a result, he suggests that the technique should be flexible enough to allow users to negotiate or design a maximum valuation that they are ready to accept in an ideal case, as well as to allocate risk aspects that may be more significant to them than those listed above. This makes the methodology quite subjective in the eyes of each investor.

It is important to note that the existence of a prototype or validation is an excellent way to reduce technological risks, so it should be a fundamental component in the evaluation. Likewise, a high-quality team also reduces business risks, which increases the value of the startup. This underlines the importance of having a well-qualified technical team for technology development.

As proposed in the Berkus valuation method, technology-related risk is one of the five key elements to consider in the valuation of an early-stage startup. The review of the literature associated with Berkus reveals that, in most cases, this analysis focuses mainly on the quality of the prototype. However, following the hypothesis of this research, there are many other components that must be analyzed around technological risk. The proposal of the new framework of this study could provide a relevant and deeper complement before carrying out an evaluation. This validates the contribution of this research to enrich existing tools or methods.

4.1.2 Scorecard Method

The Scorecard Method is a methodology developed for the valuation of startups in early stages. This approach is characterized by its quantitative nature, which seeks to assign an estimated value to a startup by weighing various key factors that are critical to its success. The first step in applying the Scorecard Method is to calculate the average pre-money valuation of pre-revenue enterprises in the target company's location and industry (Payne, 2011). This valuation changes depending on the economy and the atmosphere of competition for new companies within an area.

After identifying the average value of comparable companies, the value of each of the factors to be compared within the company must be adjusted. The following factors are normally used with their corresponding interval of importance weights. Although the importance range percentages can be adjusted for each type of company, in most cases the maximum are those established by Payne (2011) are used:

- 0–30% Strength of the Management Team
- 0–25% Size of the Opportunity
- 0–15% Product/Technology
- 0–10% Competitive Environment
- 0–10% Marketing/Sales Channels/Partnerships
- 0–5% Need for Additional Investment
- 0–5% Other

These values must be adjusted by analyzing each factor. For example, in the case of Strength of the Management Team, if the company is considered to be equal to the best that currently exists in the market, it means that it meets the maximum value of the range (30%). In the case that the startup is considered to be 110% better than what exists in the market, the percentage assigned to that factor should be 33% or, in the opposite case, if it is compared to 80% of what exists in the market for this factor, the value should be 24%. Below is an example table for a StartUp X, where the average market value is 2 M.

Table 1. *Example StartUp X Scorecard valuation methodology.*

Factor	**Range**	**Startup X**	**Factor x Av. $ Market**
Strength of the Management Team	30%	110%	(0.3 x 1.1) x 2M = 0.66 M
Size of the Opportunity	25%	80%	(0.25 x 0.8) x 2M = 0.4 M
Product/Technology	15%	100%	(0.15 x 1) x 2M = 0.3 M
Competitive Environment	10%	90%	(0.1 x 0.9) x 2M = 0.18 M
Marketing/Partnerships	10%	50%	(0.1 x 0.5) x 2M = 0.1M
Need for Additional Investment	5%	100%	(0.05 x 1) x 2M = 0.1 M
Others	5%	100%	(0.05 x 1) x 2M = 0.1 M
TOTAL	**100%**		**$1.84 M**

This method compares each of the new company's risk factors to estimate a market value compared to what exists in the market. The example in the table is only illustrative and uses random values, but it demonstrates the procedure for valuing a company in early stages.

The scenario here is similar to the situation with Berkus Method, except that here a different importance is assigned to each of the factors, with technology being usually the third most important and normally accounting for up to 15% of the startup's total value. As previously mentioned, the product and technology are highly relevant, therefore having the ability to develop a more in-depth examination is valuable. The proposal of this research takes on great relevance when considering that it can serve as a complementary in-depth analysis for current methodologies, filling methodological gaps and therefore removing subjectivity.

4.1.3 PESTEL Analysis

PESTEL analysis is a tool used to identify external forces at a macro level that influence a business and can determine its evolution. The acronym PESTEL refers to the factors that are analyzed: Political, Economic, Social, Technological, Ecological and Legal. Therefore, PESTEL analysis is a market study only of external factors that affect a company (ESERP, 2022). Studying this analysis can be interesting, as PESTEL is applicable to any business, including startups, so it is particularly valuable for investors who need to understand how these external factors can influence the startup, especially those that may be directly related to its technological aspects.

The tool consists of analyzing in detail the different factors that could affect the company, in addition to knowing the context in which it is located. According to what was proposed by the Washington State University (2024) the following factors must be analyzed as follows:

- **Political factors** involve government policies, leadership changes, foreign trade agreements, domestic political trends, tax regulations, and shifts in the level of regulation or deregulation.

- **Economic factors** take into account the current and expected economic growth, inflation, interest rates, employment and unemployment trends, labor costs, globalization's impact, disposable income for both consumers and businesses, and anticipated economic shifts.
- **Social factors** include demographic aspects such as age, gender, race, and family size, along with consumer behaviors, population growth, employment trends, sociocultural shifts, and religious or ethnic influences.
- **Technological factors** impact industries by introducing new methods for producing and distributing goods and services, as well as innovations in how businesses communicate with their target markets.
- **Environmental factors** are increasingly significant due to concerns about raw material scarcity, pollution reduction, sustainability, and carbon footprint goals.
- **Legal factors** encompass laws related to health and safety, equal opportunities, advertising, consumer protection, product labeling, and overall product safety.

Considering the factors of the PESTEL tool, both legal and political factors play a crucial role within the evaluation of technology. These factors consider the laws, regulations and policies that govern a startup's environment, as well as the certifications required to validate products or services.

Both **legislation and regulations** are widely important for startups, as they define in some way the boundaries within which the company must operate. Compliance with existing regulations ensures that the technology adheres to safety standards, ethical guidelines and industry-specific requirements. For example, startups in the biotechnology sector must comply with strict regulatory frameworks to ensure that their innovations do not pose risks to public health or the environment. Failure to comply with these requirements can result in legal sanctions, restrictions or even suspension of operations, which makes this highly relevant for investors and makes it necessary for startups to integrate compliance into their medium- or long-term strategic planning.

On the other hand, **certifications** serve as a testament to a startup’s commitment to quality and compliance. Obtaining certifications such as ISO standards or other industry-specific approvals not only enhances the credibility of the technology but also increases its marketability. Investors often consider the presence of relevant certifications as a critical factor in their decision-making process as it reduces the perceived risk associated with the investment and proves that the technology meets established performance and security parameters.

The inclusion of **environmental factors** in the PESTEL analysis underscores the growing importance of sustainability in the evaluation of technological startups. In recent years, there has been a significant shift towards environmentally responsible practices, driven by both consumer demand and regulatory pressures. While investors mostly prioritize expected returns over positive impact on the environment, more and more investors or accelerators are prioritizing sustainability, as is the case of EIT Climate-KIC, a leading climate innovation accelerator in Europe, where entrepreneurs receive first-class coaching, training and financial support to professionalize and scale their innovation (EIT Climate-KIC, 2018). Furthermore, in the case where investors find two startups similar in their value proposition, the investor will lean towards the startup that incorporate sustainable practices into their operations and product (such as the use of non-toxic materials and waste reduction strategies), considering are more likely to gain a competitive edge in the market.

Sustainability is not only a legal and ethical obligation but also a strategic advantage. Technologies that minimize environmental impact align with the increasing global emphasis on sustainability and are often favored by investors who prioritize long-term value creation over short-term gains. In this context, the environmental sustainability of a technology can influences its adoption and scalability, as well as its ability to navigate future regulatory changes that may impose stricter environmental standards.

Security in its various dimensions is an important factor in the evaluation of technology, including cybersecurity, biosecurity, and data protection, among others. This comprehensive strategy guarantees that a business not only complies with legal requirements, but also safeguards its potential consumers' data and integrity.

Cybersecurity and data protection have emerged as crucial considerations in the digital age, with the potential to dramatically impact a technology startup's profitability. Companies must ensure that their technology and processes adhere to data protection rules, such as the General Data Protection Regulation (GDPR) in Europe and other comparable legislation in other areas. Failure to comply with these standards can result in severe fines and reputational harm.

Furthermore, a startup's capacity to preserve sensitive information and ensure the safety of its customers is an important consideration for investors. Security breaches may cause not just financial losses, but also erode consumer confidence and restrict development potential.

Although the evaluation of the sustainability and security of technology can often be measured through compliance with laws and regulations, some technologies are completely disruptive, and therefore arise from a completely unexplored environment that has not yet been regulated. This is why it is essential to analyze each of these components separately in the context of technological assessment.

4.2 Technology/product assessment frameworks

As explained by the valuation frameworks Scorecard and Dave Berkus Method, it is shown that technology is one of the key factors in determining the success of the start-up, which supports the importance of the present study. According to Van Wyk (2010), "modern portfolio managers find that in addition to the traditional elements of (i) doing the numbers, and (ii) scrutinizing management, they need to be able to assess the technological viability and resilience of the companies".

More and more investors are outsourcing product evaluation to technology experts, since, as mentioned in section 3, there have been many cases of failure in which a good business model is presented, a solution to a real problem, but the technology fails, either due to problems related to the feasibility of the technology, scaling problems or even because the team is not trained to develop it.

4.2.1 Technical Due Diligence

Technology due diligence, or technical due diligence, is the analysis of the technology products, architecture, and processes of an organization. It is an important type of due diligence in Mergers and Acquisitions (Ansarada, 2023). This practice is widely used in the evaluation of buildings and software-based technologies.

The main objective of this practice is to identify potential risks and assess the technological capability of the underlying technology. Early identification and detection are achieved through a deep analysis of the company's life cycle, or in the context of this report, of startups. At the end of the process, the team in charge of carrying out the TDD delivers a report to investors or stakeholders.

Usually, investors request a TDD before acquiring startups, this way they know what they are up against and understand the risks of emerging technology. According to McKinsey & Company findings, performing due diligence on the technology of study increases the likelihood of success by 2.8 times compared to not doing so (Zhuravlova, 2024).

Technical Due Diligence is not strictly a "methodology" in the traditional sense, such as a fixed framework or model with defined steps. Instead, it is a process or practice that is flexible and adaptable. Although the process does not establish a specific and universal checklist of the aspects to be evaluated or studied within the company, there is a recommended step-by-step guide to obtaining the information in accordance with what you want to study. For example, consulting firms such as Zartis (2023) carry out the following procedure for their TDD:

1.- Pre-Due Diligence Preparation: This first step consists of an internal audit, without yet involving external consultants. This step allows to gather the necessary documentation, prepare to answer questions, and establish the objectives and timelines of the process.

2.- Initial Technical Assessment: This stage consists of the general evaluation of the technology, involving a review of documentation, architecture, infrastructure, security, or the code base, as appropriate. Any bottlenecks, security vulnerabilities, or scalability issues are identified.

3.- Stakeholder Engagement: This step ensures the alignment of all stakeholders in the Technical Due Diligence (TDD) process. Technology leaders and developers provide details on architectural choices and technical challenges. Business analysts align technical components with business objectives and translate technical metrics into key performance indicators. Project managers adjust the schedule and budget based on TDD recommendations. This step includes in-person or remote meetings with stakeholders to review all technical components in detail.

4.- In-Depth Analysis and Validation: This stage involves detailed testing and audits. Performance and scalability tests are performed to validate the system's capabilities. A security audit identifies threats and vulnerabilities, protecting intellectual property and sensitive data. Regulatory compliance checks ensure that the technology complies with industry-specific regulations. It includes questioning sessions on conditions, operation, programming, and patents between the parties involved.

5.- Final Evaluation and Reporting: After reviewing and validating all components, a final Technical Due Diligence report is prepared. This comprehensive document covers each aspect evaluated, the findings, and the recommended actions. It serves as a basis for decision-making by investors, acquirers, or internal stakeholders, providing detailed and reliable information on the identified advantages and disadvantages.

The meticulous steps of Technical Due Diligence highlight its critical role in assessing technology during acquisitions, offering investors and founders valuable insights into potential challenges. However, while TDD is widely used and effective for understanding the technology landscape, it lacks a standardized framework and does not provide quantitative data on a startup's current state. This limitation underscores the need for a more structured approach, like the proposed framework, which aims to fill these gaps and standardize technology assessment practices.

4.2.2 The technology needs value level

The importance of analyzing this aspect lies in the fact that the success of a company depends on different intensities of technology. Many companies innovate in their business model or in their value proposition, using existing technologies to create something new, without necessarily being innovative in the technology itself. In these cases, if the technology fails, existing alternatives can be used. However, there are also situations where technology is the main source of innovation, as in the case of companies that develop advanced artificial intelligence solutions. In these cases, technology is crucial for the success of the company and its value proposition depends largely on it. It is in these scenarios where our new evaluation framework becomes more relevant, allowing a thorough and accurate evaluation of the underlying technology and its potential impact on the success of the startup.

Below are the 5 levels proposed by John C. Mankins (2009), in his paper "*Technology readiness and risk assessments: A new approach"*, which indicate how significant technology is for the success of the startup.

Technology Need Value	Weighting Factor	Description
TNV-1	40%	The technology effort is **not critical at this time** to the success of the program— the advances to be achieved are useful for some cost improvements; However, the information to be provided is not needed for management decisions until the far- term
TNV-2	60%	The technology effort is **useful** to the success of the program—the advances to be achieved would meaningfully improve cost and/or performance; However, the information to be provided is not needed for management decisions until the mid- to far- term
TNV-3	80%	The technology effort is **important** to the success of the program—the advances to be achieved are important for performance and/or cost objectives AND the information to be provided is needed for management decisions in the near- to mid- term
TNV-4	100%	The technology effort is **very important** to the success of the program; the advances to be achieved are enabling for cost goals and/or important for performance objectives AND the information to be provided would be highly valuable for near-term management decisions
TNV-5	120%	The technology effort is **critically important** to the success of the program at present—the performance advances to be achieved are enabling AND the information to be provided is essential for near-term management decisions

Figure 3. *Technology need values ("TNVs") - John C.Mankins*

Source: *Mankins, J. C. (2009). Technology readiness and risk assessments: A new approach.*

From this table we can understand that the implementation of the framework proposed in this thesis, "Approaches to Assess Startup: Focus on Technological Aspects," becomes essential, especially for startups where technology plays a critical role according to the levels (3 - 4 – 5) defined by John C. Mankins. This framework allows for a detailed assessment of how technology drives the value and competitive advantage of the company, ensuring that investors and stakeholders can properly understand and value its potential impact. Thus, the framework not only helps to identify opportunities, but also to mitigate the risks associated with technological dependence, providing a robust and strategic tool for decision-making in the startup ecosystem.

4.2.3 Technology Readiness Levels – TRL

Technology Readiness Levels (TRL) is a type of measurement proposed by NASA to understand the level of a technology project. This measurement is characterized by being adaptable for different types of projects and discipline-independent. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine technology readiness levels. TRL 1 is the lowest and TRL 9 is the highest (Manning, 2023).

Table 2. *TRL*

TRL 1	**Basic Principles observed and reported.** Scientific research is beginning, and those results are being translated into future research and development.
TRL 2	**Technology concept and/or application formulated.** Occurs once the basic principles have been studied and practical applications can be applied to those initial findings. Technology is very speculative, as there is little to no experimental proof of concept for the technology.
TRL 3	**Analytical and experimental critical function and/or characteristic proof of concept.** Generally analytical and laboratory studies are required at this level to see if a technology is viable and ready to proceed further through the development process.
TRL 4	**Component and/or breadboard validation in laboratory environment.** Multiple component pieces are tested with one another.
TRL 5	**Component and/or breadboard validation in relevant environment.** Simulations should be run in environments that are as close to realistic as possible.
TRL 6	**System/subsystem model or prototype demonstration in a relevant environment.**
TRL 7	**System prototype demonstration in a space environment.**
TRL 8	**Actual system completed and "flight qualified" through test and demonstration.** It's ready for implementation into an already existing technology or technology system.
TRL 9	**Actual system "flight proven" through successful mission operation.**

Source: *Manning, C. G. (2023). Technology readiness levels. NASA.*

In the 1970s, NASA developed this scale to evaluate how close a technology was to being ready for space testing. This classification system helped NASA establish the minimum requirements for each component's readiness for flight, thereby minimizing risks in future missions (Zabala, 2023). This scale can now be adapted to various types of disciplines, so the definition of each level must be tailored to each technology. Since its introduction to EU-funded projects in 2012, the TRL system has become the standard reference for assessing the maturity of research, its readiness for market adoption, and potential investments (European Commission, n.d.).

The TRL framework is widely used in research and innovation project management by managers, investors, and grant evaluators as a common tool for managing expectations and assessing the level of development of an innovation, as well as the associated risks (Futuro Perfecto, n.d.).

As a standardized framework, where the qualitative is brought to the quantitative, it is easy to compare technologies and make decisions. By allocating a standardized and internationally recognized TRL to a technology, researchers and businesses discussing collaboration or licensing of a technology can be on the same page from the start. The TRL provides an immediate overview of the current position of a technology and the level of future work required to bring it to market (Daley, 2023).

4.3 Quality Function deployment – HoQ

In general terms, QFD is a customer-focused methodology for the design and development of products and services. According to the ASI (1987, as cited in Franceschini, 2002), QFD is defined as:

> "A system for translating customer requirements into appropriate company requirements at every stage, from research through production design and development, to manufacture, distribution, installation and marketing, sales and services" (p. 22)

In other words, Quality Function Deployment (QFD) is a structured methodology for defining customer needs or requirements and translating them into design plans for producing products that meet those needs. The term "voice of the customer" is used to describe these stated and unstated customer needs or requirements. Customer input can be gathered through various methods, such as direct conversations or interviews, surveys, focus groups, customer specifications, observations, warranty data, and field reports, among others (Kiran, 2017).

According to what Franceschini (2002) proposed in his book, the QFD has 5 phases:

- Customer Requirements: Identification and definition of customer needs and expectations in qualitative terms.

- Product Planning Specifications: Conversion of customer needs into internal company design specifications, global and measurable product characteristics that must satisfy customer requirements.

- Part/Subsystem Planning Specifications: Translation of general system specifications into detailed technical specifications for subsystems or critical parts, ensuring the realization of the essential functions for which the product was designed.

- Process Planning Specifications: Determination of necessary operations for the manufacturing process, including investments in plants and machinery, and establishment of suitable manufacturing processes to achieve the desired part characteristics.

- Quality Control Specifications: Development of methods and procedures to monitor and control quality during production, ensuring that products and processes meet the established specifications.

The first matrix to be used in QFD is known as the house of quality (HoQ). “This matrix is used to perform the basic QFD process: the transition (based on an input-output strategy) from a list of customer requirements, the “what,” to a list of considerations about “how” the requirements will be met” (Franceschini, 2002, p.27)

The HoQ is built on the solid foundations that believe and propose that a product should be designed based on the customer's tastes and reflect what the customer wants (Hauser

& Clausing, 1988). This is why once the requirements are defined, the entire product team must work together closely to get as close as possible to what is expected of the product.

The construction of a house of quality consists of different steps, the stages filling the matrix step by step, creating relationships between the client's needs and the technical requirements and finally incorporating comparisons with the competitions. The steps for constructing the House of Quality (HoQ) matrix are based on the guidelines provided by Maisano (2012), which outlines the process in a structured and detailed manner:

1. Identification of customer needs:

- Customer needs are gathered through surveys, market analysis, or interviews and listed in the left column of the matrix.
- Then, each need is assigned a level of importance, on a scale from 1 to 5, and the percentage of importance is calculated.

2. Translation of customer needs into technical requirements:

- Customer needs are translated into technical requirements, which are placed at the top of the matrix.
- The relationship between each customer need and each technical requirement is evaluated using a relationship scale (high, medium, low) to complete the matrix.

3. Benchmarking based on perceived quality:

- Customers are asked to rate how well the current model and competitor models meet each customer need on a 1-to-5 scale.
- These values are entered in the "Current Model" and "Competitor #" columns, enabling direct comparison.

4. Target values of expectations:

- An "improvement ratio" is calculated by dividing the target performance level by the current model's performance level, indicating improvement priorities.
- The potential strengths of the product for an enhanced brand image are identified based on the company’s strategic policy:
    - **1.5** for a highly important strength,
    - **1.2** for a possible strength,
    - **1.0** for a characteristic not considered a strength.
- The "absolute weight" of each customer requirement is calculated as: **Absolute weight = degree of importance × improvement ratio × strength.**

5. Technical comparison and prioritization:

- For each technical characteristic, the "relationship values" are multiplied by the "relative importance" of the corresponding customer requirements, and the results are summed for each column.
- The technical characteristics that most impact customer satisfaction are identified. Additionally, another ranking can be generated by using the "relative weight" of the customer requirements instead of the “relative importance”, to consider both the importance of the customer requirements and the company’s strategic priorities.

6. Technical benchmarking and target values:

- Each technical characteristic is compared to the reference values used by competitors to assess competitiveness.
- Target values for each technical characteristic are defined based on their importance and the benchmarking process. Improving the quality characteristics that have the highest weight and those that perform poorly compared to competitors is a priority.

7. Correlations among technical characteristics:

- Two technical characteristics are correlated if changes in one affect the other. The sign (+ or -) indicates whether the relationship is positive or conflicting.

Below is how a HoQ matrix with filled values looks like:

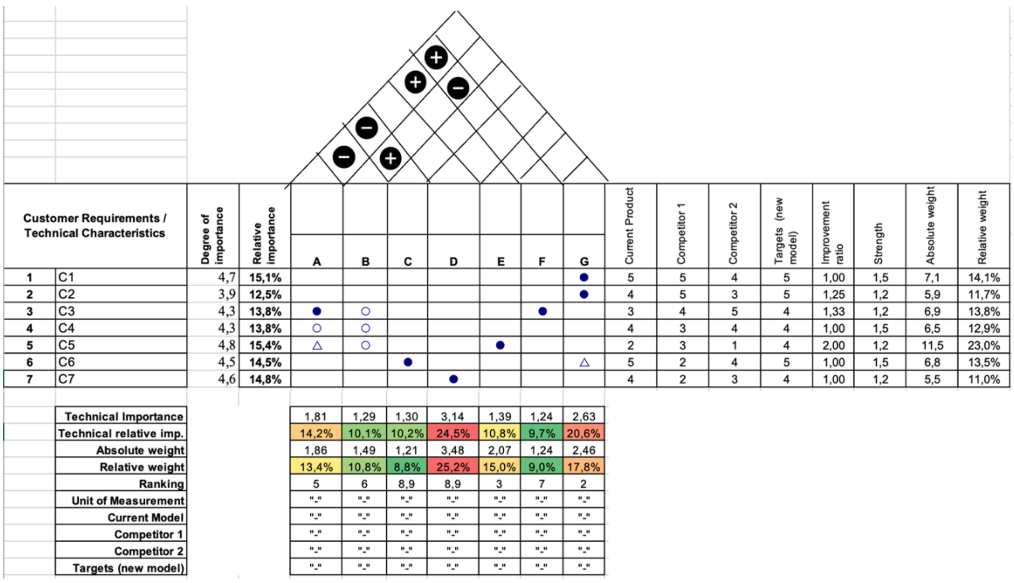

Figure 4. *HoQ example*

In conclusion, the House of Quality (HoQ) allows to translate the customer's needs into technical characteristics and to compare what the customer expects with what the company is developing. This comparison makes it easier to adjust the product design to improve its quality and better align it with market demands, creating more competitive products.

4.4 Comparative Analysis of Literature and Component Synthesis

4.4.1 Comparative Analysis of Methodologies

After extensively reviewing all current methodologies and practices related to the evaluation of startups and technologies, the advantages and disadvantages of each can be highlighted.

Table 3. *Advantages and disadvantages of current methodologies and frameworks*

Framework	Type	Advantages	Disadvantages
Scorecard & Berkus Method	Quantitative and qualitative	- Allows a more structured approach to startup valuation, simple and practical - Focuses on key risk factors, making it easier for investors to assess potential returns.	- Lacks depth in evaluating technological aspects. - Heavily reliant on subjective judgment.
PESTEL	Qualitative	- Comprehensive analysis of external factors (Political, Economic, Social, Technological, Environmental, Legal) that can impact a startup.	- Lacks focus on internal, technical aspects of the startup's technology. - Highly qualitative, making it difficult to quantify impact.
TDD	Qualitative	- Provides a detailed analysis of the technology, identifies potential risks and technological capability. - Widely used and recognized in acquisition processes.	- Does not establish a universal checklist. - Lack of specific quantitative data.
TNV	Quantitative	- Allows to evaluate the significance of technology for the startup's success. - Identifies when technology is critical to the value proposition.	- It has a general perspective, without detailed analysis of the technology.
TRL	Quantitative	- Standardized and internationally recognized framework. - Facilitates the comparison of technologies and decision making. - Adaptable to different types of projects.	- It focuses exclusively on technological maturity, not considering other critical aspects of technology.
HoQ	Quantitative	- Facilitates the translation of customer requirements into design features.	- It does not apply to investor requirements, only to customer requirements.

The analyses carried out through these frameworks allow us to extract the following positive aspects that will be highlighted and sought to be incorporated into the new evaluation framework proposed in this thesis:

- Detailed and exhaustive analysis: The TDD methodology provides a meticulous approach to identify risks and evaluate technological capacity. This level of detail is essential to ensure a complete and accurate evaluation. The greatest number of components must be incorporated for the evaluation.

- Standards and comparability: The use of TRL as a standardized framework allows technologies to be compared in terms of their maturity. This facilitates decision making and clear communication between different stakeholders.

- Evaluation of the significance of the technology: from the TNV approach, the importance of understanding how crucial the technology is for the startup's value proposition is highlighted. Incorporating levels of technological need will help to identify startups where technology is a key factor for success.

- Comprehensive impact assessment: From PESTEL Analysis, the importance of a comprehensive assessment that considers multiple dimensions of the business is rescued, thus ensuring a complete vision of the potential, the risks and how the product or service can impact the environment, from the point of view of other factors related to technology.

In summary, the new technology startup assessment framework proposed in this thesis is expected to integrate these positive aspects, seeking a balanced and comprehensive assessment. By combining the depth of TDD analysis, the standardization of TRL, the translation of requirements from HoQ, and the analysis of the technology context from PESTEL, it is expected to offer a robust and strategic tool that not only identifies opportunities for entrepreneurs, but also mitigates risks associated with technological dependency.

4.4.2 Component Identification in the Literature

In the line with the first research question: *What are the most critical technical components to assess when evaluating a technology startup?* It is possible to identify that each of the methods currently used contribute in some way to the separate evaluation of different technical components within the technology.

Table 4. *Evaluated technological components rescued from each methodology.*

Methodology	**Component to assess**
Scorecard Method and Dave Berkus Method	- The Team - Prototype - Technology
PESTEL Analysis	- Compliance with legal requirements - Compliance with certifications - Sustainability - Security
TDD	- Documentation - Infrastructure - Scalability - Patent - Code defect density - Software (Speed, quality) - Cybersecurity - Product Quality - UX * These components are not standardized for all the TDD, but are mentioned in various articles as well as those considered by different consultancies.
TNV	- Technology dependency for business
TRL	- Maturity of the technology

Each of these components will be analyzed, regrouped and validated through empirical research based on the Delphi method, which is detailed in section 5. From this process, a final list of components will be proposed that covers all critical evaluation points considered essential by investors.

4.4.3 Strategies for measures investors requirements – HoQ

Beyond identifying these components, it is crucial to address the second research question: *How can these components be effectively quantified and compared?* Given the conclusions drawn from the literature and expert insights, the framework must be **quantifiable, standardized, and adaptable** to any type of technology.

The current literature presents the House of Quality (HoQ) matrix, a proven methodology for translating customer requirements into quantifiable product specifications. This approach has been widely successful in various industries due to its ability to systematize and prioritize needs, ensuring that product development is closely aligned with customer expectations.

The proposed solution involves adapting the HoQ framework, traditionally used for translating the "voice of the customer" into product specifications, to instead capture the "voice of the investors". This innovative adaptation is particularly appropriate because HoQ's structured and quantifiable nature makes it well-suited for addressing the complexities of technology assessment in startups. In turn, it will allow us to identify which technical requirements of the technology are most relevant in a mergers and acquisitions process. By leveraging an already established and reliable methodology, the adapted HoQ framework will facilitate the systematic quantification and comparison of critical technical components, ensuring a rigorous and standardized evaluation process. This approach not only provides a structured tool that aligns with the needs of investors but also ensures that the evaluation is flexible enough to be applied across various types of technologies.

The challenge of this approach will be to determine if it is indeed possible to translate the voices of investors into technical requirements tied to technology and investment decisions, that can be evaluated and measured. In turn, each of the sections of the matrix must be adapted to be applicable to the investment context. If successful, this will provide a clear advantage in making informed investment decisions, thereby reducing the uncertainty and risk associated with the innovative but intangible nature of new technologies.

5. Empirical research approach

This section presents and analyses the data from the empirical research conducted in this thesis. The Delphi method was chosen, a structured approach to expert consultation that allows consensus to be reached through successive rounds. In the first round, data were collected through interviews with experts to obtain information from different study groups. The second round involved a validation of the findings through an online survey. The findings are presented and analyzed in the following subsections, offering a deeper and more practical understanding of the research topics.

5.1 Delphi Method Round 1: Results of the interviews

5.1.1 Overview of data collection through interviews

To gain a comprehensive understanding of technological evaluation in startups, interviews were conducted with four study groups, which were defined and justified in Section 2 of this thesis. A total of 11 participants were interviewed, with the distribution of participants across categories as follows:

Table 5. *Study group distribution and its characteristics*

Groups	Description	Q
Investors in Technology Startups	Angel investors, crowdfunding platform founders and members of accelerators specializing in technology startups.	3
Technological Startup Entrepreneurs	Entrepreneurs who develop technology (biotechnology, software and artificial intelligence models)	4
Consultants or Experts in Innovation and Technology	Professionals who advise startups on technological development or innovation strategies. Also consider mentors in incubators and innovation programs.	2
Academics with Specialization in Innovation and Technology	Researchers who have published works on technological entrepreneurship or professors of technological innovation courses.	2
	TOTAL	11

Participants were selected based on their experience and relevance in the fields of technology and innovation. Prior to the interviews, open-ended questions were designed for each study group to capture a wide range of perspectives. These questions focused on technological evaluation, key criteria, challenges, and gaps in existing methods. During the interviews, the questions were adjusted according to the interviewee's profile to gather more valuable insights. The following parameters were obtained from the interviews:

Table 6. *Interview parameters*

Interview methodology	Virtual
Budgeted time per interview	15-20 minutes
Average real time per interview	16.6 minutes

The interviews were transcribed and analyzed qualitatively, identifying recurring themes and key patterns through thematic analysis. This analysis allowed to highlight relevant quotes and categorize the findings according to their importance and relevance in the context of the study, which are detailed in the following sections.

5.1.2 Key findings from Interviews

During the interviews conducted with entrepreneurs, investors and experts, several key themes emerged that offer a comprehensive view of technology assessment in startups. These themes have been grouped under the following headings, each accompanied by the most relevant quotes that reflect the findings, in alignment with the objectives of this thesis.

Importance of Technology Assessment

This research interviewed people from various technology areas to gain a broad view on when and how technology assessment should be conducted. Each interviewee provided a unique perspective on the relevance of technology assessment, reflecting their particular environment and relationship to technology.

One central aspect that was highlighted is that while many startups are technology-based, not all of them base their value proposition on technology itself. This point is crucial and connects to what was discussed in point 4.2.2 on "Technology Need Value." Depending on the product, technology can be the core of the business or simply a platform on which the value proposition is built. For example, one food biotechnology entrepreneur highlighted:

"In biotechnology, technology is the core, and the great value is in the intellectual property that can be created around it. The value of the company is linked to the quantity and quality of patents that the technology has."

This focus on intellectual property as the core of business value underscores the importance of rigorous technology assessment when innovation on it is the primary driver of the business. In contrast, another entrepreneur working on a training videogame platform shared:

"Our platform relies on existing technologies to develop this new training proposal. When you want to launch a new value proposition, you have two alternatives: you can develop your new technology from scratch, or you can rely and lean on existing technology to build something new based on it.

Here, technology is seen more as a tool to implement the business model, which leads to a lower priority in creating technological innovation from scratch. Even though both entrepreneurs operate in very different technological sectors, they agree that it is essential to distinguish the type of innovation that is being generated. This difference is deepened by the observation of an investor who mentioned:

"When technology is what allows the business to be channeled, we do not worry so much about this. If technology is the CORE of the business, we use the opinion of experts to analyze in detail what is proposed, before deciding if the proposal/startup can enter the investment round."

On the other hand, a coach from an incubator contrasted:

"In the case of software, you have to evaluate where the value proposition is, is it in the business model or is it in the technology itself? …OpenIA developed innovation based on new technology. But whoever makes a payment gateway, put together and applied a couple of things and there is not much innovation there."

This quote reinforces the idea that technology assessment is crucial in startups where technology is the core of the business, and less relevant in those where the value lies in other aspects such as the business model or the value proposition. In addition, the connection between technology and the product was another topic highlighted by those interviewed. A software entrepreneur underlined:

"Investors in many cases care more about business aspects, not so much about technology. But as an entrepreneur, I have always thought that they should take time to understand it because it is the product. ...If you don't have a product that is not effective or efficient, there is no company that works."

Here it is highlighted that, regardless of the focus of the business, understanding and evaluating the underlying technology is essential to ensure that the final product is effective and meets market expectations.

It was agreed that those people who considered the evaluation of the technology less relevant were inserted in an ecosystem where the innovation of the proposal lay in the business model and not in the technology itself. In sectors where technological innovation is the key, such as biotechnology, intellectual property and technical validation are critical elements. On the other hand, in sectors where technology is a means to implement a business model, technological assessment may play a secondary role, although it remains essential to ensure the effectiveness of the final product. These perspectives reinforce the need to adapt the technological assessment approach according to the nature of the startup and its value proposition.

Outsourcing Technology Assessment

One of the recurring themes that emerged during interviews is the tendency of investors to outsource technology assessment in startups. This is because, in many cases, investors do not have the technical expertise to understand and assess the technology themselves. One food biotech entrepreneur observed that:

"Most investors are not experts in biotechnology, so they are always looking for someone to assess from a technical standpoint, whether what is being proposed is actually possible."

This phenomenon is not limited to biotechnology. Investors, in general, seek to understand the underlying technology in startups, but often lack the technical skill to do so. As a result, they turn to third parties to perform this assessment, as another entrepreneur noted:

"Investors want to understand our technology, unfortunately many times they cannot understand it and they look for third parties to assess it."

Delegating technological assessment is also a common practice on crowdfunding platforms, where the viability of a startup can determine its success in raising funds. However, this external assessment does not always entail an additional cost for investors or platforms, as one CEO of a crowdfunding platform commented:

"We do not pay experts to perform due diligence, because it may happen that the startup does not enter the investment round and ultimately does not get funded. That is why we consult with well-known experts who are willing to support, since they do not want to damage the reputation of the different technological areas."

This approach allows investors and platforms to mitigate risks without incurring high assessment costs, using their network of contacts to obtain reliable assessments. Finally, incubators and accelerators also adopt this practice to compensate for the lack of internal technical expertise. As one interviewee explained:

"Although as accelerators we may not be experts in certain areas, we always try to leverage evidence from someone, whether it is academic support… if the idea comes from an institution or university, or from patents. We have a network of people who are experts in different subjects, and we consult with them."

This trend reflects the importance of technological evaluation in the investment process, and how actors in the entrepreneurial ecosystem seek strategies to ensure that informed decisions are made, even when they do not have the necessary technical experience.

Investor Requirements

During the interviews, different approaches emerged regarding the critical components that investors require before deciding to invest in a startup. Among them, the validation of the technology, its scaling strategy and the intellectual protection of the product were the most considered and named.

Nearly x% of the interviewees spoke about the importance of the validation of the technology. Below are clear quotes of these intentions:

"... generally, empirical bases are sought, that is, to demonstrate and validate through experiments or tests that this is possible."

"We get a lot of startups with some degree of validation... whether it is a paper or something else. Generally, the order is first the research and then comes the idea of selling it."

On the other hand, the CEO of a crowdfunding company told us the following:

"Many companies that are not well validated do not enter the world of crowdfunding, because they must go public to tell what they do, given that they are publicly exposed to scrutiny. Crowdfunding tends to discourage those who are not technologically savvy."
These quotes can be used to testify to the great importance that technology validation has for investors. This validation is often accompanied by the protection of intellectual property.

"I have seen in our company and others that investors worry about whether there are patents or whether there is a future intellectual property strategy... Therefore, the team that is capable of executing the technological development becomes very important." - *Diego*

"If there is a patent, we already know that the product is validated."- Federico

Nearly 73% of those surveyed consider that in order to invest in a science-based venture, it must be able to be protected intellectually to a certain degree. On the other hand, there were entrepreneurs who considered that their proposals could not be protected by patents, but were protected from competition through an innovative business model.

Cases of failure

During the interviews, participants were asked about their knowledge of startups that failed due to technological problems. 91% of the interviewees agreed that they knew of companies that failed due to not meeting the necessary technological requirements. The main factors identified were a lack of technological maturity, insufficient validation, challenges in scalability, and the inability of the founding team to develop the technology effectively.

While many of the investors are not afraid of risk, a percentage of them took into consideration the stage of maturity of the idea to avoid eventual failure. For example, the CPO of a crowdfunding platform shared his experience with startups that, despite raising funds, failed due to their technological immaturity:

"We have had a company fail, but generally it was when we invested in less mature startups... after that we stopped investing in companies in the idea phase."

This approach of prioritizing startups with greater technological maturity and validation has become essential to reduce the risk of failure. An entrepreneur recalled a case in the agricultural sector, where the company was unable to overcome the challenges of scalability:

"I know many cases where the business has failed due to problems with technology… the first one that comes to mind is… a company inserted in the agricultural world, where many viruses are present, these guys wanted to control pathogens and had problems scaling. Taking it to the market was very expensive. Finally they had to close"

This case is closely related to what was mentioned by two other interviewees, who shared opinions, pointing out the differences between working in a controlled environment and scaling the technology to industrial levels:

"The Petri dish is very different from doing it on an industrial scale, this is a risk factor to consider. The question is always how to go from doing it by hand in a laboratory, in a super-controlled environment, to taking it to mass production."

"One of the great shortcomings of many technological bioentrepreneurs is that they do things thinking only about the laboratory and they forget about scaling, how to take it to large volumes and how those large volumes are economically possible. Is it possible to bring this to an industrial level?"

These comments reflect the critical need to consider scalability and economic viability from the early stages of technological development to avoid later failures in the market.

5.1.3 Common themes and patterns

When thematically analyzing the interviews, several recurring themes and patterns emerged, reflecting the complexity and diversity of approaches in the technological evaluation of startups. Below, the most prominent themes, the patterns identified, and a conclusion for each of them are summarized.

a) Types of Innovation in Value Proposition

Recurrent theme: The interviews clarified the importance of distinguishing between two types of innovation in a value proposition.

1. **Value proposition based on new technology**: This type of innovation centers on the development or application of a new technology that directly drives the value of the product or service. The success of the startup often hinges on the uniqueness and effectiveness of this technology.
2. **Value proposition based on a business model**: Here, the innovation lies not in the technology itself but in the business model—how the product or service is

delivered, monetized, or scaled. The technology is an enabler rather than the core of the value proposition.

Identified pattern: Investors consider the type of value proposition to determine which components should be evaluated during the due diligence process. For technology-driven innovations, the focus may be on patentability, technological feasibility, and scalability. For business model-driven innovations, the emphasis might shift to market fit, operational scalability, and compliance.

Conclusion: In both cases, technology serves as the means to deliver a product or service. However, the key difference lies in how the technology is leveraged—either as the core innovation itself or as a tool that supports a novel business model. Understanding this distinction is crucial for accurately assessing the value and potential of a startup.

b) Delegation of technological evaluation to third parties

Recurrent theme: The outsourcing of technological evaluation is a common practice among investors, grant funds, and crowdfunding platforms. Due to a lack of technical expertise, investors often rely on external experts to assess the technological viability of startups.

Identified pattern: This practice is driven by the need to mitigate risks and ensure that the technology meets necessary standards, without incurring the high costs associated with in-depth due diligence.

Conclusion: Given that investors are typically not technology experts, it is crucial to develop a user-friendly framework that bridges the gap between them and the technical requirements.

c) Essential Components Required by Investors

Recurrent theme: Several key components consistently emerged as priorities for investors when evaluating startups. These elements are seen as crucial for minimizing risk and ensuring the potential success of the technology.

Identified pattern: Investors tend to focus on the following areas:

- **Scalability**: The ability of the technology to scale economically and feasibly is critical. Both investors and entrepreneurs emphasized the importance of technology that can scale, not just in terms of technical feasibility but also economic viability. The potential for growth is a major determinant of a startup's long-term success.

- **Validation**: Proof that the technology works, or will work, is the primary requirement. This is often the first requirement, serving as the foundation for further evaluation.
- **Documentation**: Comprehensive documentation is necessary to facilitate validation and understanding of the technology.
- **Level of innovation**: Investors look for unique technologies that offer a competitive edge.
- **Intellectual property protection**: Existing or pending patents provide confidence in the technology's protectability.
- **Maturity**: The stage of development of the technology helps assess risk. More mature technologies are often seen as less risky, as they have undergone more extensive testing and development.
- **Technical team**: The expertise and capability of the team are crucial in executing and scaling the technology. A strong team can significantly reduce the perceived risks associated with the technology.
- **Compliance with certifications**: In certain cases, compliance with certifications is essential to go to market, as is sometimes the case with biotechnology or health-related technologies. Compliance with certifications is an attraction for investors looking for technology that is safe.

Conclusion: These components collectively help investors assess the feasibility, risks, and potential of a startup's technology. A strong emphasis on these areas can significantly enhance a startup's attractiveness to investors.

5.1.4 Comparison with Literature Review

This section compares the findings obtained from the interviews with the theoretical review presented in previous chapters. The aim is to identify similarities, areas where empirical findings provide new insights and a compilation of the components.

Similarities:

- The depth of the technology assessment is directly related to the role that technology plays within a startup. In projects where technology is the core of the business, the assessment should be thorough. In contrast, in startups where technology is a tool to implement a business model, the assessment can be less critical, focusing on aspects such as scalability, data protection, and legal compliance. This aligns with John C. Mankins' "Technology Need Value" framework, which assesses how crucial technology is to business success.

- The literature on due diligence does not offer a detailed and standardized checklist for assessing technology, but rather a general methodology on the processes and steps to follow. However, some studies highlight key components that need to be assessed, such as scalability, documentation quality, technological validation and patent analysis, etc. These aspects coincide with the findings obtained from the interviews.

- Maturity is a key component in technology evaluation, as supported by the literature through frameworks like Technology Readiness Levels (TRL). Maturity indicates the developmental stage of the technology. Both the literature and interview findings highlight that some investors prefer to invest in more mature technologies to reduce risk. Conversely, other investors are drawn to less mature, emerging technologies, seeing potential for higher returns as the technology and startup grow. This aligns with the strategic balance between risk and reward identified in both sources and testifies to the importance investors place on this component when evaluating technology.

New perspectives:

One significant new insight that emerged from the interviews is the widespread practice of delegating the technology analysis to third parties. While it is well-known that expert consulting firms are often hired to conduct due diligence, the extent to which investors rely on these third parties was unexpected. This finding suggests that many investors, particularly those without a technical background, prefer to outsource the technology evaluation to specialized firms to ensure a thorough and unbiased assessment.

After having evaluated the similarities, the new perspectives with the literature and the identified patterns, the results on the components can be summarized in the table below. Among the components identified in the interviews, the vast majority of them are validated by the literature review.

Table 7. *Components identified in the literature and interviews*

Literature Review	Both	Interviews
- Compliance with legal requirements - Sustainability - Security - Documentation - Infrastructure - Code defect density - Software (Speed, quality) - Cybersecurity - Product Quality -UX	- Compliance with certifications - Prototype - Technical team - Intelectual property protection (Patent) - Maturity of the technology - Scalability - Documentation	- Level of innovation - Validation

In summary, the process of discarding components specific to certain technologies and regrouping them under broader categories led to the identification of 15 key components. These components will now move forward to the second round of validation using the Delphi method. To facilitate this, each respondent receives a detailed summary of the conclusions, including descriptions and examples for each of the components identified: **Documentation, Compliance with certifications, Compliance with legal requirements, Viability, Validation, Prototype, Level of innovation, Difficulty to replicate, Intellectual property, Security, Technological infrastructure (Hardware/Software), Interoperability, Technical team, Maturity, Scalability, and Sustainability. This refined list will serve as the foundation for the next phase of evaluation.**

5.2 Delphi Method Round 2: Results of the questionnaires

After identifying key parameters through expert interviews and comparing them with existing literature, a thematic analysis was carried out to determine which components were most relevant or in demand by investors. As a result of this process, a total of 15 critical components were identified.

Based on these findings, participants from the first round were invited to continue with the second phase of the research. Experts were provided with a summary of the identified components, accompanied by a brief explanation of the methodology used to select the components based on contributions from other experts and support from the relevant literature. In addition, they were provided with a brief description of each of the 15 components, including illustrative examples to facilitate their understanding.

The survey was divided into **three sections**:

- The first part focused on identifying the profile of the expert around innovation, classifying them as entrepreneur, investor, academic, mentor, consultant or other.
- The second part was dedicated to the evaluation of each of the 15 components previously identified.
- The third part was dedicated to the regrouping and ordering of the components.

5.2.1 Overview of data collection and survey design

The first part of the questionnaire consisted of a question designed to identify the type of expert and their relationship with the innovation area. Respondents were asked to select their role from the options of investor, entrepreneur, consultant, mentor, academic or other. The objective of this classification was to allow the identification of possible differences in the responses according to the different roles occupied by the experts.

The second section was intended to validate the components presented and qualify their relevance. The validation of these components was carried out using a survey designed specifically for this purpose. In the survey, participants were presented with a scenario in which a new disruptive technology had been developed that required thorough evaluation. They were asked to assign a value or relevance to each of the 15 components using a scale from 1 to 5, where 1 represented “not at all relevant” and 5 “very relevant”. This approach allowed quantitative data to be collected on the perceived importance of each component from the experts' perspective. At the end of this section, an additional question was included allowing experts to indicate whether they considered that any relevant component had been omitted in the first phase of the research. They were given the opportunity to add that component and provide any additional comments.

The main objective of this section of the questionnaire was to reach a consensus on the relevance of investor requirements. It was assumed that deviation in results could be significant, as the importance of requirements would vary depending on the specific technology being assessed. To address this potential variability, respondents were asked to place their responses in the context of a completely new technology in the technology area they were most familiar with (biotechnology, software, artificial intelligence, renewable energy, etc.).

This approach allowed for capturing differences in the relevance of components depending on the technology in question, providing more detailed insight into those components that might not be relevant to certain technologies. Such results might indicate that some components are not easily adaptable to all technology areas and might also be specific to certain technologies. This suggests the need for further analysis, as it might be necessary to regroup these components under broader categories covering all technology areas, thus ensuring that the assessment framework is sufficiently flexible and applicable to diverse innovations.

The last part of the questionnaire focused on the possible regrouping of components. The experts were asked to indicate whether they felt that any of the components could be adequately covered within another. The aim of this section was to obtain support and suggestions before making decisions on regrouping. This regrouping was mainly done to assess the clarity of the components presented and to adjust them to a more coherent and understandable proposal. Each case was assessed individually to ensure that any regrouping was well-founded and free of bias, considering the different experiences of the interviewees.

5.2.2 Quantitative analysis of component relevance

In this section, the results obtained from the section of the questionnaire intended to quantitatively assess the relevance of the 15 components previously identified will be analyzed. The experts were asked to classify each component on a scale of 1 to 5, where 1 represented "not at all relevant" and 5 "very relevant.

The quantitative analysis was carried out by calculating the means, standard deviations and distributions of the responses, which allowed identifying patterns and trends in the assessment of the components. From these results, the level of consensus among the experts was evaluated, as well as the possible differences in the assigned relevance. This analysis was key to identifying the highest priority components and those that could vary depending on the technology, which allowed adjusting the evaluation framework so that it was flexible and adaptable to different technological areas.

Table 8. *Statistics of the components in the survey.*

Component	Average Relevance	Standard Deviation	(≥3): % Respondents
Documentation	4.1	1.17	89%
Comp. with certifications	2.8	1.36	67%
Comp. with legal requirements	4.3	0.87	100%
Validation	4.3	0.5	100%
Prototype	4.2	0.83	100%
Level of innovation	3.7	0.97	89%
Difficulty to replicate	4	0.87	100%
Intellectual property	3.6	0.88	89%
Security	3.6	0.73	100%
Technological infrastructure	3.3	0.87	89%
Interoperability	3.1	1.17	78%
Technical team	4.3	1	89%
Maturity	3.6	1.01	89%
Scalability	4.6	1.01	89%
Sustainability	4	0.71	100%

A criterion was established to consider a component of high relevance, which requires that more than 80% of respondents rate it with a relevance between 3 and 5, and that the standard deviation is less than 1.2, which would indicate a consensus among the participants. When applying this criterion, the components Compliance with certifications (67%) and Interoperability (78%) did not reach the 80% threshold, suggesting that they are not perceived as highly relevant by the majority of experts. In addition, these components presented greater variability in the responses, with standard deviations of 1.36 and 1.17 respectively, which reinforces the idea that their relevance depends more on the specific context of each technology or industry.

However, those components that did not meet the 80% threshold should be re-evaluated based on the information provided in the last part of the questionnaire, where respondents had the opportunity to suggest regroupings or adjustments. This feedback will allow us to analyse whether some of these components can be combined with others or whether they require a specific approach depending on the type of technology being assessed. For example, Compliance with certifications could be more relevant in highly regulated sectors, such as biotechnology, and less so in others, justifying its possible regrouping within a broader component such as Compliance with legal requirements.

On the other hand, when evaluating the components with the highest relevance according to the average of responses, several key elements stand out. Scalability is the highest-rated component, with an average of 4.6, indicating that respondents consider it crucial for the success of a technology, especially in terms of its ability to grow and adapt to new demands. Other components with high relevance include Validation, Technical team, and Compliance with legal requirements, all with averages of 4.3, reflecting the importance of having a solid technical team, complying with legal requirements, and having a technology validated before launching on the market.

It is relevant to highlight that the Validation and Sustainability components present the lowest standard deviations, with 0.5 and 0.71 respectively, which demonstrates a strong agreement among experts about the high relevance of these components, regardless of the type of technology evaluated. This solid consensus reinforces the idea that both are crucial components in any technology assessment process, being essential both to ensure that the technology works and to guarantee its long-term sustainability.

The results of the quantitative analysis also show that no component was rated by a high percentage of respondents with scores of 1 or 2, indicating that there was no significant consensus on the low relevance of any component. Furthermore, no small standard deviation was observed in these cases that would suggest a large consensus on the low relevance of the components. This suggests that, although some components showed variability in their assessment, there was no widespread perception that any of them were completely unimportant in the technology assessment process.

In summary, the components with the highest relevance according to the averages are Scalability, Validation, Technical team, and Compliance with legal requirements, all of them with a high consensus among respondents, as reflected by their low standard deviations. On the other hand, the components that did not reach the 80% threshold will be re-evaluated and adjusted based on the respondents' suggestions, which will allow refining the assessment framework to ensure its flexibility and applicability in different technological contexts.

5.2.3 Analysis of component regrouping

In this section of the questionnaire, experts were asked to assess whether any of the 15 components could be merged or covered within another, with the aim of improving the clarity and coherence of the assessment framework. The analysis at this stage focused on identifying possible redundancies between the components and assessing whether the suggested regrouping was suitable to simplify the framework without losing precision. Each suggestion was assessed individually, considering both the experts' experience and the applicability of the components to different technologies.

The first component to be assessed is the **prototype**, which demonstrated great relevance, with an average of **4.2** and **100%** of respondents assigning it a relevance score greater than 3. However, **44%** of experts suggested that this component could be integrated within the validation component. This suggestion is based on the fact that the prototype is a crucial stage of the technological development process and is part of the different types of validation that are carried out during this process. By validating the technology, the prototype allows its viability and functionality to be assessed before its final implementation, ensuring that it meets the established requirements. Although its great relevance allows it to be assessed as a single component, it was decided to regroup the

prototype component within **validation**, in order to simplify and clarify the evaluation framework.

The second component to be regrouped was **compliance with certifications**. Two interviewees pointed out that, when a technology is very disruptive, it can be extremely difficult to certify. In addition, 33% of respondents considered this component as "not relevant at all" (1) or "very little relevant" (2). On the other hand, some experts commented that the certification process requires large investments, so it is generally carried out after receiving funding, although this varies according to the type of technology.

Considering the opinions collected and the divisions reflected in the standard deviation, it is evident that for some interviewees compliance with certifications is relevant, while for others it is unimportant. This depends mainly on the type of technology, since, as noted in the interviews, not all innovations need certifications. However, in sectors such as biotechnology, certification takes on special relevance, being a minimum requirement to enter the market. Given the context and the observations of experts, it was decided to merge **compliance with certifications** with **compliance with legal requirements**, to simplify the framework and address both aspects under a single component.

5.3 Implication for the proposed framework

The results obtained in the two rounds of the Delphi method have direct implications for the development and refinement of the proposed evaluation framework for emerging technologies in startups. Based on the initial interviews and subsequent surveys, the key components that investors consider most relevant when evaluating technological viability were identified and validated.

The second round also allowed for the regrouping of some components, which contributed to simplifying and clarifying the framework without losing sight of critical aspects. Components such as the prototype were merged with validation, and compliance with certifications was integrated into compliance with legal requirements, which reduced redundancies and facilitated a more coherent and holistic evaluation.

An important finding was that a large part of the interviewees mentioned that investors, not being technology experts, often outsource the technical evaluation without following a clear or standardized evaluation framework. This fact underlines the need for a formal framework to guide the assessment process, ensuring that decisions are based on well-founded criteria and not entirely dependent on external assessments without a clear structure.

The process also revealed that some components may be more or less relevant depending on the nature of the technology and the sector, which underlines the need for the framework to be **flexible and adaptable** to different technological areas. The ability to adjust allows the framework to be useful for assessing both disruptive technologies facing certification difficulties and technologies in highly regulated sectors, such as biotechnology.

In summary, the implications for the proposed framework include a clearer structure, the reduction of redundancies, and the incorporation of flexible components that can be adapted to different technological contexts. This approach ensures that the proposed framework is both rigorous and adaptable, making it an effective tool for the assessment of emerging technologies in startups, giving investors a solid basis for making informed decisions.

6. Creation of the evaluation framework

In this section, the process of creating the evaluation framework for technology startups is presented, with a specific focus on the technological aspects that are critical to the success of these emerging companies. This framework has been designed based on the findings obtained in the literature review, the interviews conducted, and the adaptation of existing methodologies, such as the House of Quality (HoQ), to align with the "Voice of the Investors."

The proposed framework is based on the need to provide investors with a clear and structured tool to evaluate the technological viability of a startup and in turn give entrepreneurs a tool to understand what the main requirements of an investor are for investing in their product. This is particularly crucial in cases where technology is the main source of innovation, and the success of the startup depends on its development and scalability. The components of the framework are derived from the recurring themes and patterns identified in the interviews, explained in section 5, as well as from the theoretical frameworks reviewed in section 4.

Based on the established requirements, the framework must be standardized, measurable, and adaptable to any type of technology. A framework is proposed that translates investors' requirements into specific technical criteria for evaluation. It includes an adaptation of the House of Quality (HoQ), tailored specifically for investors and startups. This approach assigns relevance scores and assesses the presence of each component, enabling a quantitative evaluation of the various requirements, ensuring both clarity and precision in the assessment process.

6.1 Identification of essential components of the framework

The creation of the framework began with a thorough literature review and the integration of insights gained through interviews and surveys with industry experts. This process allowed us to answer the first key question of this research: **What are the most critical technical components to assess when analyzing a technology startup?**

From this analysis, 13 essential components were identified that are determinants for the success of a startup, especially in the early stages of investment. These components, which include factors such as documentation, security, scalability, intellectual property, and sustainability, emerged from both the theoretical review and empirical validations obtained in the interviews and surveys. Each of these elements was evaluated in terms of its relevance to technological viability and its impact on investor perception.

The methodology used to identify these components combined theory with practical perspectives from experts, ensuring that the proposed framework is solidly grounded in academic knowledge and market realities. This integration ensures that the framework is not only theoretically robust, but also practical and applicable in real contexts of evaluating technology startups. Furthermore, by combining theoretical perspectives with empirical evidence, the framework is adapted to both emerging and more established startups, thus expanding its relevance and applicability at various stages of business development.

The components identified reflect the requirements or “voices” of investors. This means that investors evaluate or request a detailed review of these components before making an investment decision. Below is a description of what each component refers to and why they are important to consider.

Scalability

Scalability refers to a technology's ability to handle increasing workloads or expand its capacity without compromising performance. For instance, a software platform that can easily add more users or process higher data volumes without major modifications is considered scalable.

Maturity

Maturity assesses how developed and stable the technology is, often measured using frameworks like Technology Readiness Levels (TRL). A more mature technology, such as a software product that has passed several stages of testing and refinement, is generally seen as lower risk for investors.

Sustainability

Sustainability evaluates whether the technology can operate in an environmentally and socially responsible manner. For example, a renewable energy startup that minimizes carbon emissions and uses sustainable materials would score high on sustainability.

Difficulty to Replicate

This refers to how easy or hard it is for competitors to replicate the technology. A highly complex, patented biotechnology that requires specialized knowledge and equipment would be difficult to replicate, giving the company a competitive edge.

Validation

Validation checks whether the technology has been proven to work as intended in real-world conditions. For example, a medical device that has passed clinical trials would be considered validated.

Interoperability

Interoperability measures how well the technology can integrate with other systems or platforms. A cloud software solution that easily integrates with existing enterprise systems, such as ERP or CRM software, would demonstrate strong interoperability.

Technological Infrastructure

This refers to the hardware and software framework supporting the technology. For example, a robust cloud infrastructure with high availability and security would be considered solid technological infrastructure for a SaaS startup.

Security

Security covers various aspects depending on the technology. It includes **cybersecurity** to protect against digital threats, **biosecurity** for safeguarding biological materials, and **physical security** to prevent unauthorized access to hardware. Each type of security is essential for ensuring the safe and reliable use of the technology in its respective field.

Level of Innovation

The level of innovation assesses how groundbreaking or unique the technology is. A company developing a novel AI algorithm for autonomous vehicles could be considered highly innovative.

Documentation

Documentation includes all the written materials that describe the technology, its use, and its development. High-quality, comprehensive documentation can facilitate the integration, maintenance, and scaling of a product, like detailed API documentation for a software tool.

Legal and Certification Compliance

This ensures the technology complies with legal standards and industry certifications. For example, a medical device company would need FDA approval or CE marking to legally operate in different markets.

Intellectual Property

Intellectual property covers patents, trademarks, and copyrights that protect the technology from being copied. A software startup with a patented algorithm for data encryption would have strong intellectual property protection.

Technical Team

The technical team refers to the developers, engineers, and experts responsible for building and maintaining the technology. A startup with an experienced team, including seasoned engineers and industry veterans, would be considered more likely to succeed.

6.2 Grouping of components

It was decided to group the components in order to have clearer and more organized information. This regrouping was obtained after the second round of the Delphi method, since interviewees commented that certain terms belonged to others. Much of the decisions made for regrouping are based on section 5.2.3. This grouping not only simplifies the analysis by reducing complexity, but also allows related or dependent components to be evaluated together, providing a more coherent and holistic view of each technological aspect.

On the other hand, thanks to Table 9, certain subcomponents that were mentioned in the literature and interviews can be identified and should not be forgotten. Unlike components, subcomponents can only belong to a certain technology group. In any case, it is worth reviewing each of the subcomponents to assess whether they belong or are related to the technology in question. By grouping conceptually similar components, the framework facilitates the identification of interdependencies and possible synergies, which can be crucial for a more accurate and effective evaluation.

Table 9. *Grouped components*

Viability & Scalability	Scalability	
	Maturity	
	Sustainability	
	Difficulty to replicate	
	Validation	Viability Proof of Concept, Prototype
	Interoperability	Retro-compatibility
Product	Technological Infrastructure	Quality of hardware, software, code, Defect density
	Security	Cyber-security, Data Security, OpSec, Bio-security
	Level of Innovation	
Compliance & Standards	Documentation	
	Legal and Certification Compliance	
	Intellectual Property	Patent, copyrights
	Technical Team	

This strategic grouping not only organizes the information in a more accessible way, but also facilitates the focus on the key relationships between components, which improves the clarity and precision of the evaluation process. It's important to note that this grouping doesn't mean certain components are excluded; rather, components are considered as part of a broader requirement. When analyzing these broader categories in more detail, the specific technical requirements, such as those previously identified separately, can be effectively addressed within the larger context. After identifying the essential components to be evaluated for the technology, the next step is to translate investors' requirements into clear and actionable technical specifications, which will be addressed in section 6.3.

6.3 Translate investor requirements into technical requirements

In this section, will be explore how the identified investor requirements—referred to as the "Voice of the Investors"—can be translated into specific technical requirements within the proposed framework. This translation is crucial as it ensures that the framework not only captures the expectations of investors but also provides actionable and measurable criteria for evaluating a startup's technological readiness.

Each component of the framework is associated with 1 or more technical requirements that vary depending on the technology and industry. By aligning these technical requirements with the broader goals outlined by investors, the framework remains both relevant and adaptable across different technological landscapes. Below is a table that illustrates how investor requirements can be translated into specific technical requirements, with examples provided for various components:

Table 10. *Translation table of investor requirements into technical requirements that a startup must meet.*

Component	Investor Requirement	Technical Requirement Example
Compliance with Regulations and Certifications	Ensures that the product adheres to legal regulations and industry standards	ISO 14001 (Environmental Management), CE Marking (European Union), FDA Approval (Medical Devices), GDPR (General Data Protection Regulation)
Scalability	Ability to scale operations as the market grows	Modular software architecture, Cloud infrastructure, Load balancing, Horizontal scaling capabilities
Intellectual Property	Protect the innovation from being replicated	Filing of patents, Trademark registration, Copyright protection, Maintenance of trade secrets
Technological Infrastructure	Ensure robust and reliable technical foundation	Use of enterprise-grade servers, Redundant networking, Backup and disaster recovery systems, Use of scalable cloud services
Maturity	Product readiness for market launch	Completion of beta testing, User feedback integration, Finalized user documentation, Production-ready deployment pipeline
Sustainability	Long-term viability of the product with minimal environmental impact	Use of renewable energy sources, Eco-friendly materials, Compliance with sustainability certifications (e.g., LEED, Energy Star)

The examples provided in the table 10 illustrate how investor requirements can be tailored into concrete technical criteria that are relevant to the specific technology being evaluated. This translation ensures that each component of the framework is not only assessed in line with investor expectations but also based on the practical realities and standards of the industry.

As startups operate in diverse industries with varying regulatory landscapes and technical demands, the ability of the framework to adapt these technical requirements to specific contexts is key to its effectiveness. For instance, while a startup developing cloud-based software solutions may focus on ensuring a robust technological infrastructure through the use of scalable cloud services and high-availability servers, a startup in the electric vehicle (EV) industry might prioritize the technological infrastructure required for battery management systems. This would include the development of advanced battery technologies, and the integration of these systems with vehicle powertrain components to optimize energy efficiency and range.

This adaptability also allows the framework to evolve alongside technological advancements and changing market conditions, ensuring its continued relevance. As new technologies emerge and investor priorities shift, the framework can be recalibrated to incorporate new technical requirements, maintaining its utility as a comprehensive evaluation tool.

6.4 Framework Requirements

As outlined in section 4 and 5 of this thesis, the proposed framework must meet the following established requirements:

- **Standardized**
- **Measurable/Quantitative**
- **Adaptable to any type of technology**

To achieve the objective of a **measurable** framework, the challenge lies in translating qualitative components into a quantitative measurement scale. To address this, the methodology applied in TRL (Technology Readiness Level) or TNV (Technological Need Value) was used as a reference, where a numerical scale defines a qualitative characteristic for each level. A 1 to 5 scale was adopted, where 1 represents no fulfillment of the component's characteristics, and 5 represents full compliance with the component. Below is an example of how the established scale works for the **Maturity** component. The complete table with definitions for each of the remaining components can be found in the Appendix 1.

Maturity

- **1**: Early-stage concept with minimal development.
- **2**: Partially developed with many features incomplete.
- **3**: Partially developed product with some functional features.
- **4**: Mostly developed product with few remaining issues.
- **5**: Fully developed, market-ready product with thorough testing.

This structured approach ensures that each component of the framework is evaluated consistently and objectively, facilitating a clearer assessment of the startup's technological readiness. By adopting this **standardized** measurement system, the framework not only allows for the precise quantification of qualitative aspects but also enhances comparability across different startups, providing a robust tool for decision-making in technology assessment by part of investors.

One of the key strengths of the proposed framework is its **adaptability**, which allows it to be effectively applied across a wide range of technologies and industries. The framework achieves this adaptability by structuring its evaluation around global components that are universally relevant to technological assessment. These global components, such as Compliance with Certifications, Maturity, and Scalability, provide a consistent foundation for evaluating any technology. However, the true flexibility of the framework lies in its ability to accommodate the specific technical requirements that vary from one technology to another.

For instance, within the Compliance with Certifications and regulations component, the framework recognizes that different technologies may require adherence to different standards. A technology developed for the healthcare sector may need to comply with stringent ISO standards for medical devices, while another technology in the renewable energy sector might need to meet specific environmental certifications. Meanwhile, some technologies, particularly in emerging fields, may not yet be subject to formal certification requirements. The framework's adaptability ensures that these varying needs are accounted for, allowing the assessment criteria to be tailored to the specific regulatory and technical context of each technology. This approach not only enhances the relevance and accuracy of the evaluation but also ensures that the framework remains useful and applicable across diverse technological landscapes.

In summary, the proposed framework meets the requirements of being standardized, measurable and adaptable, providing investors with a clear and objective tool to assess the technological viability of startups in various sectors. By establishing a quantitative methodology based on a scale of 1 to 5, a consistent and comparative assessment of critical components is guaranteed. Furthermore, the framework's ability to adapt to different technologies and regulatory contexts reinforces its utility in a dynamic business environment.

6.5 Final Framework: An adaptation of House of Quality for investors and startups

As mentioned above, the objective of the new framework is to rate and measure the situation of a startup in relation to its technology. To achieve this, the adaptation of a tool already validated in other contexts is proposed: the House of Quality (HoQ). While the matrix is used to translate customer needs into technical product specifications, it is possible to adapt this tool to address the expectations and requirements of investors. This structured adaptation will allow prioritizing and measuring these criteria in a quantitative way, facilitating investment decision-making based on objective data, ensuring that the framework meets the stated objectives. Below is a step-by-step guide to filling out the matrix, with its respective adaptations:

1. Define the investor requirements ("Voice of the Investors"):

- Start by identifying the main requirements or concerns of investors in relation to the startup's technology. These can include scalability, intellectual property, technological maturity, security, sustainability, among others.

- These requirements are placed in the first column of the HoQ matrix.

2. Identify the technical parameters ("Technical Requirements"):

- Next, the specific technical parameters that are directly related to each of the investor requirements are identified. For example, if one of the requirements is "validation", the technical requirement could be PoC or a prototype at a certain level of progress.

- These parameters are listed in the top row of the matrix.

3. Assign importance levels to the investor requirements:

- The investors or the evaluation team must assign the level of importance to each of the requirements (from 1 to 5). In this way, the most critical requirements will receive greater weight in the evaluation.

4. Establish relationships between investor requirements and technical parameters:

- The matrix must be filled out by assigning scores to determine how strong the relationship is between each investor requirement and the technical parameters. This is done using a scale (for example, 1, 3, 9), where 9 indicates a strong relationship and 1 a weak relationship.

- This section is key, as it shows which technical aspects have a more direct impact on investor requirements.

5. Compare the startup's technological capabilities:

- Introduce a column in the matrix that evaluates how the startup is positioned against its current technological capabilities. In addition, two columns will be entered, one to establish the value that investors want the technology to meet against those parameters and another column that calculates the capacity for internal improvement (Improvement Ratio). This ratio helps determine how much room for improvement exists in each investor requirement.

- This column will allow to identify the areas that require more attention or investment to achieve better technological performance.

6. Introduce the “Investment Appeal” column:

- The **Investment Appeal** column is filled in, which replaces the “Strength” column of the traditional HoQ. This column will measure the attractiveness of the startup for investors, evaluating how the technical parameters contribute to strengthening the startup's image and its strategic value for investors.

- The Investment Appeal will be determined based on how the startup can offer an attractive return, managing the technological risk efficiently. The scale to define the value will be the following:

- 1.5 for a highly important investment appeal.

- 1.2 for a potential investment appeal.

- 1.0 for a characteristic not considered relevant for the investment.

7. Calculate the “Absolute Weight” and comparison

- The absolute weight of each investor requirement is calculated as: **Absolute weight = degree of importance × improvement ratio × investment appeal.** Along with that, is possible to obtain the relative weight, which represents the relative percentage of the absolute weight.

- For each technical characteristic, the "relationship values" are multiplied by the "relative importance" of the corresponding investor requirements, and the results are summed for each column.

- The technical features that are most relevant to the investor are identified. In addition, another ranking can be generated using the “relative weight” of the investors' requirements instead of the “relative importance”, to consider both the importance of the investors' requirements and the strategic priorities related to the startup's technology.

This adaptation of the House of Quality (HoQ) allows investors to evaluate technology startups using a quantitative and structured methodology, which facilitates decision-making based on concrete data and reduces the risks associated with investing in innovation. At the same time, it provides entrepreneurs with a clear tool to focus their efforts on areas that will attract more investment. Thanks to this tool, each of the technical requirements can be evaluated in detail, identifying a ranking of relevance for investors, and the matrix also allows the ranking to be compared with the current technological situation of the startup.

Among the main adjustments made to the traditional HoQ, the elimination of the comparison with competitors is included, since in the context of startups and the protection of intellectual property it is difficult to obtain this data, and it does not take on greater relevance when the technology is very disruptive and does not have direct competitors. On the other hand, the "Strength" column was renamed "Investment Appeal”, evaluating how technological requirements become more relevant to the startup's image in the eyes of investors.

6.6 Practical example of the matrix

Below is a practical example to illustrate how investor requirements are identified and measured through the adapted matrix. It is important to note that this case is completely fictitious, and the values assigned are random for the sole purpose of clarifying the process. These values may change depending on the specific context in which the startup is located and the different preferences of each investor.

The hypothetical case is about a startup that has developed a battery for electric cars, notable for its ultra-fast charging and ease of recycling. The battery offers a significantly faster charging speed than those already on the market. In addition, it is designed so that the materials are easily recyclable, which reduces the environmental impact and costs associated with waste treatment, making it a very disruptive technology and highly attractive to investors.

For practical purposes, 9 components have been selected, which are translated into technical requirements as shown in table 11. After identifying the requirements, the matrix is filled with the defined values, which should look like figure 5. In this way, Technical relative importance can be compared with Relative weight and effectively see what the investor expects and how it is being fulfilled. By identifying in detail, the relevance of each of the technical components, it allows the investor to make informed investment decisions with a clear overview of the state of the technology. On the other hand, it allows entrepreneurs to understand which technical parameters they must improve with the development of their product to be more attractive according to what investors are looking for.

Table 11. *Translation of investor requirements into technical requirements*

Investor requirements	Technical requirements
Documentation	- Durability and performance test reports. - Detailed Technical Specifications
Legal and Certification Compliance	- UL 2580 certification - IEC 62660 certification - ISO 14001
Interoperability	- BMS compatible with different systems
Intellectual property	- Patent
Validation	- PoC - Battery prototype for light transport
Infrastructure	- Energy capacity - Battery life - Modular Design
Sustainability	- Ecological materials - NO use of limited resources - ISO 14001 - RoHS (R. Hazardous Substances)
Level of Innovation	- New system of charge ultra-fast
Security	- UL 2580 certification - IEC 62660 certification

	Investors Requirements / Technical Characteristics	Degree of importance	Relative importance	Durability and Performance Test Reports A	Detailed Technical Specifications B	UL 2580 certification C	IEC 62660 certification D	BMS compatible with different systems E	Patent F	PoC G	Battery Prototype for Light Transport H	Energy capacity I	Battery life J	Modular Design K	Ecological materials L	NO use of limited resources M	ISO 14001	RoHS (R. Hazardous Substances)	New system of charge ultra-fast N	Current StartUp	Targets (new model)	Improvement ratio	Investment Appeal	Absolute weight	Relative weight
1	Documentation	4,8	13,0%	●	●				○			○	○	○					○	5	5	1,00	1,5	7,2	13,2%
2	Legal and Certification Compliance	3	8,2%			●	●									△	●	●		3	4	1,33	1,2	4,8	8,8%
3	Interoperability	4	10,9%					●						●						4	4	1,00	1,2	4,8	8,8%
4	Intellectual Property	3	8,2%						●										○	4	4	1,00	1,5	4,5	8,3%
5	Validation	4	10,9%	○					●	●	●									3	4	1,33	1,2	6,4	11,8%
6	Infrastructure	4,5	12,2%									●	●	●					●	4	5	1,25	1,5	8,4	15,5%
7	Sustainability	4	10,9%									○	○		●	●	●			3	4	1,33	1,2	6,4	11,8%
8	Level of Innovation	4,8	13,0%					△	●			○	○	○					●	4	4	1,00	1	4,8	8,8%
9	Security	4,7	12,8%	△	△	●	●				△							○		4	5	1,25	1,2	7,1	13,0%
	Technical Importance			1,65	1,26	1,93	1,93	1,16	3,61	1,17	1,28	1,81	1,81	2,49	1,13	1,23	2,08	1,28	2,84						
	Technical relative imp.			5,8%	4,4%	6,7%	6,7%	4,1%	12,6%	4,1%	4,5%	6,3%	6,3%	8,7%	3,9%	4,3%	7,3%	4,5%	9,9%						
	Absolute weight			1,67	1,32	1,96	1,96	0,88	3,00	1,06	1,19	2,01	2,01	2,46	1,06	1,15	1,85	1,18	2,84						
	Relative weight			6,1%	4,8%	7,1%	7,1%	3,2%	10,9%	3,8%	4,3%	7,3%	7,3%	8,9%	3,8%	4,2%	6,7%	4,3%	10,3%						

Figure 5. *Adapted Matrix for framework to assess Technology in startup.*

7. Discussion

In this section, the key findings of the research will be discussed in relation to the objectives and questions posed at the beginning of the study. Throughout this work, the essential technological components and requirements that both investors and entrepreneurs consider critical for an accurate technological assessment were explored in detail. At the same time, it was validated that technological assessment is relevant to defining the success of a startup, especially in those whose innovation core lies in technology. The results obtained not only provide a comprehensive view of the critical factors that must be considered when evaluating a startup's technology, but also highlight the importance of a specialized framework in a context where traditional methodologies may be insufficient. These findings, their relationship with existing literature, and their implications for practice in the technological innovation ecosystem will be analyzed in detail below.

The research was developed based on two research questions, the answers to both were found during the study process.

RQ1: What are the most critical technological components to assess when evaluating a technology startup?

To identify the essential components, two approaches were used: theoretical and empirical. The first included a literature review and analysis of current methodologies to determine the key factors in technological assessment. The second, using the Delphi method, collected information in two rounds: an initial one to obtain an overview of the ecosystem and another to validate the identified components.

11 experts in the technological field were interviewed, including investors, entrepreneurs and academics. Triangulation between the results obtained from the interviews and the literature allowed the findings to be validated and reinforced. Initially, 15 components were proposed, which were reduced to 13 after the second round, reorganizing some based on their relevance in specific scenarios.

After the second round of the Delphi method, 13 key components for the evaluation of technological startups were identified: scalability, technological maturity, sustainability, difficulty to replicate, validation, interoperability, technological infrastructure, security, level of innovation, documentation, legal and certification compliance, intellectual property and technical team. The most relevant components, according to the experts' consensus, were scalability, validation, technical team and compliance with legal requirements, which obtained the highest averages and a low standard deviation, reflecting a high level of agreement among the participants.

After successfully identifying the components, the next step was to answer the second research question:

RQ2: How can these components be effectively quantified and compared?

The results of the study indicated that the relevance of each component varies depending on the technology being evaluated. This highlights the need for the evaluation process to be adaptable, allowing the importance of components to be adjusted based on technological particularities. This ensures that each evaluation is accurate and focuses on the most critical aspects for each case.

To effectively quantify and compare these components, the House of Quality (HoQ) matrix was used, a methodology validated in other contexts and now applied to the technological evaluation of startups. The HoQ offers a flexible structure that allows key components to be translated into quantifiable criteria, making their evaluation and comparison easier. This tool ensures that the framework is adaptable, maintaining its rigor and applicability in different technological contexts.

Finally, with the answers to the two research questions, the objective of the research was fulfilled: development of a framework for the evaluation of technological startups focused mainly on technological and technical aspects of the product. This process not only allowed to identify the essential components that must be considered in the technological evaluation, but also provided a solid basis to validate the research hypothesis:

"A framework that specifically focuses on the technological aspects of a startup will enable investors to make more informed and precise investment decisions, whilst also providing entrepreneurs with a clear understanding of the key requirements they must meet to attract investment, thereby reducing uncertainty and the risk associated with the intangible and innovative nature of new technologies."

The validation of this hypothesis was carried out throughout all phases of the study. Both the theoretical analysis and the literature review showed the lack of methodologies that address in-depth the evaluation of technology in startups. The fact that 91% of the interviewees mentioned knowing cases of failure due to technological problems, mainly scalability, reinforces the premise that technological evaluation is crucial. This lack was the driving force for building the framework proposed in this thesis.

In the empirical phase, the implementation of the Delphi method was key to validate the identified technological components. Experts from different sectors of the technological ecosystem corroborated the relevance of these components in the context of disruptive technologies, which consolidated the validity of the proposed framework.

These findings demonstrate that a technology-focused approach, such as the proposed framework, can fill the gap in traditional startup evaluation methodologies, allowing for more informed decisions. A valuable tool is offered to both investors and entrepreneurs by providing an adaptable framework that allows each technology to be evaluated according to its particular characteristics, helping to reduce the uncertainty and risk associated with the evaluation of emerging technologies.

This framework represents a significant contribution to the innovation ecosystem, addressing current shortcomings in startup evaluation methods, such as subjectivity and lack of depth in the evaluation of the technological component. 82% of respondents indicated that investors often rely on external experts to obtain an approximation of the viability of the technology, which is done, in most cases, without a structured process. The proposed framework will provide a key structure for investors to make more informed decisions, thus complementing existing methodologies and covering areas that are not well studied.

In a current landscape where deep tech technologies are positioned as fundamental to addressing global challenges such as climate change mitigation and compliance with the Sustainable Development Goals (SDGs), the accurate assessment of these technologies is more critical than ever. This sector has grown significantly in the last decade, going from representing approximately 10% of venture capital funding to 20% today (Bobier et al., 2023). The proposed framework is therefore not only relevant in practical terms, but also in strategic terms for the future of the technological ecosystem.

Limitations and recommendation for future works

Although this study provides a solid basis for evaluating technology startups, several limitations must be considered. First, the sample size was small. While there are many investors and entrepreneurs in the startup ecosystem, not all focus on truly disruptive technologies. This limited the diversity of perspectives and may have influenced the results, as some components might vary in relevance depending on the type of technology being evaluated.

Additionally, the process of contacting and organizing interviews with experts was complex and lengthy, which impacted the pace of the research. The difficulty in coordinating interviews further reduced the sample size and the representativeness of the data collected. Moreover, although the Delphi method was effective in identifying and validating key components, the consensus reached is heavily influenced by the subjective experiences of the participants, introducing a certain degree of subjectivity into the results, particularly in such a dynamic field as emerging technologies.

Future studies could benefit from a larger sample size, including participants from different regions and sectors, to obtain a broader and more representative view of the startup ecosystem. Beyond expanding the sample, it would also be valuable to explore complementary methodologies, such as longitudinal studies to assess the long-term impact and effectiveness of the proposed framework over time.

Furthermore, future research could focus on quantifying the economic value of the technology based on the components identified in this study. By linking these components with economic outcomes, researchers could provide a more comprehensive tool for investors, allowing them to better estimate the potential financial return of a startup. This would elevate the practical utility of the framework, offering both a qualitative and quantitative basis for decision-making, thus bridging the gap between technical assessment and financial evaluation.

8. Conclusion

This study has succeeded in meeting the proposed objectives by developing an innovative, adaptable and specialized framework for the evaluation of technological startups, focusing on the technological and technical aspects of the product. Through a theoretical and empirical approach, 13 key components that are critical for technological evaluation were identified and validated. By answering the research questions posed, the study not only identified the essential technological components, but also validated the importance of the specialized approach to evaluate emerging technologies.

The proposal of this framework provides a valuable tool for both investors and entrepreneurs, as it provides a more precise and adaptable approach compared to traditional methodologies. This advance is particularly relevant in an increasingly complex innovation ecosystem, where technology plays a central role in the differentiation and success of startups.

The findings of this study underline the need for more rigorous and structured technological evaluations, capable of reducing the uncertainty and risk associated with investing in disruptive technologies. The framework's ability to adapt to different types of technologies ensures its applicability across a range of sectors, reinforcing its potential to contribute to the decision-making process in an increasingly innovation-oriented market.

While the limitations of the study open up space for future research, the development of this framework is an important first step towards improving the evaluation of technology startups. Future studies may expand this approach, considering a greater diversity of cases and exploring the relationship between technological components and economic outcomes. In this way, the framework may evolve into an even more comprehensive tool that not only facilitates technical evaluation, but also contributes to predicting the financial impact of startups.

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Appendix 1

Table 12. *Level of development by component*

Component	Level 1	Level 2	Level 3	Level 4	Level 5
Scalability	Minimal scalability, cannot handle growth	Limited scalability with significant challenges	Moderate scalability with some inefficiencies	Good scalability with minor adjustments needed	Highly scalable, can grow without performance issues
Maturity	Early-stage concept with minimal development	Partially developed with many features incomplete	Partially developed product with some functional features	Mostly developed product with few remaining issues	Fully developed, market-ready product with thorough testing
Sustainability	Unsustainable and resource-intensive	Moderately unsustainable with some negative impact	Some sustainable practices but with inefficiencies	Mostly sustainable with minor improvements needed	Fully sustainable, environmentally and socially responsible
Difficulty to Replicate	Easily replicable by competitors	Moderately easy to replicate	Moderately difficult to replicate	Difficult to replicate with specialized knowledge	Very difficult to replicate due to high complexity or patents
Validation	No validation, untested technology	Limited validation with basic testing	Moderate validation with testing in controlled environments	Substantial validation with real-world testing	Fully validated and proven in market conditions
Interoperability	Incompatible with other systems	Limited interoperability with significant integration issues	Moderate interoperability with some integration challenges	Mostly interoperable with minor integration issues	Fully interoperable, seamlessly integrates with other systems
Technological Infrastructure	Minimal infrastructure, insufficient for operational needs	Limited infrastructure with significant constraints	Moderate infrastructure with some inefficiencies	Mostly solid infrastructure with minor adjustments needed	Robust infrastructure, highly reliable and scalable
Security	Vulnerable to threats, lacks basic security measures	Basic security measures but prone to breaches	Moderate security with some vulnerabilities	Good security with minor risks	Highly secure with comprehensive protections in place

Level of Innovation	Low innovation, little differentiation	Moderately innovative but not groundbreaking	Moderately innovative with some unique aspects	Highly innovative with significant differentiation	Exceptionally innovative, groundbreaking technology
Documentation	No documentation available	Limited and incomplete documentation	Moderate documentation with some gaps	Comprehensive documentation with minor gaps	Fully detailed and clear documentation, easy to follow
Legal and Certification Compliance	Non-compliant with legal and certification standards	Partially compliant with significant gaps	Moderately compliant with some gaps	Mostly compliant with minor gaps	Fully compliant with all legal and certification requirements
Intellectual Property	No intellectual property protection	Limited protection with unregistered IP	Moderate protection with some registered IP	Mostly protected with registered patents and trademarks	Fully protected with comprehensive IP strategy
Technical Team	Inexperienced or unqualified team	Basic team with some relevant skills	Moderately experienced team	Highly skilled team with strong experience	Exceptionally qualified and experienced team