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How start-ups translate learning from innovation failure into strategies for growth

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ABSTRACT

Start-ups can make a decisive contribution to the development of innovation. These organizations are designed to experiment with new technologies and business models. In their growth process, learning from failure plays a decisive role. This study enriches our understanding of learning from failure, particularly in start-ups, by analyzing 21 innovative start-ups that have faced experiences of failure. The theories of organizational learning and dynamic capabilities are applied to identify the responses of start-ups to failure and their implications in terms of learning. Six response strategies were identified: external monitoring, internal evaluation, resource acquisition and mobilization, value creation and capture, team-level entrepreneurial, and organizational learning. These response strategies are grouped into the three dynamic capabilities dimensions: sensing, seizing, and transforming. These strategies are relevant for start-ups to overcome difficulties and continue their growth and innovation. They also offer a guideline for start-ups to develop strategies for systematic learning from failures.

1. Introduction

Recent research has underlined that new and continued innovations of products/services, organizations and technology represent a crucial way to navigate and overcome turbulent times and sustaining market competition (Cozijnsen et al., 2000; Ahn et al., 2005); they are a competitive necessity for the survival, competitiveness and growth of firms (Hernandez-Espallardo et al., 2012; Forsman, 2021) and whole ecosystems (Baloutsos et al., 2020; Corvello et al., 2023). Despite this relevant and critical role, many innovation attempts fail (Cozijnsen et al., 2000; Rhaiem and Amara, 2021). Rhaiem and Amara (2021) noted that up to 90% of innovation projects fail entirely or partly. As Qin and van der Rhee (2021, p.4) argued, "Failure is an inherent result of innovation due to the highly uncertain nature of innovation projects."

In general, innovation is a problematic phenomenon to evaluate. Significant difficulties are found in evaluating innovation failures, an area of research that has yet to receive much attention (Towsend, 2010; Maslach, 2016). Existing studies typically offer insights into the factors influencing the success of innovation, with limited consideration of failed innovations (Maslach, 2016; García-Quevedo et al., 2018). Generally, failures are related to harmful and undesirable performance outcomes (Dahlin et al., 2018). Mueller and Shepherd (2016, p. 461) suggest a failure refers to "the closure of an initiative to create value that has failed to meet its goals." They can occur in different stages of the innovation development, i.e., before investing resources (failure of the idea), during the development phase (technological failure), or after the innovation has been introduced in the target market (commercial failure) (Shepherd et al., 2009; D'Este et al., 2016; Rhaiem and Amara, 2021). Thus, Forsman (2021, p. 4) defined innovation failure as a "terminated innovation initiative that has failed to meet its previously set goals."

While literature presents studies that examined the reasons (and factors) for innovation failures (Cozijnsen et al., 2000; Eggers, 2012; Forsman, 2021), the consequences of such failures – i.e., what happened afterward and the organizations' reactions – are aspects still to be fully explored. There is a need to increase understanding of how firms respond to innovation failures and, specifically, attempt to reduce or avoid the negative consequences by adopting or implementing new practices and strategies in the future. Organizations can experience positive effects from innovation failures, such as opportunities to learn

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and develop improved innovation strategies (Leoncini, 2016; Guzzini et al., 2018; Hartley and Knell, 2022), but also adverse effects, such as traumatic experiences, increased perceived uncertainty, aversion to risks and innovation attempts (Shepherd and Kuratko, 2009; Välikangas et al., 2009). Inevitably, innovation failures influence the future strategies and trajectories of firms that, in turn, can try to capitalize from them.

Considering the crucial role played by start-ups in the context of innovative processes, the understanding of how they face and learn from failures is a critical area of investigation. Furthermore, start-ups represent an under-researched category compared, for example, to large firms (Allmendinger and Berger, 2020). Innovation is imperative for start-ups to be 'born innovative,' i.e., created with innovative imprinting and perspective from inception. They are new firms, generally, with a high technological value created to bring breakthrough innovations and technologies to specific markets (Audretsch et al., 2014; Colombelli et al., 2016; Santisteban et al., 2021). They can often innovate more rapidly than established firms (Kurpjuweit and Wagner, 2020) and play an essential role in innovation ecosystems (Baloutsos et al., 2020). Incumbents seek collaboration with start-ups and seek to facilitate cooperatio n through dedicated programs (Weiblen and Chesbrough, 2015). However, potential failures are part of start-ups' life due to the high technological and market uncertainty they face (Cardon et al., 2011; Mantere et al., 2013; Yamakawa et al., 2015). Thus, start-up firms are intriguing cases to explore because they are designed as experiments, i.e., organizations established to develop and experiment with a new Business Model (BM). Indeed, a BM is subject to changes and failures, and learning opportunities emerge from these failures (Blanc, 2010). So, innovation failures may represent an opportunity to develop more appropriate BMs and define new competitive strategies. Given the nature of start-ups, the related 'liabilities of newness,' and the resource constraints (especially in terms of funding, experience, and knowledge), innovation failure can be a likely outcome for them. Considering they have a small margin of error (Cope, 2011), start-ups must embrace innovation failure as a learning opportunity and then adopt new strategies to avoid other failures that can be fatal. Learning from failures allows start-ups to discover new knowledge, identify unanticipated problems, anticipate future innovation failures (Qin and van der Rhee, 2021; Rhaiem and Amara, 2021), and implement strategy changes (Greve, 1998). So, start-ups are expected to possess or develop the ability to systematically learn from mistakes and failures (Blanc, 2010). This capacity allows them to change and adapt to the external environment, perceiving mutations and reconfiguring their resources, representing their dynamic capabilities (Teece, 2007).

Although start-ups can transform failure into an opportunity for growth, their strategies for this purpose have yet to be outlined. In the management literature, while various studies address aspects of innovation failure, there must be more integrative frameworks to understand the strategies and practices start-ups can adopt to learn from failure. Start-ups may adopt different responses to failures, which need to be mapped out to outline how they can translate experiential knowledge into a learning process for growth. It is essential to increase understanding on the dynamic nature of the learning process from failure, which tends to be not linear but rather complex and iterative. There is a need to expand the theoretical framework of understanding how the start-ups' dynamic capabilities can be observed in practice. From a theoretical perspective, it is crucial to comprehend the extent to which learning from failure can be elucidated through the lens of dynamic capabilities. This understanding helps delineate alternative strategies that start-ups can implement to transform failures into valuable learning opportunities, fostering growth and resilience within the organization.

Furthermore, the investigation of the start-up's responses to innovation failure can help to enrich the studies on learning from innovation failures by providing insights about the contextual factors affecting learning from innovation failure, offering a reference for comparative studies across different contexts. Due to the high rate of failure among start-ups, understanding how they can turn failure into success provides valuable insights for theory building and implications for practice to outline possible actions for entrepreneurs, investors, and policymakers to manage innovation failure. For this reason, this study aims to fill these gaps and answer the following critical research questions: *How do start-ups respond to innovation failures? What strategies and practices do start-ups learn from innovation failure?*

A qualitative approach has been adopted based on multiple case studies to answer the above questions. The case studies have been selected from the Italian context, which, in recent years, has been characterized by a growing number of start-ups, particularly new firms with a high technological value and strong disposition towards innovation. Indeed, the Italian government, in response to the need to catch up with the technological gap distinguishing traditional Italian SMEs and support the development of technology-oriented innovation ecosystems, has incentivized through a specific law (Law Decree 179/2012 or Decreto Crescita 2.0, and then Law n. 221/2012) the development of start-ups that must be distinguished by the development, production and marketing of innovative products or services with high technological value. The boost of the creation of start-ups in Italy due to governmental support provided an novel context of analysis to investigate how start-ups can learn from failure. This study focuses on those Italian start-ups that have experienced innovation failures and used failures as a learning opportunity to implement new practices or strategies, replacing the old ones by nurturing their dynamic capabilities. Accordingly, the study excludes those start-ups that, after failure, decided to cease business.

To analyze the case studies, a qualitative narrative approach was used by interviewing, as suggested by Forsman (2021), the founders of innovative start-ups that experienced an innovation failure by transforming failure into an opportunity to define a new competitive strategy. The critical analysis of the insights extracted from the interviews has shown that start-ups have developed their dynamic capabilities by learning alternative practices. Thirteen main start-up strategies have been identified. They have been classified into six categories: external monitoring, internal evaluation, resource acquisition and mobilization, value creation, capturing team-level entrepreneurial learning, and organizational-level learning. Then, applying the dynamic capability framework (Teece et al., 1997; Teece, 2018), these strategic categories have been interpreted through the lenses of the three dimensions distinguishing a dynamic capability (Teece, 2018): sensing, seizing, and transforming.

This study offers several contributions. First, it contributes to the emerging literature on innovation failure by exploring this phenomenon in start-ups. Second, it highlights how failure contributes to start-ups supporting organisational learning mechanisms by developing new competencies and capabilities. It emphasizes the strategic relevance of learning from failures to allow firms to survive mistakes and turn failures into opportunities for growth, nurturing the development of dynamic capabilities. For practice implications, the study offers insights to start-ups, entrepreneurs and managers to understand how to approach failure in their endeavours and the strategies they can implement to turn a failure into a lesson learned to move their business to a new level.

The paper is structured as follows. Section 2 provides the conceptual background of the study and outlines the importance of learning from failures for start-ups. Section 3 describes the research design and method. Then, section 4 discusses the findings. Finally, section 5 outlines the implications and avenues for future research and conclusions.

2. Theoretical background and learning from the failure of start-ups

Start-ups are ever-evolving organizations. They innovate by experimenting with new technologies and business models (Blanc, 2010). This experimentation is a learning process through which young firms change their internal functioning, their positioning concerning the

surrounding environment and their interaction methods with the outside world (Ehrenhard et al., 2017). While failure is hardly what entrepreneurs aspire to, failures of varying severity are inevitable in start-ups (Klimas et al., 2021). Two fundamental theoretical perspectives support understanding the start-ups' learning from failures. The organisational learning theory discusses how firms can learn to fit the continuously evolving business landscape. Simultaneously, the dynamic capabilities theory outlines the fundamental importance for firms to recombine their resources and capabilities to support growth continuously. These conceptual backgrounds support the increased understanding of the dynamics of adaptation in start-ups (Almeida et al., 2003; Ma et al., 2020) and how start-ups can learn from failure.

2.1. Organizational learning

Organizational learning theory (Argyris and Schön, 1978) offers a flexible framework for analyzing learning processes, including learning from failure. Organizational learning theories analyze how organizations learn, how individual learning can be translated into organizational learning, and how these processes can become increasingly efficient by explicitly managing them (Basten and Haamann, 2018). Among these theories, the contribution of Argyris and Schön and the distinction between single-loop and double-loop learning is of particular importance. Single-loop learning is "instrumental learning that changes strategies of action or assumptions underlying strategies in ways that leave the values of a theory of action unchanged" (Argyris and Schön, 1996, p. 20). Double-loop learning entails changing the assumptions, goals, and decision-making processes when interacting with the environment and proving them wrong.

Start-ups often face high levels of uncertainty. Start-ups employ a combination of levers to acquire knowledge to adapt to ever-changing circumstances. These levers require planning, rapid learning, and adaptation (Sommer et al., 2009). Prior research identified several formal and informal mechanisms through which organizational learning can occur in start-ups. These include alliances, the mobility of experts, and geographic co-location (Almeida et al., 2003). More recently, technology has become a driver of learning in start-ups, offering efficient access to data and information, increased opportunities for communication and networking, and a mechanism to develop and acquire new knowledge and skills (Caseiro and Coelho, 2023).

Organizational learning occurs through people (Huber, 1991; Kim, 1993). It presupposes a restructuring of the people's mental models through a process of acquiring and interpreting information and assimilating experiences, building new knowledge and insights that enhance performance, adapting to changing environments, achieving targeted goals more effectively over time, and refining strategies, processes, and behaviors based on the lessons learned from past experiences (Davenport and Prusak, 1998). For start-ups, it is essential that the trial-and-error learning of entrepreneurs and their co-workers' core team is based on mechanisms such as learning by doing, by experimenting, and by specializing (Rosemberg, 1982). For this reason, failure represents a learning opportunity for any organization (Leoncini, 2016; Guzzini et al., 2018; Hartley and Knell, 2022), specifically for start-ups (Blanc, 2010). For start-ups, the innovation failure is an opportunity to reflect on the viability of their business assumptions and actions. So, innovation failure can induce both single-loop and double-loop learning. Firstly, changes are made to the start-up's growth trajectories to adapt its processes, enhance customer relationships, and revise the resource and capability's structure and combination. Secondly, the business model, fundamental value propositions, and business hypothesis are revised, modifying strategy, products offered, and reference markets (Hartley and Knell, 2022). So, in the case of double-loop learning, a radical change in business assumptions takes place, and new strategies are formulated (Qin and van der Rhee, 2021). For this reason, innovative failure represents an opportunity for start-ups to sustain organizational learning to gain insights to revise their strategies and recover and improve the organization's performance (Cannon and Edmondson, 2005; Forsman, 2021).

2.2. Dynamic capabilities

The theoretical framework of dynamic capabilities describes how organizations evolve by identifying opportunities in the external environment and pursuing them by recombining their resources and capabilities (Teece et al., 1997; Teece, 2018). Three dimensions characterize dynamic capabilities: sensing, or the ability to identify opportunities in the external environment; seizing, i.e., the ability to seize opportunities through appropriate initiatives; transforming, or the ability to change the organization to make a particular way of doing systematic business (Teece, 2018). Dynamic capabilities are built on individual and organizational strategies, activities, skills, and knowledge (Teece, 2018). The dynamic capabilities framework has been adopted by several studies to analyze the dynamics of start-ups. These studies suggest that start-ups possess distinctive dynamic capabilities compared to large businesses, which allows them to be more innovative (Ma et al., 2020; Zahra et al., 2006). Thus, Zahra et al. (2006) compared dynamic capabilities between start-ups and established firms, and argued that the configuration and attributes of these capabilities in start-ups are, among others, focused, simple first and then complex, rapidly changing. Hanchi and Kerzazi (2020) suggest thatthe innovative capacity of start-ups itself can be interpreted as a higher-order dynamic capacity which, by combining elementary capabilities, allows new firms to explore the environment, rapidly identifying and seizing new opportunities.

Start-ups are conceived as transitory organizations built to experiment with new business models (Gonçalves et al., 2022). They are often driven by a team of skilled and entrepreneurial individuals whose business processes are not yet consolidated. These characteristics make them inherently agile and able to identify and adapt to new opportunities (Selig and Baltes, 2019). Due to their characteristics and the innovative features of their business models and products, failure is part of the natural evolution of start-ups, and learning from failure is a necessary component of the dynamic capabilities of start-ups (Giglio et al., 2023).

Failure to innovate questions the relationship between start-ups and their environment (Edmondson, 2011). Thus, failure changes how they can perform sensing, seizing and transforming. However, how failure translates into the development of dynamic capabilities requires improved understanding. Recent studies proposes the dynamic capabilities approach (Foss et al., 2023; Corvello et al., 2023). They demonstrate that it is necessary to investigate dynamic capabilities as a valuable framework to investigate adaptation. This approach can also be fruitful in investigating how start-ups can learn from failure.

2.3. Learning from failure in start-ups

Start-ups are small businesses in an embryonic phase of their life cycle that provide for the achievement of profits through a promising innovative capacity (Scott and Bruce, 1987). They are intrinsically innovative, usually small or medium-sized enterprises. Their goal is to translate ideas or technologies into new products and, ultimately, new business models. Discovering, developing and implementing a new, viable business model to exploit market opportunities is an essential part of the activity of start-ups (Ehrenhard et al., 2017). Such innovative, entrepreneurial activities will likely encounter small or more significant failures (Klimas et al., 2021; Dobusch et al., 2022; Joseph and Aboobaker, 2023). No consensus exists on the definition of innovation failure in start-ups.

Scholars have described such failure as an inherent outcome of innovation projects (Jenson et al., 2016; Maslach, 2016). The systematic literature review by Rhaiem and Amara (2021) highlighted that innovation failures are related to the absence of successful factors and that scholars consider these failures as failed tentative initiatives to meet

their goals at any stage of the innovation development (Shepherd et al., 2009; D'Este et al., 2016; Maslach, 2016; Mueller and Shepherd, 2016). Innovation failures can occur early or later in the innovation process (Forsman, 2021; Rhaiem and Amara, 2021) but, they can also be referred to different variants such as in terms of size (big or small), nature (radical or incremental), typology (e.g., product or process innovation) or technology (technological or not-technological) (Rehn and Lindahl, 2012; Khanna et al., 2016; D'Attoma and Ieva, 2020). In general, it can be said that this type of failure refers to a disappointing performance level of innovation (Forsman, 2021). However, such events can have a range of effects, both positive and negative and with different levels of severity (Shepherd and Kuratko, 2009; Guzzini et al., 2018; Klimas et al., 2021). Among the positive effects of failure is the opportunity to learn and acquire new, valuable knowledge regarding the firm and its environment.

The innovation management literature has yet to address possible failure and the opportunity to learn from it (Leoncini, 2016). Learning from failure differs from learning from success, although both are based on feedback loops (Edmondson, 2011; Magazzini et al., 2012). If success pushes firms to strengthen their skill base (Lee and Miesing, 2017; Gong et al., 2019), failure challenges and pushes them to change it even more radically (Edmondson, 2011). These changes occur at the individual, group and organizational levels, with complex interdependencies between the various levels (Cannon and Edmondson, 2005). The gravity of failure and the importance of its effects can vary greatly, generating significant variations in the competencies of organizations (Hartley and Knell, 2022). Finally, failure has important emotional implications, which condition the learning processes (Shepherd and Kuratko, 2009; Tan et al., 2009).

The precise nature of start-ups makes the learning from failure processes in these organizations even more specific. Start-ups are naturally innovative and experimental, making learning from mistakes a strength (Audretsch et al., 2014; Colombelli et al., 2016; Santisteban et al., 2021). They are often made up of teams of entrepreneurs and a few other employees, whereby the individual, team and organizational levels are intertwined (Ehrenhard et al., 2017). Finally, they are subject to the liability of newness and smallness (Stinchcombe, 1965), so the effects of failure can be severe.

Several prior studies have sought to understand the factors that determine the adaptability of start-ups (Devarakonda et al., 2022; Lago et al., 2023). The motivation for these studies is that it is necessary to identify the levers that allow adaptation to be made more efficient and effective in new businesses. These studies, however, treat learning in an undifferentiated way concerning the nature of the events that generate it. Essentially, they do not distinguish whether learning occurs following a positive event or a failure (Magazzini et al., 2012). Thus it is, necessary to investigate which specific levers can be exploited to generate learning from failures in the case of start-ups. Using the conceptual backgrounds of organizational learning and dynamic capabilities as interpretative lenses of analysis, this study analyses the dynamics of adaptation in start-ups (Almeida et al., 2003; Ma et al., 2020) and how start-ups can learn from failure and consequently adopt alternative learn-based strategies supporting the development of their dynamic capabilities.

3. Research design

3.1. Sampling and data collection

This research is exploratory and aims to achieve an understanding of start-ups' responses to innovation failures. Hence, a multiple case study along the lines of a grounded theory approach for the inductive building of theory (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Gioia et al., 2013) represents a suitable approach to examine the emerging phenomenon under consideration where little is known and to provide detailed empirical descriptions. Given the topic's novelty and that start-ups are a type of firm less investigated in the literature, such an approach improves our understanding of start-ups' responses to innovation failures. To investigate our research questions, we explored founders' views and strategies of start-ups that have experienced innovation failures. We conducted qualitative research by focusing on 21 Italian start-ups. Table 1 reports the characteristics of start-ups in the sample and details the failures.

Case studies have been selected from an Italian context, which is characterized by a growing number of start-ups, particularly of new firms with a high technological value and strong disposition towards innovation in recent years. Indeed, the Italian government has boosted the creation of start-ups in response to the desire to reduce the technological gap distinguishing traditional Italian SMEs and supporting the development of technology-oriented innovation ecosystems. The national Government issued 'Decreto Crescita 2.0' (or Law Decree 179/2012) presenting 'Further urgent measures for the growth of the country', converted by Parliament with Law n. 221/2012. This law (precisely, article n. 25 paragraph 2) highlights, for the first time in the Italian regulatory body, a specific definition of innovative start-ups with high technological value: "An innovative start-up has as its exclusive or prevalent corporate purpose the development, production and marketing of a product or service with high technological value". Accordingly, an innovative start-up must possess at least one of three crucial parameters, i.e., percentages of R&D investments (15% of revenues, or operating costs if they exceed the revenues), number of highly skilled employees (at least one-third of employees must hold a PhD or a research tenure, i.e., expert researchers), and holding patents (or a registered software).

The Italian context is characterised by the presence of micro and small-medium sized enterprises (over 90%) but historically has a limited business demographic due to the high degree of bureaucratisation of firms which raises the costs of entering the market, creating a entry barrier, thus reducing the dynamism of the economic system and also

Table 1
Sample characteristics.

	Location	North	43%
		Center, South and Islands	57%
Start-ups'Characteristics	*Innovative requirements*[a]	% R&D investments	90%
		No. highly skilled employee	33%
		Holding patents	10%
	Sector	Services	81%
		Others (industry/ crafts/manufacturing)	19%
	Firm size (Employee class)	0–4	71%
		5–9	29%
Founders' characteristics	*Industry experience*	≤3 years	67%
		≥4 years	33%
	Age	≤40	52%
		≥41	48%
	Education	Bachelor's degree or lower	38%
		Master's degree or higher	62%
Details about the failure	*Phase of innovation development where the failure occurred*[b]	Innovative idea/ project development	38%
		Technology development	29%
		Post market introduction	43%
	Type of failure[b]	Failure of the idea	38%
		BM failure	29%
		Technological failure	33%
		Product/service rejected by the market	29%

[a] Start-ups can also have more than one requirement; hence the total percentage can be greater than 100.

[b] Start-ups may have experienced multiple failures in different phases; hence the total percentage can be greater than 100.

innovation. From this perspective, the novel policies have favoured new forms of entrepreneurship, i.e., the birth of innovative start-ups, through a series of facilitations (e.g., reducing firm management costs, introducing exemptions from tax legislation and labour law for new businesses, etc.). To support start-ups' development, the Italian government has made considerable efforts regarding regulations and policies, including implementing specific funds, programmes, and new financial instruments to support them[1] (MiSE, 2022a). This is because start-ups are considered new firms with a pivotal role in sustaining Italy's economic and social development. They are recognised as a growth engine for the entrepreneurial landscape, contributing to the country's innovation ecosystem and the national economy – in terms of contribution to employment and value of production[2] (MiSE, 2022b). In 10 years, the number of innovative start-ups has increased from 1467 units registered in 2013 at 14,708 as of October 1, 2022, growing on average by 29% per year (data retrieved from the latest annual report of the MiSE to the Parliament). This data is even more relevant when analysing the five-year period ending in 2022; in fact, it can be noted that the growth of the system has been significant as the number of innovative start-ups increased (between 2018 and 2022) by approximately 46.1%. Hence, considering the boost to the creation and development of start-ups in Italy, they represent a suitable context of investigation for the purpose of our study.

Twenty-one start-ups were selected through purposeful sampling (Patton, 2014); precisely, we departed from start-ups that had experienced an innovation failure, i.e., that failed to meet the previously set goals or predefined technological requirements (Maslach, 2016) and created value through the stages of the innovation development (Shepherd et al., 2009; D'Este et al., 2016; Forsman, 2021; Rhaiem and Amara, 2021). To verify that the start-ups included in the sample met this requirement, we asked them if they believed they had experiences consistent with our working definition of innovation failure proposed by Forsman (2021), i.e., in terms of innovation initiatives that have failed to meet the previously set goals, and the related disappointing performance level of innovation, or underperformance.

Being a hidden population, i.e., there is no specific register to classify start-ups that have experienced an innovation failure or that describe them; we initially resorted to firms – listed in the business register of innovative start-ups. We had the opportunity to have direct contact with the founders, and they described the business innovation failures they experienced. We focused on still active start-ups and have not ceased (and have not been deleted from the business register). The empirical analysis provided evidence that such failures are related to the introduction of innovations that have failed (e.g., in terms of technological requirements) and have not achieved the previously set objectives in line with the definitions of previous studies (Maslach, 2016; Forsman, 2021). Some interviews allowed us to connect with other start-ups pertinent to our study and facilitated the connections with the founders (snowball sampling technique). Given the hidden population characteristics discussed previously, this additional step was beneficial for achieving the sample size.

These start-ups were interviewed by analysing their responses to innovation failure and how it translated into organisational learning. The start-ups have been selected from different sectors to gather case studies that would provide different perspectives of innovation failures. One of the start-ups operating in the field of advanced financial services described their innovation failure in terms of the 'breakdown' of their BM and of how they failed in creating and distributing value to various actors/stakeholders (proving the importance of double-loop learning in revising the fundamental assumptions at the basis of their BM). Another start-up operating in sustainable/renewable energy and electronic devices reported a failure relating purely to technological innovation. In contrast, other start-ups have faced innovation failures at some early stages of the Technology Readiness Level (TRL) scale and have yet to reach later levels of TRL, showing the relevance of sustaining single-loop learning mechanisms based on reviewing and changing processes and resource structure.

Data was collected between November 2022 and January 2023 through interviews with the founders of start-ups. As data sources, we used in-depth, open-ended interviews with start-up founders to evaluate their experience with innovation failures and, to understand the consequences and how they learned from them. We adopted an interview protocol that was standardized across the interviews. First, we asked the founders to provide information on their start-ups (e.g., when it was founded) and, above all, on their main characteristics, with particular attention to those peculiar to and linked to their nature as innovative start-ups (as noted above, these ventures should meet at least one of the three subjective requirements and have exclusive/general corporate purpose on development, production and marketing of innovative products/services with high technological value). We then focused on innovation failures faced by start-ups and the related consequences, practices, and strategies adopted. Specifically, we asked informants to illustrate the innovation failures they experienced with the related consequences, how they responded to them, and the subsequent strategies and practices they adopted to overcome the uncertainty and learn from them.

3.2. Data analysis

First, we have identified the strategies and practices shared and provided by the start-ups' founders. Then, we reviewed the literature on innovation failures and the related strategies or outcomes to confirm or disconfirm the gathered narratives and experiences, followed by the identification of novel insights emerging from the collected data to extend the literature and improve our knowledge of the connection between innovation failures and start-ups' responses in terms of strategies and practices. The analysis of interviews led to the codification and categorization of the responses of start-ups. The research team of this study shared the tasks of analysing the interview results. Two researchers examined the interview transcripts through manual coding. The other two researchers acted as interpreters of the theoretical contribution associated with the key emerging dimensions (Gioia et al., 2013). In these phases, the research team engaged in discussion sessions. The open codes obtained have been broken into relevant concepts and then grouped into categories (Glaser and Strauss, 1967). Table 2

Table 2
Categories of responses strategies of start-ups to innovation failures.

Categories	Definition
External monitoring	Strategies related to how the start-up monitors the external environment and detects new business opportunities.
Internal evaluation	Strategies related to how the start-up formulates strategies and business models to seize the opportunities detected in the external environment.
Resource acquisition and mobilization	Strategies related to how the start-up routinises new practices developed in response to the failure episode.
Value creation and capturing	Strategies related to how the start-up appropriates the value generated by new business strategies and practices.
Team level entrepreneurial learning	Strategies with which the entrepreneurial team learns from failure and strengthens its competences.
Organizational level learning	Strategies by which individual and team skills and practices are transformed into organizational skills and practices.

[1] For example, the Smart&start program, National Innovation Fund, dedicated voucher, and equity crowdfunding regulation.

[2] The latest reports by MiSE (MiSE, 2022a; 2022b) show that – in the last year – overall, the more than 14,000 innovative start-ups, reach about 2 billion euros of production value, the total number of employees is around 21,000.

presents the identified categories. These categories included external monitoring, internal evaluation, resource acquisition and mobilization, value creation and capturing team-level entrepreneurial learning, and organizational-level learning; then, we combined the six categories into three categories of dynamic capabilities proposed by Teece (2018), namely sensing, seizing, transforming. Our final data structures and the related framework is reported in Fig. 1. We combined the identified categories into general categories, as shown in Fig. 1. Table 2 provides an overview of the findings.

Fig. 1 shows the final aggregate dimensions identified, associated with the three main elements of dynamic capabilities (Teece et al., 1997; Teece, 2018).

4. Findings

The interviews with founders reveal how start-ups responded to innovation failures. Interviewees discussed the strategies and practices they adopted after failures and their learning experience. Our results identified 13 types of responses to innovation failures adopted by the start-ups. The coding process led to grouping the 13 responses into six aggregate themes. The first two of these six themes concern the ability of the start-up to identify opportunities and risks. The following two concern the ability to formulate strategies of response and interaction with the external environment, while the last two concern the ability to transform internally. As explained in depth in the discussion of the results, this tripartition reflects the typical dimensions of dynamic capabilities (Teece et al., 1997; Teece, 2018). So, the six themes can be grouped into sensing, seizing and transforming categories.

4.1. Sensing

Innovation failures experienced by the interviewed start-ups changed how they observed the external and internal environment and evaluated the information obtained. In response to innovation failure, indeed, start-ups implemented external monitoring strategies but – at the same time – developed internal evaluation practices to compare external opportunities with internal competencies.

4.1.1. External monitoring

Entrepreneurs have highlighted that their firms have changed how they relate to the environment regarding response times. In particular, they have begun to implement waiting strategies, prolonging the observation of the environment before acting (wait and see strategies). Furthermore, the experience of failure prompted many of them to observe the experiences of others (vicarious learning) systematically.

Wait and see. The interviewed founders reported that the innovation failure increased their risk aversion and perceived uncertainty of the surrounding contexts; consequently, they adopted a wait-and-see approach based on various strategies/practices as a response.

Innovative start-ups operate in environments characterized by high uncertainty and are subject to frequent changes in markets and technologies. Most interviewees underlined that the high level of uncertainty, particularly technological, has led them to enter the market after the information about the business landscape in which they operate is more complete and clearer to make decisions. The innovation failure they experienced made them more cautious, especially about the decision to enter a new market. One of the interviewed entrepreneurs stated:

> "We *aimed at entering a new market close to ours, but we decided to wait for uncertainty reduction. Our company is small and young; we must avoid wasting resources, particularly money. This choice is fewer resources and energy consuming for us; in sum, we should wait until there are as few uncertainties as possible*".

Failure increased their prudence, in particular regarding

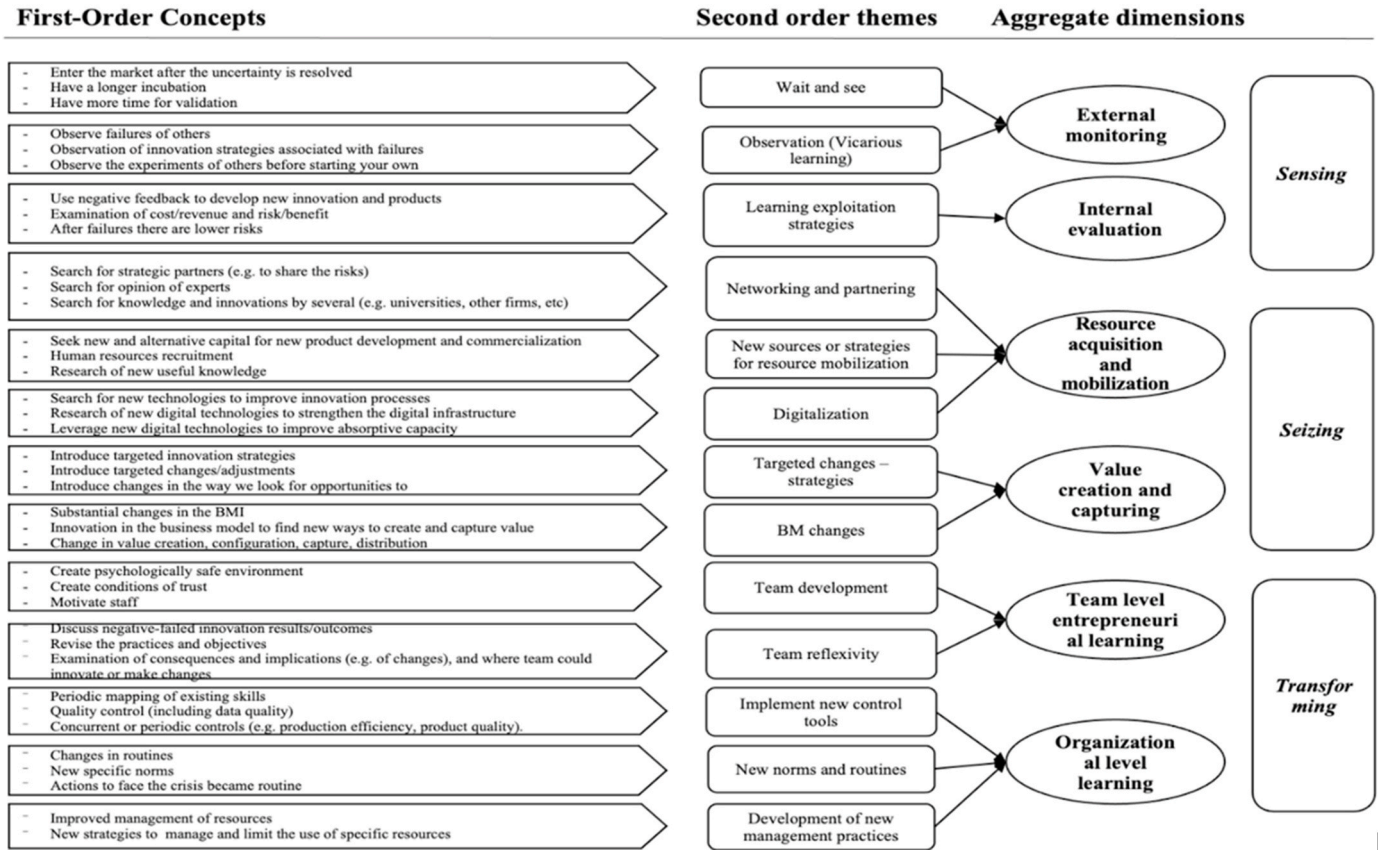

Fig. 1. Concepts, themes and categories.

technological investments that can be potentially irreversible. A start-up's founder described it as, "*Our company is a service company and operates in one of those contexts that I consider to be one of the most uncertain and subject to change in recent years, namely that of financial services, characterized by the affirmation of fintech and the advent of a series of new breakthrough innovations. After experiencing an initial innovative failure, our approach was to wait for the uncertainty to pass or at least be significantly reduced. […] To avoid further costly investments before entering new sub-markets, we have preferred in this phase to have a more cautious approach and wait for the evolution and full affirmation of some types of technological innovations*".

Innovations require a period of incubation before approaching the market and having the opportunity to exploit them (McGrath and O'Toole, 2021). However, several founders have revealed that their firms have had limited incubation periods for their innovations for various reasons, such as a desire to speed up the process, the naiveness to consider they had arrived (and therefore being able to forge ahead), to limit costs, and so on. According to some founders, these concurred in several respects to the innovation failures of the start-ups. After that, they represent a critical aspect to consider for the future. After experiencing failure, several start-ups decided to extend the time of incubation of their innovations as well as the time spent on their validation.

Incubation of innovation activities for more significant periods can allow start-ups to wait for the evolution of the market, the acceptance of users/consumers, and the technologies, and prevent some risks related to entering markets too early.

A start-upper, for example, stated that "*we are working on an innovation project, but – given our previous experience mistakes – we will take more time and have a greater period of incubation to avoid a potential failure.*" Similarly, another founder pointed out that "*our innovation is at a level between 3 and 4 of the technology readiness level [TRL] scale, and we prefer to reach the highest target levels before celebrating; put simply, we want to limit its weaknesses; hence, we are still developing our prototype and – in addition – we are thinking to resort to incubators to have a further reassurance*".

With specific reference to validation before proposing an innovation, an entrepreneur stated, "*Based on our recent experience, good intuition is just a first step, but a subsequent validation is needed and very crucial; […] relying only on good intuitions can be extremely risky, while a greater validation is necessary to wait and see. I think to have more chances and avoid another failure, we are trying to insert as many validation steps as possible in our new project*".

Observation. Based on their previous mistakes and failures, many start-ups of our sample started to adopt an approach based on observing others' behaviours. Interviewees underlined that observing others' experiences offers the opportunity to adopt less risky practices. This learning process denoted the development of a start-up's capacity for vicarious learning (Huber, 1991; Roberts, 2010; Rosemberg, 1982). Observing other firms' failures, strategies, and experiments allowed start-ups to reduce uncertainty and potentially avoid errors.

In an interview, a founder said, "*We have observed other companies that have experienced failure. This has allowed us to limit other expenses*". This logic is particularly suitable for start-ups characterized by non-negligible resource constraints. Thus, they can also observe experiments undertaken by others before starting their own and especially their innovation strategies (i.e., they can be free-riding on the experiments and innovation failures of others); the latter is beneficial to avoid similar failures, but they should be examined and compared to the specific context and reality of the start-up to consider potentially different effects and don't lose promising innovation and market opportunity. Some strategies may be valid and effective in the specific environment of the start-up or its segment/niche market (Greve, 1995). Failures of others can draw the attention of founders and should be interpreted and contextualized to specific cases. While such an approach helps start-ups avoid failure, i.e., they are less likely to suffer another innovation failure, although they can risk missing opportunities (e.g., profit or development). This is consistent with studies highlighting that firms can benefit from more observed failures to improve their estimates of the risky and harmful actions leading to failures (Greve and Rao, 2006).

Accordingly, an interviewee highlighted that "*observing failures of others has helped us to have a more careful and thrifty approach to an innovation project we are undertaking and to avoid setting up some experiments which would have been costly for us.*" Similarly, another one underlined the importance of observing multiple failures: "*after our failure, we have observed about four failures of other companies in our same sector, namely the energy sector and alternative or renewable sources. We have paid attention to the evolution of the sector and their strategy within this specific industry*".

Finally, most interviewed start-uppers highlighted that after the innovation failure experienced, they introduced changes in how they look for breakthrough opportunities to innovate and examine provenances such as future predictions and recombinant innovations. A founder underlined that "*we had to rethink how we operate and try to innovate; a change was necessary, and we started to give more weight to market forecasts and the main technological innovation trends in our sector to evaluate evolutions better and where to position ourselves.*"

4.1.2. Internal evaluation

In addition to the above-discussed external monitoring strategies, the start-ups' founders shared their experiences with practices and strategies adopted for internal evaluation. In this sense, start-ups can compare external opportunities with internal competencies and implement learning exploitation strategies. Several start-ups implemented as a response to failure an examination, sometimes concomitant, of cost/revenue and risk/benefit. The traumatic effects of innovation failures have led them to design innovation activities carefully and monitor the related costs and underlying risks. Some founders highlighted that this practice is beneficial and that new companies usually overlook it. For example, one interviewee stated, "[after experiencing failure] *we started implementing cost/revenue analysis followed by a realist risk/benefit evaluation by the whole team.*"

Start-ups frequently adopt feedback-seeking behaviours to reduce perceived uncertainty and risks. They can benefit from positive and negative feedback; the latter is beneficial compared to internal resources and capabilities to trigger learning. A founder pointed out that "*for our start-up, feedback is a vital source to implement and further improve our products; before our failure, we didn't consider it systematically, but now we are more aware of its importance. […]. Furthermore, I can say that this practice is very functional and is helping us to avoid further errors; therefore, I would certainly recommend it to other start-ups.*"

Several founders reported that after the innovation failure, they were now capable of more effectively assessing risks and lowering them as they had more knowledge and understanding of technologies that may be at an early stage and not yet known to the market (such as cryptocurrencies, blockchain, specific batteries, and applications) as well as dynamics of the market and the competition. A founder reported that "*failure for us was a learning opportunity. Risks were lower thanks to the advancements of specific technologies such as digital platforms, and we could implement innovation activities in unexplored markets; thanks to the new knowledge acquired, we could implement new and better changes by combining them with our existing basic knowledge and competencies*".

4.2. Seizing

The interviews revealed that start-ups responded to innovation failures by implementing new strategies to interact with the external environment, including new resource acquisition and mobilization methods for value creation and capturing.

4.2.1. Resource acquisition and mobilization

Networking and partnering. During the interview, several founders

mentioned that they were very active in networking and partnering to cope with uncertainty. They gathered experience from their previous failures and realized the significance of seeking strategic partners to share the risk of innovative projects and avoid future innovation failures.

> To quote a start-upper: "*The failure harmed our business and negatively impacted our ability to undertake other risky innovation activities immediately; in such a situation, we decided to search for a strategic partner, a company bigger than us, with more industry experience and better equipped in terms of resources. This represented a reassurance for us to share the risk with someone else, potentially able to mitigate it.*"

> Partnerships can take many forms and provide value in different ways, including but not limited to financing, expertise, technology, knowledge, and access to networks. A founder stated that "*our new partner, a big company in the field of software, helped us to mitigate our uncertainty and to develop the new service; additionally, they helped us to improve our distribution channels*."

Founders underlined that alliances were developed not only with large firms but also with small businesses. Both types of partners allowed them to share the risk and develop crucial innovation activities together. Smaller enterprises are beneficial for critical phases like feedback, beta-testing innovative products, and facilitating dialogue with customers and actors, while large firms provide necessary support due to their greater resources. For example, a founder stated that "*for our subsequent innovations to be effective, we have chosen not only large partners but also smaller ones; the latter helped us in some phases that had been in a certain sense neglected, or sometimes even avoided by the big ones, such for example a more direct and time-consuming phase such as initial feedback on the innovative service and the direct dialogue with some users selected as champions*."

In addition to the size of the firms, the start-ups were looking for expert actors who could compensate for their shortcomings in terms of experience and knowledge. The opportunity to work and relate to subjects more expert than them was perceived to avoid or at least reduce mistakes; this is also possible thanks to combining the partners' experience and knowledge with their own. A founder noted, "*After the failure, we needed the support of some more experienced people; we were not looking for funding or other resources, but an experience*."

Moreover, other actors/players in the innovation ecosystem provided practical knowledge to continue the path of innovation after an initial failure. Among them are universities, incubators/accelerators, dedicated hubs, and specific start-up initiatives that bring access to networks with professionals, firms, and investors. This is very useful for start-ups to speed them up and receive support (e.g., mentoring and networking). A founder stated, "*After the bad experience of a failed innovative project, we felt alone and left to ourselves; however, looking around, we found various initiatives ready to help us try again with a second project; with our team, we participated in an acceleration call, and we received useful help from experts in the field*"; similarly, another founder reported that his start-up received support from university researchers, met during an innovation fair, an event related to technology transfer, and also from a local incubator.

New strategies for resource mobilization. Founders were seeking more than just networking and partnering after the innovation failure experienced; they were also seeking new resource mobilization strategies. Start-ups undertake actions to access new and strategic resources regarding financial capital, skilled workers, and knowledge (e.g., tacit knowledge).

New and alternative sources of financial capital were helpful in start-ups to support new product/service development and commercialization. New and specific forms of innovative or alternative financial resources, such as crowdfunding, minibonds, and microfinance tools, have appeared recently. The failure pushed start-ups to experiment with these new forms. A founder reported that "*after having previously experienced a failure with one of our services - we decided to use crowdfunding to have faster access to financial resources than traditional funding channels, and because we believed that such a system could help us a lot in the marketing phase by being able to count on a crowd of supporters who would therefore be our first customers. And in fact, it was, so in this sense, it was a profitable experience*."

Failure also pushed start-ups to acquire new knowledge after an innovation failure—founders aimed at gaining knowledge about market trends, competitors, and products. The new knowledge helps them overcome uncertainty and risk aversions. An entrepreneur stated that "*we were quite suspicious about the further development of an innovation that we were carrying out after the success of the proof-of-concept phase, i.e., about a TRL 3; in particular, we had some doubts about the evolution of the specific market segment and how consumers could perceive it; therefore, we needed new and additional knowledge for these purposes*". In some cases, the existing relations with some partners favoured connections to tacit knowledge. By contrast, the knowledge provided by customers in some specific events (such as a crowdfunding campaign or an application to call for co-design of products) was helpful to change the trajectories of the innovation activities.

Attracting new skilled and talented employees represented an opportunity for start-ups to improve their human resources base and face future changes. Our interviews have demonstrated that developing a qualified team is seen as one of the actions companies need to overcome initial obstacles and avoid future failures. A founder said, "*To challenge the market and bring our innovative activities to higher levels, we cannot succeed without including new people who know how to use specific technologies and software. Therefore, we consider them vital to avoid failures.*" another reported that "*our company has two founders, apart from us there are only two employees, so our start-up is a sort of micro-enterprise born to try to develop an innovative project focused on the exchange of goods and services; however, the first unsuccessful attempts and therefore the failure of both service and business model innovation forced us to turn to other types of development and services. Now we have expanded the team and added new employees; in this way, we should have a better chance of success*".

The open approach suggests that the process of acquiring new knowledge mostly happens outside the start-up. Frequently, founders tried to gain new knowledge from their customers/users or partners ("*We decided to leverage an open approach before we were mainly closed to the external, but it is a powerful aspect to exploit*"). In some cases, recruiting these new employees was possible thanks to the relationships with stakeholders that acted as catalysts/facilitators.

Digitalization. Several interviewed start-ups understood the importance of embracing digitalization as a transformative process, particularly after experiencing an innovation failure. Digitalization represents a valuable step for new ventures to improve their performance continuously. Founders declared that they are searching for new technologies to enhance the innovation activities of their start-ups. As stated by one of them: "*We decided to use some new technologies that we didn't use before, such as artificial intelligence, cloud computing and digital platforms; this helped us to have significant improvements in terms of innovation outcomes*"; or in another case: "*the use of new technologies is vital for start-ups these days; we are no less, and we always try to be efficient and avoid future failures by exploiting the potential of the latest technological discoveries*". These firms benefit from new technologies like digital platforms, AI, blockchain, etc.

New and small businesses like start-ups often need to be equipped more from a digital/technological point of view, given the high costs to fully incorporate and exploit such systems. Their digital infrastructure can be weak and inadequate to compete in the market. Furthermore, this weakness may lead to slowdowns in innovation activities. To solve this potential issue, several start-ups are actively searching for digital technologies to strengthen their digital infrastructure. A founder said, "*Our company is a little behind in terms of being equipped with the latest digital technologies; after an initial failure of product innovation, we became aware of this limit, and we tried to implement new technologies to make up for it*

suddenly and therefore have an adequate infrastructure for our new and imminent needs of an innovative as well as competitive nature."

Interviewees reveal that they are frequently trying to leverage new digital technologies to acquire, assimilate, transform, and exploit external knowledge. This means that they not only absorb but also interpret and transform the acquired knowledge coherently with their innovation processes to improve their existing products/services or to create new innovative ones. A founder said, "*Digital technologies had a valuable power for our start-up. They helped us to improve our capacity to acquire, transform, and exploit knowledge from outside, while, many times before, we had failed in this*."

4.2.2. Value creation and capturing

Start-ups have developed new strategies for value creation and capturing actions, taking into account the new understanding of the environment and the resources acquired following the experienced failures. These include new targeted strategies or even overall business model changes.

Targeted changes – strategies. Targeted changes to existing strategies allowed start-ups to create and capture value more effectively. Start-ups try to introduce targeted innovation strategies by assessing the scope of the challenge they meet each time. Indeed, the challenges are unforeseeable; therefore, firms must attempt to navigate uncertainty. A founder stated "*We thought our strength was the product, but we found that customers weren't as impressed with the performance as we expected. So, we have focused on the quality of the service and, above all, on the training that we provide together with our platform.*"

Start-ups introduce changes and adjustments of various kinds and then activate continuous review or refinement processes ("*We tried before to adjust what was possible, and then we opted for targeted and more radical changes*"). These changes or adjustments are related, for example, to the development (and management) phases of technological innovations, the introduction of innovation in the market, and so on.

Business Model changes. Founders reported that failures have led them to make substantial changes in the BM to change the trajectories of the business and succeed on the market. The experienced mistakes let them understand the pitfalls and strengths of their BM, as stated by a founder "*We immediately thought about changing the business model because somehow it didn't work; hence, we have tried to capitalize on the knowledge gained from our failure and now we focus on a different configuration based on a specific and more targeted market segment, value creation for our partners and value distribution differently between the stakeholders"*. The failure acted as an experimentation process to understand if and to what extent the adopted BM was working and the need to change it. This is a common feature of many start-ups' learning process that have reconfigured their BM after an innovation failure.

The changes in the BM were in several phases of value creation, configuration, capture, and distribution. An emblematic case was a founder that said, "*We found ourselves having to make important decisions after the failure; first of all, it was important for us that our customers and users were satisfied. This happened by giving them new and additional services and making them participate in developing the new project; furthermore, we had to consider some aspects such as their data and the value to attribute to them.*". Another founder underlined that their innovation failure related to the BM was in the phase of "*creating more value for our final customers and involving them in the development step of our product innovation process*." Similarly, an interviewee said that "*we tried a novel approach to innovate and create value for our partners, but without success*." A start-up, whose service is based on an innovative digital platform, faced problems related to the two sides of the market identified (with the related revenue stream), failing in creating value for both the parties and facing the well-known chicken-egg issue/paradox. In this case, they faced an innovation failure in the phases of value configuration (structure of their BM, in terms of the composition of resources/capacities to implement innovation processes to further develop the platform, and the connections between systems) and capturing (in particular in terms of value capture by the platform itself and the supply-side actors within it, and also of value distribution). Some respondents highlighted failure in more than one phase and due to the novelty of the innovation initiative, e.g., "*We tried to do things differently with our innovative business but, perhaps, we cannot change the 'rules of the game' in the service industry; apart from that, in our case, I think we failed to create and capture value.*"

Most of the interviewed start-ups reported that after a failure they feel more equipped to see their BM more critically and be ready to make changes if necessary to better fit the market and competition. The learning opportunities emerged from their experiences of failures were useful to effectively calibrate customer targets and develop a more in-depth understanding of their operation processes. They learned the importance of implementing specific internal actions such as internal meetings to discuss changes to be made to the BM, investments in new technologies and market research, sometimes through specific external consultants, and in other some cases, also the hiring of new employees, albeit with occasional or part-time collaboration relationships.

4.3. Transforming

The start-ups that were part of our study provided valuable insights into specific actions that could be taken to introduce changes at both the team and organizational levels. These changes had the effect of integrating the novelty brought about by the experienced failure into the regular structure and processes of the organization.

4.3.1. Team-level entrepreneurial learning

Start-ups, especially in the initial stages, are entrepreneurial teams looking for a business model and a higher level of structuring. Entrepreneurial team-level learning processes are an essential element of growth at this stage. They involve both team development activities and competence development activities through group reflexivity.

Team development. Failures are potentially traumatic events that generate distrust and uncertainty about the future. In this scenario, founders found out that it is essential to create trust within the team and a safe environment from a psychological point of view. A demoralized team that lacks trust can significantly damage both the work environment and the ability to innovate. Founders often strive to enhance the organisational atmosphere following failures by fostering a psychologically safe environment. In such a space, everyone should feel empowered to freely share their thoughts, ideas, and opinions without fear of negative repercussions. A founder stated, "*It was essential to ensure the sense of safety for our team; having a psychologically safe environment represents the only way, in my opinion, to overcome the difficulties faced recently […], no one should feel in danger, impute mistakes to others and not express their opinions*".

Start-ups inherently carry risks associated with innovative endeavors and objectives. Ventures of this nature are prone to facing setbacks and failures. Employees who feel motivated, secure, and trusted are more likely to be committed and engaged in their work and face failures. Therefore, start-ups that offer incentives to their employees can bolster this level of dedication, fostering a culture where the team is more inclined to strive for improvement and resiliently pursue success, even in the face of previous failures. Therefore, motivating employees has positive effects, particularly in innovation or R&D teams where risk-taking and exploration are critical. Accordingly, a founder reported that "*we always try to motivate our employees, being a new and small firm, although with ambition, we should share the same vision and to be in a sense all aboard on the same 'ship'; hence, we included incentive mechanisms and favoured moments of brainstorming*". Another founder pointed out, "*We decided to implement specific systems to manage the conflicts, and I can say that it works well.*" This also emphasizes the importance of start-ups implementing conflict management systems that can positively affect their employees and the subsequent capacity to innovate and undertake risks.

Team reflexivity. Start-ups can also benefit from higher levels of team reflexivity. Employees must discuss negative and positive innovation

outcomes/results for these ventures. One of the interviewees stated: "*After the failure, we needed to implement and increase discussions and reflections within our company's team; we believe it is important for positive results, but also, and maybe more important, for negative ones; without this, it will be difficult to change our practices in a useful and efficient way and hence avoid failures shortly.*"

Start-ups benefit from revising practices and innovation objectives through continuous revisions according to the team's shared vision. Such an approach can led start-ups to refine processes and, at the same time, increase flexibility, i.e., the capacity to adapt to changing scenarios. Among the phases of revising practices described by the founders are problem elaboration, solution, improvement, prototyping, and value analysis. Frequently, start-ups seek greater team cooperation that can lead to significant benefits. A founder stated, "*With increased cooperation, we all grow together and avoid more missteps*".

4.3.2. Organizational level learning

In transforming start-ups into established firms, failures can play a decisive role. Failures induce changes integrated into the entrepreneurial structure and processes, defining traits the organization retains.

Implement new control tools. Most founders reported that after failures, their organizations implemented new forms of control, such as quality assurance and mapping tools. These enhance the entrepreneurs' knowledge of the current status of the venture and its limits. Such an approach provides information on the trajectories of the start-up based on objective measures and its progress/developments.

A periodic mapping of the firm's existing processes and resource structure gives founders a clear picture of what is missing. This represents a vital phase for new and small firms that need to continuously acquire or develop new resources and equipment to survive and improve their competitiveness and performances. Some start-uppers state innovation failures are linked to the lack of control systems that could have helped avoid errors. A founder stated, "*To improve our internal control, we decided to implement a specific data mining system*." Similarly, other start-ups increased their attention level on the quality of controls. To quote another start-upper, "*Our start-up had never been particularly attentive to quality control until we experienced failure; in light of this, we place great importance on quality controls in our new projects*." Another founder stressed the importance of controlling the quality of products/services and data and said, "*We experienced a major change in something we were not used to, that is, the management of big data. Specifically, we faced difficulties and needed to transform most unstructured data into structured ones.*"

New norms and routines. Most start-ups highlighted that they responded to the innovation failure by building new norms or routines and often adapting these routines to the 'new normal', the start-up's new context. Some founders highlighted that they changed their routines because, after the failure, they had found a new balance and shifted their efforts and activities in other directions; the new routines were helpful, for example, to overcome the difficulties, and the pandemic now became everyday life. A founder stated that "*we changed our internal routines to face both a failure mainly due to the COVID-19 pandemic that led us to rethink our business and way to innovate*".

Start-ups have established new specific norms after experiencing a failure, as they believe these norms can help them avoid a second failure. In some cases, interviewees have highlighted that they inevitably changed their modus operandi due to the adaptation to the new reality after the experience of failure. This is because the changes worked well and slowly became new routines. A founder reported that "*when our first idea failed, to avoid closing the business, we tried in every way to find new customers. We exploited the contacts that old customers gave us. We saw that it worked, and it became our way*."

Development of new management practices. In response to innovation failures, new management practices are often developed to reduce uncertainty. These failures often expose the limitations of start-up managers, particularly in terms of resource management. However, the failures also present an opportunity for start-uppers to begin planning, which can help them identify existing and potential resources in accordance with the objectives of their company. Start-ups need to have the ability to manage strategic resources for their core business. These resources include raw materials, human resources, finance, Intellectual property rights (IPRs) new technologies, and both tangible and intangible assets. Even if a start-up fails, it must continue to develop these abilities for future success. Several founders highlighted the need to improve the management of resources in the sense of increasing efficiency. This is a critical phase as resource constraints characterize start-ups; hence, managing these scarce resources should be a primary goal of these ventures. A founder said: "*One of our limitations was a less efficient management of some crucial resources such as funding and intellectual property rights; hence, it was a vital and new imperative for us to improve these management areas*."

Many founders highlighted that their firms implemented new strategies to manage and limit the use of specific resources that were (very) often limited. Some of them, for example, reported that it was essential to manage the resources more effectively based on the underlying risks of the projects. In this sense, some start-ups have begun rationalizing resource use by envisaging a more structured management plan. As stated by one of the interviewees, "*Being a start-up established two years ago, we have limited resources and assets, so it is essential for us in the future to avoid waste and unnecessary risky projects*."

Others, after failure, pay increasing attention to and try to introduce practices related to the circular economy, recycling, and waste management.

5. Discussion

Start-ups are organizations designed to experiment with technologies and BMs (Blanc, 2010), and failure is inherently part of their experimental nature. Adopting a qualitative analysis based on multiple case studies selected from the Italian context, this study provides insights into how start-ups translate innovation failure experiences into new growth strategies. Although failure can be fatal for start-ups, it can also represent an opportunity to understand the gap between business assumptions and actions and the current competitive reality. So, failure makes start-ups aware of the importance of activating learning mechanisms to develop dynamic capabilities with reflection and inquiry competence to deal with competitive challenges and effectively conceive and manage their innovation processes and products.

The findings of this study pertain specifically to start-ups. While they may also apply to established companies, it is essential to note that the consequences of failure and learning methods vary significantly due to the significant differences in organizational structure and available resources. Therefore, to generalize the insights of this study, it is crucial to consider the contingent context of the application and subject it to a test for corroboration.

This study suggests that start-ups should view failure as an opportunity to learn and use the lessons learned to develop new strategies and practices to prevent future failures that could be detrimental to the business. To manage the learning process successfully, having people act as learning agents is crucial. Entrepreneurs play an essential role in this regard since they need to scan the external environment by observing the experiences of others, promoting experimentation, gaining a better understanding of internal resources, identifying crucial external knowledge to acquire, shaping networking to access relevant know-how and rethinking the business model based on a more refined understanding of the market. To succeed, start-ups must prioritize learning mechanisms and cultivate a secure learning environment as knowledge-creating companies. The learning mechanisms can take different forms, such as participation in acceleration programmes and innovation fairs, providing connections to expert knowledge, and getting access to support systems like university researchers and local incubators; exploiting customer feedback and co-design opportunities during events like

crowdfunding campaigns that can also be instrumental in redirecting the innovation trajectory; and by hiring skilled and talented employees enhancing the start-up's human resources.

The first consequence of failure experiences is that start-ups change how they monitor the environment for innovation opportunities and how these opportunities are evaluated against internal capabilities. While velocity is a characteristic of start-ups (Harms, 2015), after experiencing failures, young firms learn to consider the correct timing for their decisions and to wait before acting. If, from one perspective, not being a first-mover implies the loss of advantages (for example, deriving from technological leadership), by contrast, start-ups can obtain advantages such as a reduction of uncertainty. Entering the market after resolving uncertainty is a well-known risk-reducing strategy (Eggers, 2012). In particular, the validation of innovations, ideas, and technologies has been indicated by start-uppers as a phase in those failures and has proven to deserve more time and attention. Validation is often considered a vital step for start-ups (Ries, 2011), as it leads to building a sustainable business by supporting learning and translating experiments into actions.

Failure pushes start-uppers to seek efficient forms of learning to identify new strategic routes of growth. Insights from studies have shown that firms can learn from the experiences of others, highlighting the importance of organizational learning (Levitt and March 1988). The observation of the failures of other firms can represent an essential venue for learning (Greve, 1996; Greve and Taylor, 2000; Greve and Rao, 2006). Greve and Rao (2006) provided evidence that firms' failure rates were reduced by observing the failures of others before and during the lifetime of organizations and that they learn more efficiently from these failures of others than from their own experiences. Our analysis demonstrates that this form of learning, vicarious learning (Huber, 1991; Roberts, 2010; Rosemberg, 1982), represents a vital learning mechanism for start-ups, which generally tend to limit themselves to looking internally for the solutions they require.

A crucial insight is that after experiencing innovation failure, start-ups are more attentive to feedback and carefully assess opportunities based on the organization's skills. This is consistent to other studies that suggest that failure can activate a feedback analysis, leading to changes in innovation processes (Maslach, 2016). A second area in which the investigated start-ups have demonstrated that they turned learning from failures into the formulation and implementation of strategies to take advantage of external opportunities is a more thorough evaluation of their business ideas. Indeed, a start-up is generally born around an idea (Colombelli et al., 2016). When this idea is totally or partially a failure, start-ups are pushed to develop systematic research methods, exploit opportunities, and formulate strategies.

To overcome their limits regarding resources, referred to as liability of smallness and newness (Stinchcombe, 1965), the start-ups learning from failure push them to build a network of external partners to collaborate with given future opportunities. They experiment with a broader spectrum of strategies for acquiring resources of various natures. Crowdfunding is an emblematic example: many start-ups use reward-based crowdfunding models to raise funding and collect feedback by pre-selling their innovative products/services (Belleflamme et al., 2014). Digitalization also has a vital role in improving their competitiveness (e.g., in terms of cost reduction) and ability to innovate (Troise et al., 2022). Digital technologies provide an infrastructure that supports innovation. Nambisan (2017, p. 1032) described a digital infrastructure as "digital technology tools and systems (e.g., cloud computing, data analytics, online communities, social media, 3D printing, digital maker spaces, etc.) that offer communication, collaboration, and/or computing capabilities to support innovation and entrepreneurship." In supporting start-ups, digital technologies play a vital role in improving their innovation processes (Jiménez-Barrionuevo et al., 2011) by increasing their absorptive capacity (Molina-Morales et al., 2019; Cuevas-Vargas et al., 2022). This confirms Huber et al. (2020) study which demonstrated that the implementation of technological tools supports the system of assimilation, acquisition, transformation, and exploitation of knowledge for innovation purposes, and of Daniel and Huang (2019, p. 14), who underlined that this nexus (i.e., between new technologies and absorptive capacity) "*is essential for firms to generate new knowledge resources and develop latent knowledge if firms can use this knowledge nexus with a tacit-explicit-latent perspective knowledge.*"

For start-ups, failure becomes a driver to reflect and inquire about their business model. The learning process assists them in formulating and experimenting with strategies and new ways of acquiring and combining resources to create, deliver, and capture value (Johnson et al., 2008; Teece, 2010). This generates that evolution process that characterizes the transition from a start-up to a consolidated firm. The third key finding from our research reveals that start-ups are adept at assimilating the lessons from innovative failures and integrating them into their daily operations. This process effectively transforms the organization, enhancing its structural maturity. Notably, some of the most significant changes take place within the entrepreneurial team itself, where the insights from setbacks catalyze a more robust and systematic approach to their collective work.

Start-ups in their initial stages are little more than teams of colleagues, and only later do they transform into structured organizations (Ries, 2011). It is essential to avoid failure that undermines the innovative capacity of the team. Several studies underlined the importance of creating a safe environment to maintain members' cohesiveness, learning ability, risk-taking behaviours, and work engagement (Edmondson, 1999, 2004). This environment allows team members to cultivate confidence (e.g., propensity for risky activities or experiments) and avoid fears related to punishment for mistakes. West (1990) reported that psychological safety plays a crucial role in producing innovation in groups, while Gu et al. (2013, p. 91) specifically focused on new technologies and argued that "*In teams where a sense of psychological safety can be established, members are willing to voice their concerns and act on crucial information from each other; as such, speaking-up has been considered a predictor of successful implementation of new technologies*".

Furthermore, group dynamics and team reflexivity represent crucial elements for the start-up to exploit failure as an opportunity to learn and acquire new skills. Schippers and Den Hartog (2007, p. 189) reported, "*Reflexivity — the extent to which teams reflect upon and modify their functioning — has been identified as a possible key factor in the effectiveness of work teams*". Several scholars highlighted the critical role of reflexivity in innovation teams, understood as a deliberate process of discussing innovation outcomes and revising practices accordingly (Schippers et al., 2014, 2017). Such processes/practices can assist teams to avoid failures in their innovation projects (Cannon and Edmondson, 2005).

After a failure, start-ups change their routines and the rules that govern their operation. In the phase following the failure experience, learning processes take place to consolidate the new practices. Frequently, firms can restructure the norms in challenging and turbulent environments (García-Morales et al., 2009). Thus, founders can challenge existing norms and discuss new routines (Schippers and Den Hartog, 2007). In some cases, start-ups develop the level of their internal routines, modifying them to efficiently perform tasks such as managing experiments, innovation processes, and assimilating knowledge (Camisón and Forés, 2010).

5.1. Theoretical contribution

This study contributes to advanced theory in several ways. It first provides conceptual insights, based on empirical evidence, to better understand the learning mechanisms in start-ups (e.g., Steiber et al., 2020; Corvello et al., 2023) and specifically how they can learn from failure (Leoncini, 2016; Hartley and Knell, 2022). It confirms other studies in the literature that learning is one of the main concerns of start-ups and takes place at several levels: individual, team, and organization (Harms, 2015). Start-ups leverage learning processes involving

external (Almeida et al., 2003) and internal (Sommer et al., 2009) actors and resources. The literature on learning from failures highlights those failures in innovation are relatively in an early stage but suggests that a proactive approach can assist organizations in turning crises into opportunities for redefining their strategy and business model, fostering growth (Qin and van der Rhee, 2021; Hartley and Knell, 2022). This study confirms that failures challenge the vision of the environment and organizational functioning (Guzzini et al., 2018). In start-ups, this happens for the first time and in a context of high agility, ability to learn and innovation (Harms, 2015). So, failures contribute to the learning processes of start-ups and their transformation into structured businesses.

The study also contributes to the organizational learning theory. It highlights how failures can represent a vital opportunity for start-ups to activate learning processes (Guzzini et al., 2018). Sometimes, start-ups limit their processes to specific activities, objectives, acquisition methods, and resource utilization. However, failures force them to re-evaluate the underlying assumptions of their innovation process. Resorting to the classical distinction by Argyris and Schön (1978, pp. 2–3), an alternation and interweaving of single-loop and double-loop learning is observed: failure challenges the start-up's perception of the environment, questioning entrepreneurs' assumptions and prompting start-uppers to reformulate them; after the initial 'shock', learning processes tend to be more incremental, aimed at refining business practices and routines.

The insights of our study suggest that in the case of start-ups, the boundaries between the two types of learning appear more blurred. Start-ups are relatively unstructured organizations (Baloutsos et al., 2022): entrepreneurs' mental models, business routines and practices, and decision-making models are only sometimes consolidated. Indeed, the mental and decision-making models are in the formation process. Double-loop and single-loop learning are continuously intertwined. The metaphor for this learning process is a spiral, in which, starting from the experience of failure onwards, the learning cycles get tighter and tighter from radical to incremental change.

Finally, the study contributes to the literature on dynamic capabilities (Teece et al., 1997; Teece, 2018). The analysis of entrepreneurs' responses to failure in innovation highlighted learning processes in three areas that can be traced back to the three main dimensions of the dynamic capabilities proposed by Teece: sensing, seizing, and transforming (Teece, 2018). Our study has highighted that start-ups can benefit from failure as it presents an opportunity to develop dynamic capabilities. By analyzing and learning from their failures, start-ups can improve their ability to interact with their environment and manage internal transformations. We contribute to the literature on dynamic capabilities, highlighting how failure in innovative processes can be an opportunity for their acquisition and development. By analyzing the issue in the context of start-ups, we help to understand how dynamic capabilities are developed in an area of particular interest, namely that of young innovative firms in consolidating.

5.2. Managerial implications

For practice, the study offers implications that can support start-uppers, entrepreneurs, and managers to understand how to approach failure in their endeavours and the strategies they can implement to turn a failure into a lesson learned to move their business to a new level. The first relevant implication is acknowledging the entrepreneurs' importance in systematically addressing learning from failure. Start-uppers must develop a mental propensity towards reflection and inquiry to translate failures into learning opportunities to build their business. When failure cannot be avoided, it should translate into an opportunity to assess business assumptions and processes, distinguishing the business model with openness towards the definition of strategies that can help overcome the shortfalls.

This study outlines the strategies that start-uppers should consider when establishing their business idea and revising its validity. The classification of these strategies following the dimensions of the dynamic capabilities model offers an interpretive lens to identify the vital capacity that start-ups should develop to go from establishment to consolidation. The three essential dimensions of the dynamic capability, i.e., sensing, seizing, and transforming, should be considered as the approaches to building a capacity of "learning from failure."

Finally, although innovation failure is certainly not a desirable outcome, it needs to be considered by start-uppers as an inherent dimension of their business, given start-ups' experimental and innovative nature. The study provides directions for overcoming the crisis generated by the failure through interventions directed at consolidating the entrepreneurial team and the organizational structure and processes and changing the modes of interaction with the external environment. Furthermore, the study offers insights to all those interested in innovation and start-ups, such as policy-makers, innovation managers in large firms, and ecosystem innovation intermediaries, suggesting that failures should be seen as part of the journey of start-up formation and growth. Therefore, there should be resources and institutional initiatives that could support start-ups going through a learning process from failures to make sure that the failure is translated into strategies of growth.

5.3. Limitations and future research

Although the study makes an original contribution to understanding how start-ups can learn from failures and develop dynamic capabilities, it presents limitations that need to be acknowledged to generalize insights. The first critical limitation is the context-dependent nature of the empirical study. It focuses on a sample of Italian start-ups. Even if the Italian case presents elements of interest, contextual factors, like the national culture or legislation, could have affected the results, potentially limiting their generalizability. Furthermore, this study focused on small early-stage start-ups. The start-up concept, however, also includes more prominent and mature firms. Our results should be carefully evaluated before extending them to this type of organization.

We only used one source of data (i.e., one informant) per organization. Even if this practice is quite common in studies involving entrepreneurial ventures, where the entrepreneur is assumed to have deep knowledge of the organization, this could have introduced bias in our data. Future research should consider multiple informants and triangulate between sources of data. Moreover, start-ups in our sample have been purposefully selected, which can be another source of bias.

Our study considered a broad and diversified spectrum of phenomena that may fall under the definition of innovation failure. Organizations may react differently to failure depending on its nature (e.g., technological or market) and severity. Future studies should look at what happens as the type of failure faced by start-ups varies.

Future research venues should extend the sample of case studies to explore if different contexts of analysis affect the implications of the analysis. Furthermore, the qualitative investigation could be triangulated with a quantitative research to identify and validate the constructs of start-ups' strategies of learning from failures and run an inquiry to systematically outline what strategies are more significant to support the development of dynamic capabilities of start-ups when facing failures.

6. Conclusions

Our study analyzes start-ups' reactions to innovation failure and the learning processes these experiences activate. It underlines how start-ups are organizations created to experiment with new technologies and business models. They are naturally prone to innovation failures and require effective learning processes. The study analyzes the responses of start-ups using a theoretical approach that combines organizational learning theory and dynamic capabilities theory. The results presented in the article contribute to understanding the dynamics of start-ups' growth and the phenomenon of learning from failures. They

significantly impact entrepreneurs, managers, and policy-makers interested in innovation processes and negative experiences' role in the difficult path that leads to success.

Declarations of interest

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CRediT authorship contribution statement

Vincenzo Corvello: Conceptualization, Investigation. **Ciro Troise:** Formal analysis. **Giovanni Schiuma:** Investigation. **Paul Jones:** Formal analysis.

Data availability

Data will be made available on request.

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