Technovation 127 (2023) 102830

Contents lists available at ScienceDirect

Technovation

journal homepage: www.elsevier.com/locate/technovation

To learn or not to learn from new product development project failure: The roles of failure experience and error orientation

Xiangming (Tommy) Tao[a,*], Paul J.A. Robson[b], Catherine L. Wang[c]

[a] Science Policy Research Unit, University of Sussex Business School, Brighton, BN1 9SN, United Kingdom
[b] School of Business and Management, Royal Holloway, University of London, Egham, TW20 0EX, United Kingdom
[c] Brunel Business School, Brunel University London, Uxbridge, UB8 3PH, United Kingdom

A R T I C L E I N F O

Keywords:
Learning from failure
Innovation failure
Error orientation
New product development
High-tech ventures

A B S T R A C T

New product development (NPD) project leaders' learning varies after experiencing project failure, as not all failure experience equally promotes learning and not all project leaders equally learn from failure. Drawing on the sensemaking and error management perspectives, this study focuses on two research questions: to what extent does project failure experience (i.e., the percentage of project failures in the overall project portfolio managed by a project leader and the time elapsed since last project failure) affect NPD project leaders' learning from failure? To what extent does a project leader's error orientation (i.e., error competence and error strain) moderate the effect of project failure experience on NPD project leaders' learning from failure? Based on survey responses collected at two distinct time points from 237 NPD project leaders in high-tech ventures, our results show that the percentage of project failures negatively affects learning from failure, and their negative relationship is weakened as error competence increases. In contrast, the time since project failure positively affects learning from failure, and their positive relationship is weakened as error strain increases. Our findings emphasize that a simplistic approach to learning from failure fails to uncover the transformative mechanisms involved in turning failure into learning in the NPD process. Instead, we suggest a customized approach to comprehending how project leaders can capitalize on project failure considering their failure experience and error orientation to learn from NPD project failure.

1. Introduction

Innovation is a tempting yet challenging journey fraught with challenges and even failure (Forsman, 2021; Wang, 2023). This is particularly true for innovation projects (Morais-Storz et al., 2020; Puliga et al., 2023; Qin and Rhee, 2021), such as new product development (NPD) projects, that form the lifeline of high-tech ventures (Chang and Taylor, 2016). These projects are inherently risky, making failure a likely outcome (Urbig et al., 2013; Hu et al., 2017). However, the fact that an innovation project failure event increases ambiguity can trigger sensemaking (Morais-Storz et al., 2020), which can serve as a fundamental learning experience (Shepherd et al., 2011, 2014). While research on learning from innovation failure has gained momentum recently (for a review, see Rhaiem and Amara, 2021), the literature lacks a clear understanding of the factors that determine whether individuals will learn from failure or not, particularly in the NPD context. To gain a better understanding of how individuals learn from project failure, our study focuses on the project failure experience of NPD project leaders, as well as their behavioral and emotional tendencies towards project failure, both of which may jointly impact their learning from NPD project failure.

Despite acknowledging that innovation failures can differ on multiple dimensions and not all failures equally stimulate learning (Khanna et al., 2016), most existing studies to date have not distinguished between the nature of such failures (Baxter et al., 2023). As a result, the relationship between project failure and learning from failure remains inconclusive. For instance, Shepherd et al. (2013) conceptualize that employees who experience more negative emotions from entrepreneurial project failures will learn less than those who experience less negative emotions. However, within a research project context, Shepherd et al. (2011) find that scientists learn more from research project failures when they have greater time since their last project failed. These complex findings prompt our first research question: *To what extent does NPD project leaders' project failure experience affect their learning from NPD*

* Corresponding author.
E-mail addresses: X.Tao@sussex.ac.uk (X.(T. Tao), Paul.Robson@rhul.ac.uk (P.J.A. Robson), Catherine.Wang@brunel.ac.uk (C.L. Wang).

https://doi.org/10.1016/j.technovation.2023.102830
Received 31 March 2023; Received in revised form 19 June 2023; Accepted 26 July 2023
Available online 4 August 2023
0166-4972/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

failure?

Our study focuses on two main aspects of project failure experience, namely the percentage of prior project failures in the overall project portfolio managed by a project leader (Hu et al., 2017) (henceforth the percentage of project failures), and the time elapsed since last project failure (Shepherd et al., 2011) (henceforth the time since project failure). By doing so, we aim to shed lights on the nature of project failure experience and clarify its thus far inconclusive effects on learning from project failure. Further, as individual learning is the result of personal and situational drivers (van Gelderen et al., 2005), understanding how learning takes place needs to consider individual difference (Seckler et al., 2017). For instance, He et al. (2018) reveal that emotional regulation moderates the inverted U-shaped relationship between business failure velocity and subsequent learning behaviors of entrepreneurs, which suggests that the relationship between project failure experience and learning may depend on the NPD leaders' attitudinal and behavioral tendencies towards failure. Individuals' differing innate attitudes and emotional tendency towards non-attainment of goals as well as related strategies to deal with them are captured by the concept of error orientation (Rybowiak et al., 1999). While it is recognized that error orientation moderates the extent to which a problem promotes or hinders learning (Funken et al., 2020), further investigation is necessary to comprehend the specific effect of error orientation within the NPD context. Therefore, our second research question is: *to what extent does NPD project leaders' error orientation moderate the relationship between their project failure experience and learning from NPD failure?*

The error management perspective deals with the non-attainment of goals and the underlying mechanism of failed goal pursuit (Frese and Keith, 2015). Error orientation has been empirically justified as a boundary condition for turning problems into entrepreneurial learning (Funken et al., 2020). Thus, we argue that an error management perspective provides a useful theoretical lens to distinguish boundary conditions that help explain the transformation of NPD project failure into learning. Two distinctive component factors of error orientation are thus focused in this study. Firstly, error competence (i.e., enhanced confidence in one's ability to handle and recover from errors quickly) suggests a positive behavioral tendency towards learning from failure. Secondly, error strain (i.e., innate emotional tendancy towards errors resulting from fear of making errors) (Schell and Conte, 2008) suggests a negative emotional mechanism towards learning from failure. These two contrasting behavioral and emotional mechanisms are included in this study to help us understand the perplexing relationship between project failure and subsequent learning.

Overall, our study aims to explore whether NPD project leaders learn from failure, using sensemaking and error management frameworks. To achieve this, we conducted a survey at two different time points with NPD project leaders from 237 high-tech ventures in China. Our research contributes to the literature on learning from innovation failure in several ways. Firstly, it helps resolve the controversy surrounding the relationship between project failure and subsequent learning from failure, providing valuable insights into this area of research (Rhaiem and Amara, 2021). Unlike previous studies, which have focused on either overall project failures (e.g., Shepherd et al., 2013) or specific project failures (e.g., Patzelt et al., 2021; Shepherd et al., 2011), our study considers both factors and distinguishes their opposing effects on learning from NPD project failure. By doing so, we provide a more comprehensive understanding of the factors that contribute to learning from project failure in the NPD process.

Secondly, our study takes an error management perspective to examine how project leaders' behavioral and emotional tendencies towards failure (i.e., error orientation) impact learning from project failure in the NPD process. This approach expands the theoretical scope of the error management perspective to include the research field of learning from innovation failure (Rhaiem and Amara, 2021). Furthermore, our study sheds light on the distinct roles of specific elements of error orientation (i.e., error competence and error strain) in facilitating or hindering the transformation of NPD project failure into subsequent learning from failure.

Finally, we add to the literature on learning from failure by examining project failures that happen during the NPD process. So far, research on learning from failure has focused on one-off events, such as failure in terms of bankruptcy and termination of the business (e.g., He et al., 2018; Liu et al., 2019; Ucbasaran et al., 2013) or entrepreneurial project (e.g., Shepherd et al., 2009; Shepherd et al., 2013; Shepherd et al., 2014; Patzelt et al., 2021). However, less attention has been paid to learning from project failure that occurs during the innovation process (Salerno et al., 2015). By exploring project failures within the NPD process, our study sheds new light on an area that has been largely ignored in the literature on learning from failure.

2. Theoretical background

2.1. Learning from project failure

Project failure can occur at any stage of the NPD process, ranging from idea generation to full launch (Qin and van der Rhee, 2021). This can be attributed to various factors, including inadequate progress or unsatisfactory outcomes (Morais-Storz et al., 2020). Perceptions of project failure can vary between decision makers, who own the option to terminate a project, and project team members, who are the option (Shepherd et al., 2014). In line with previous studies (e.g., Shepherd and Cardon, 2009; Shepherd et al., 2011), our study defines project failure as "the termination of a project due to the realization of unacceptably low performance as operationally defined by the project's key resource providers (as opposed to projects terminated for other strategic reasons)" (Shepherd et al., 2009, p.589).

When a project fails, project members often perceive a significant deviation from the expected success. This perceived discrepancy serves as a trigger for sensemaking efforts (Shepherd et al., 2014) that prompt individuals to seek explanations and subsequently take actions, such as learning from the failure, in response (Zhang et al., 2022). Therefore, we define learning from project failure as "the sense that one is acquiring, and can apply, knowledge and skills" (Spreitzer et al., 2005, p.538) from their prior experience of project failure. This definition aligns with the sensemaking perspective, placing emphasis on the subjective interpretation of learning by individuals (Byrne and Shepherd, 2015; Shepherd et al., 2011; Zhang et al., 2022).

Although sensemaking primarily occurs in the present, individuals often make sense of situations by drawing upon their past experiences (Morais-Storz et al., 2020). Retrospective sensemaking plays a crucial role in understanding "what happened" in a specific situation, considering one's expectations. It addresses the fundamental question of "what to do now", offering valuable insights and guidance for future actions (Weick et al., 2005). Indeed, sensemaking unfolds as a dynamic process, "which involves the reciprocal interaction of information seeking, meaning ascription, and action" (Thomas et al., 1993, p.240). When individuals acquire information from failure experience and effectively process it to revise their belief systems, new knowledge is created (Shepherd et al., 2011). This sensemaking process thus provides a theoretical framework for understanding whether NPD project leaders engage in learning from project failure during the NPD process.

Drawing upon the sensemaking perspective, prior research has investigated learning from failure across a range of respondents such as entrepreneurs (Liu et al., 2019), employees (Zhang et al., 2022), research scientists (Shepherd et al., 2011) and project members (Morais-Storz et al., 2020). However, there is a noticeable dearth of empirical studies specifically examining learning from project failure within the context of NPD, particularly focusing on the role of NPD project leaders. This is a significant research problem as NPD project leaders play a crucial role in preventing NPD project failure in the first place, making the decision to terminate projects when they fail to meet performance expectations (Shepherd and Cardon, 2009; Shepherd et al., 2014).

Additionally, unlike the one-off events such as business failure or entrepreneurial project failure, NPD project failure can provide project leaders with more opportunities to apply what they have learned from prior failures to new projects by actively re-engaging with the NPD process (Ahn et al., 2005), thereby completing the learning cycle within the continuous innovation. While learning from failure can also take place at both the team and organizational levels (Dahlin et al., 2018), our study focuses on individual-level analysis - NPD project leaders, who serve as the decision-makers regarding project termination within the NPD process.

Processing failure can be challenging, and how to facilitate learning from innovation failure are not fully understood (Kim and Lee, 2020). Understanding what factors facilitate learning from innovation failure can be complex as it involves analyzing different levels of factors (Rhaiem and Amara, 2021). Specifically, project failure can be a double-edged sword: it can hinder learning and restrict the motivation to try again (Shepherd et al., 2013), or stimulate learning and adaptation (Elmquist and Le Masson, 2009). We argue that such a controversial relationship may depend on different dimensions of project failure experience, a distinction that has seldom been made in prior research (Khanna et al., 2016). To better understand this relationship, our study considers two dimensions of project failure experience: the percentage of prior project failures and the time since project failure.

Moreover, according to Zhang et al. (2022), the attitude that individuals hold towards failure plays a pivotal role in the sensemaking process as it influences their interpretation of failure events from diverse perspectives. Our study further investigates how attitudinal and behavioral tendencies towards error (i.e., error orientation) among NPD project leaders affect the failure-and-learning relationship. By doing so, our research endeavors to shed light on the ambiguous relationship between project leaders' project failure experience and subsequent learning while considering their error orientation in dealing with NPD project failure.

2.2. Error orientation

Previous research commonly adopts a shared definition of failure and error due to their interconnectedness, resulting in overlapping mechanisms and findings across studies (Dahlin et al., 2018). They are often regarded as "being unwelcome, harmful, and leading to the non-attainment of goals" (Funken et al., 2020, p.316), which indicate a deviation from expected and desired goals (Seckler et al., 2021). Nevertheless, it is important to clearly distinguish between failures and errors, as they represent distinct concepts. Errors refer to incorrectly executed tasks or routines, whereas failures encompass undesired performance outcomes (Dahlin et al., 2018).

Furthermore, it is essential to note that not every error leads to failure. Some errors can be promptly detected and rectified, while others may occur within a safe environment and not result in failure, which is an outcome stemming from an error (Frese and Keith, 2015).

Error management perspective acknowledges that it is impractical to eliminate all errors and instead focuses on minimizing their negative impact and improving processes to prevent similar errors from recurring (Frese and Keith, 2015). This perspective aligns with the core responsibilities of NPD project leaders in the NPD process, who are accountable for ensuring effective error management (Steele and Watts, 2022). However, despite its significance as a relatively proximal factor influencing learning from failure, error orientation has received minimal attention in the existing innovation literature, with only a few exceptions such as the work of Funken et al. (2020) in the entrepreneurship domain. Our study posits that the error management perspective can serve as a complementary theoretical framework to the sensemaking perspective, providing further insight into how NPD project leaders' error orientation during daily operations of the NPD process influences the extent to which their project failure experiences impact their learning from such failures.

Evidence suggests that individuals tend to adopt a particular error orientation, but a tolerating work environment can modify how individuals view errors (van Dyck et al., 2010). Error orientation consists of varied component factors (Rybowiak et al., 1999), and hence its unidimensionality has been questioned. Error competence and error strain, as salient components of error orientation, have stood the test of time in various research settings (Emby et al., 2019; Hetzner et al., 2011; Schell and Conte, 2008). Error competence is defined as one's perception of own ability to handle and recover from failures in the short-term, while error strain is the innate negative emotional tendencies towards failure due to fear of committing an error (Rybowiak et al., 1999) (different from the negative emotions triggered by failure experience, which we will discuss later). Together error competence and error strain depict behavioral and emotional tendencies towards errors (Schell and Conte, 2008).

It is worth noting that error competence and error strain gauge individuals' innate tendencies towards errors, rather than response to a specific error. They are expected to be negatively correlated but conceptually distinguished from each other, making them suitable for clarifying the specific functions of representative behaviors and emotions towards failure in our context – NPD project failure. Accordingly, below we delve into the relationships between project failure experience and learning from failure, and further explore the moderating roles of error competence and error strain in shaping these relationships.

3. Hypotheses development

NPD projects that are important to employees often engender feelings of psychological ownership (Pierce et al., 2001), where they feel they have control over them, and a deep knowledge of them (Shepherd and Cardon 2009). After experiencing project failure, project leaders may undergo negative emotions such as grief (Shepherd et al., 2009). While negative emotions can initially stimulate an individual's focus on the causes of project failure, they can also hinder learning from failure, particularly when they accumulate across multiple project failures (Shepherd et al., 2013). The process of contemplating the causes behind a high percentage of failures and dealing with associated negative emotions can trigger ruminative thinking (Nolen-Hoeksema et al., 2008), diverting individuals' attention towards the negative emotions triggered by failure rather than the actual causes of the project failure (Shepherd et al., 2013). This negative cycle of thinking can perpetuate a cascade of ruminations, further amplifying negative emotions and narrowing an individual's attention (Shepherd et al., 2009). Consequently, it hampers the sensemaking process, including information seeking and interpretation of meaning. As a result, learning from project failure is adversely impacted.

Further, a high percentage of project failures can have detrimental consequences, including dysfunctional or pathological consequences (Shepherd and Cardon 2009). These consequences may manifest as self-doubt, helplessness, and self-stigmatization (Seckler et al., 2017), all of which impede learning from project failure (Shepherd et al., 2013). NPD project leaders who experience self-stigmatization are likely to suppress their inclination to discuss prior project failures and seek feedback from other team members involved in the same projects. This, in turn, has a detrimental effect on their learning from failure. Notably, as project leaders accumulate more project failures, they are more prone to feelings of helplessness and self-stigmatization. Thus, a higher percentage of project failures in the overall project portfolio managed by NPD leaders negatively impacts their learning from failure due to the negative emotional response associated with cognitive and motivational deficits. Thus:

Hypothesis 1. NPD project leaders' percentage of project failures in the total number of projects managed has a negative effect on their learning from failure.

Drawing upon the sensemaking perspective, learning from failure entails an ongoing process of constructing plausible retrospective accounts that inform and shape current actions (Weick et al., 2005). However, unraveling these intricate and interconnected relationships, to effectively learn from failure and develop novel strategies for future projects, requires a significant amount of time (Shepherd et al., 2011). Particularly, the aftermath of a project failure signifies a period dedicated to actively scanning for pertinent information, processing it, and deriving valuable lessons from the experience (Weick, 1979). As such, the availability of time as a resource for project leaders to engage in reflection and assimilation of project failures during the NPD process is important.

When NPD project leaders have a greater amount of time elapsed since their project failure, they are more likely to perceive the discrepancy between the current state and the desired goal, considering the failure as negative feedback (Maslach, 2016). This informative feedback, in turn, assists NPD leaders in exploring alternative approaches and increase the variability in their decision-making processes. These factors collectively contribute to a shift towards a generative mode of searching for solutions and facilitate learning from failure (Minniti and Bygrave, 2001). Furthermore, Shepherd et al. (2011) discover that organizational members who have had more time since their project failure tend to derive more valuable lessons from the failure experience compared to those with a shorter time interval. Based on these insights, we hypothesize that:

Hypothesis 2. NPD project leaders with greater time since their failed project learn more from the failure experience than those with less time since their project failed.

The error management perspective highlights significant variations in individuals' error competence (van Dyck et al., 2010), which can affect the failure-and-learning relationship within the context of NPD. On the one hand, error competence reflects one's sense of efficacy in error and failure situations (Schell and Conte, 2008), balancing out the negative emotional response to a failure. Individuals with a high level of error competence can buffer the negative emotional response typically associated with failure. This is attributed to their strong sense of self-efficacy (Bandura, 1986), which helps alleviate negative emotions triggered by project failures. This helps them stay focused on the task in hand. Once NPD project leaders effectively manage the negative emotional response associated with an increased percentage of project failures, they can impartially evaluate the project failures and identify the root cause of those project failures. This process is often accompanied by a sense of normalization of failure experience, which helps moderates the negative emotional response (Shepherd et al., 2011).

Moreover, error competence can neutralize the negative emotional response triggered by an elevated percentage of project failures. This allows NPD project leaders to effectively navigate and address the task at hand. Instead of succumbing to feelings of helplessness and stigmatization, the increased percentage of project failures signals that the expected goal has not (yet) been achieved, accompanied by a sense of urgency (Frese and Keith, 2015). This sense of urgency motivates individuals to take proactive actions to mitigate adverse outcomes (Rybowiak et al., 1999), whilst simultaneously engaging in cognitive processing of the failure situation and perceiving failures as valuable learning opportunities (Seckler et al., 2017). Consequently, NPD leaders with a high level of error competence exhibit a strong confidence in facing the challenges posed by project failures. They possess the ability to swiftly detect and handle the increased percentage of project failures, actively seeking solutions to counteract the negative effects of a higher percentage of project failures on learning from failure.

On the other hand, NPD project leaders who possess high error competence are more inclined to view project failure as a discrepancy, which initiates a sensemaking process of deep thinking, reflective analysis, and systematic cognitive examination of the NPD project failure. This process exhibits similarities to metacognition (Seckler et al., 2017), encompassing the stages of planning, monitoring, evaluating, and revising one's actions towards goals. Research has shown that metacognition has a positive effect on cognitive processing and learning (Frese and Keith, 2015). Error competence is built upon an individual's knowledge and ability to analyze failure experiences and develop strategies to effectively cope with them. Studies have indicated that error competence is positively associated with action-orientation after failure, taking initiatives (Rybowiak et al., 1999), and engaging in reflective practices within the workplace (Hetzner et al., 2011). NPD project leaders with high error competence tend to view NPD project failure as an opportunity for learning and are more likely to harness the motivating function of negative emotional responses to failure (Seckler et al., 2017). Moreover, they display a proactive approach in transforming project failure into valuable learning experience, especially when given ample time since the project failure. Thus, we hypothesize that:

Hypothesis 3a. Error competence moderates the negative relationship between NPD project leaders' percentage of project failures and their learning from failure; the negative relationship is weakened as NPD project leaders' error competence increases.

Hypothesis 3b. Error competence moderates the positive relationship between NPD project leaders' time since project failure and their learning from failure; the positive relationship is strengthened as NPD project leaders' error competence increases.

The emotional response to a project failure differs from the innate emotional tendencies associated with error strain. Error strain pertains to individuals' inherent negative emotional tendencies due to the fear of making errors (Rybowiak et al., 1999). It represents a general predisposition to perceive errors negatively. It is thus conceptually distinct from an individual's emotional response to a specific failure, although error strain can moderate an individual's emotional response to failure.

According to Emby et al. (2019), error strain can inhibit productive coping activities as it distracts limited cognitive resources from task-related thinking and behavior towards emotion-focused coping activities (Frese and Keith 2015). As error strain intensifies, individuals are likely to experience elevated stress levels and display resistance towards change (Hetzner et al., 2011) when confronted with a high percentage of project failures. When individuals are preoccupied with their negative emotions, they may delay necessary actions to rectify the failure, which can have dysfunctional effects on learning (Frese and Keith, 2015).

A high level of error strain makes it more challenging for project leaders to cope with negative emotional responses to a specific project failure, thus impeding their sensemaking process (Morais-Storz et al., 2020). Error strain encompasses a generalized fear of making errors, which includes elements of stigma and fear (Keith and Frese, 2005). When error strain is elevated, it intensifies the negative emotions experienced following a project failure, leading NPD project leaders to develop a fear of committing failures. The heightened negative emotional response may cause individuals to repeatedly and passively focus on the failed events, even with adequate time since the project's failure. Consequently, rumination may occur, characterized by poor concentration, diminished energy, and inaction (Nolen-Hoeksema et al., 2008), ultimately hindering learning from failure (Seckler et al., 2017). Based on the theoretical framework (see Fig. 1), we hypothesize that:

Hypothesis 4a. Error strain moderates the positive relationship between NPD project leaders' percentage of project failures and their learning from failure; the negative relationship is strengthened as NPD project leaders' error strain increases.

Hypothesis 4b. Error strain moderates the negative relationship between NPD project leaders' time since project failure and their learning from failure; the positive relationship is weakened as NPD project leaders' error strain increases.

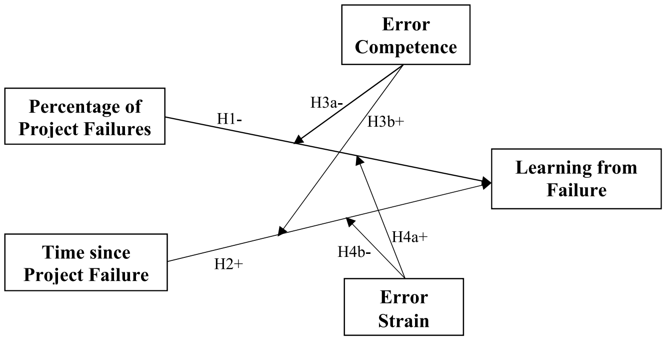

Fig. 1. Theoretical framework.

4. Methods

This study is based on survey data from high-tech ventures in Shanghai, China, collected at two points in time to mitigate the risks of cross-sectional data. Given the high level of innovativeness and inherent risk of uncertainty (Hu et al., 2017), NPD project failure is a common phenomenon in high-tech ventures (Urbig et al., 2013). As such, high-tech ventures in China represent "an exciting laboratory" for examining the innovation process (Liu et al., 2014, p.414) and the role of learning from failure in that process. Shanghai, as one of the most high-tech cities in China, has an extremely high concentration of high-tech sectors (Tao et al., 2023). We thus selected high-tech ventures in Shanghai as our sample frame.

4.1. Data and sample

Our sample frame consisted of 1812 high-tech ventures with technology-based NPD projects, spreading across all the 16 administrative districts of the Shanghai, China. These ventures were officially recorded by the *Science and Technology Commission of Shanghai Municipality* on June 5, 2017, recognizing the innovativeness of their NPD projects. We surveyed all the high-tech ventures via an initial online survey and followed by three waves of reminders (using email, telephone, and on-site visit). The survey questionnaire was developed in English and then translated into Chinese by a bilingual, native Chinese speaker. An iterative process followed until the Chinese and English versions reached consensus. The questionnaire was piloted with 10 NPD project leaders in high-tech ventures in China. Because NPD project leaders are expected to have comprehensive knowledge of their projects (Shepherd et al., 2013), our respondents were NPD project leaders (see Table 1), as nominated by the executives of the high-tech ventures. We obtained details of the executives from the company's registration records on China's *National Enterprise Credit Information Publicity System*. After strictly deducting ineligible questionnaires, we received 237 useable responses – an effective response rate of 13.08%.

To assess non-response bias, we compared all the variables of the late respondents (akin to the non-response group) with those of the early respondents, resulting in no significant differences, providing evidence on the lack of non-response bias. To minmise the risks of recall bias this study followed guidelines recommended by DeRue and Wellman (2009) for minimizing recall bias: (1) the project failure examined in this study occurred within the last three years; (2) these events were meaningful enough to be remembered and distinguished by respondents; and (3) all respondents were directly involved in the failed projects they reported. Moreover, the three-year time frame also allowed us to research the outcomes (e.g., learning from failure) several years after the project failures had occurred (Liu et al., 2019). Our on-site follow-up visits and face-to-face interactions also proved that NPD leaders had no problem remembering the details surrounding the highly impactful event of NPD project failure in the last three years.

Table 1
The sample profile.

Characteristics		Frequency	Percentage
Gender	Male	128	54.0
	Female	109	46.0
Age	29 or less	35	14.8
	30 to 40	87	36.7
	41 to 50	97	40.9
	51 and above	18	7.6
Educational level	Below bachelor	3	1.3
	Bachelor	166	70.0
	Master	65	27.4
	PhD	3	1.3
Venture size	50 or less	47	19.8
	51 to 100	108	45.6
	100 to 150	32	13.5
	151 to 200	18	7.7
	201 to 250	16	6.7
	251 to 516	16	6.7
Ownership type	Privately held	196	82.7
	Joint share	20	8.4
	Foreign-invested	17	7.2
	State-owned	4	1.7
Industry type	Electronic information	103	43.5
	New energy and materials	41	17.3
	Integrated optical	35	14.8
	New biotechnology	32	13.5
	Others	26	11.0

Note: N = 237.

4.2. Measurements

Established measures with seven-point Likert scales were used wherever possible to maximize construct validity (see Table 2). We also carefully followed the recommended best-practice for scale adaption (Heggestad et al., 2019). NPD project leaders were firstly asked to answer questions reflecting on their own experiences of working on NPD projects in their current firms and their error competence and error strain. Six months later, the same respondents were further asked to answer their learning from failure.

Time since project failure (Time 1). Referring to Shepherd et al. (2011), we measured time since the last project failure by asking "how long ago (in months) did you experience your last NPD project failure". Thus, all the time measures related to NPD project listed in the remaining sections are reported in monthly unit.

Percentage of project failures (Time 1). Based on Shepherd et al. (2011), this study asked each respondent to "indicate the total number of NPD projects they had managed in their current position within the last three years" as well as what the "the overall number of failed NPD projects that they had managed in their current position within the last three years". The percentage of project failures was operationalized as the ratio of the number of failed NPD projects to the number of managed NPD projects (Hu et al., 2017; Wolfe and Shepherd, 2015). The descriptive statistics indicated that, on average, the respondents in their current positions have managed 5.81 projects within the last three years, 1.79 of which ultimately failed.

Error competence and error strain (Time 1). Consistent with Schell and Conte (2008), nine relevant items of the error orientation questionnaire (EOQ; Rybowiak et al., 1999) were used to measure attitudinal and behavioral tendencies. These included four items for error competence and five items for error strain (see Table 2).

Learning from project failure (Time 2). Consistent with a sensemaking perspective on failure (Cardon et al., 2011; Liu et al., 2019; Morais-Storz et al., 2020), our study focuses on how NPD project leaders make sense of failure to inform their current NPD projects. This conceptualization is highly relevant to the concept of "project-related learning" (i.e., learning related to individual's performance) rather than "personal-related

Table 2
Measurements.

Items	Standardized loading	t-value
Error Competence **(α=0.881; CR=0.876; AVE=0.639)**		
EC 1. When I have made an error, I know how to correct it.	1.000 [a]	
EC 2. When I do something wrong at work, I correct it immediately.	.953	13.342
EC 3. If it is at all possible to correct an error, then I usually know how to go about it.	.943	13.541
EC 4. I do not let go of the goal, although I may make an error.	.884	13.280
Error Strain **(α=0.919; CR=0.921; AVE=0.700)**		
ES 1. I feel embarrassed when I make an error.	1.000 [a]	
ES 2. I find it stressful when I err.	.893	14.773
ES 3. I am often afraid of making errors.	.964	15.222
ES 4. If I make an error at work, I "lose my cool" and become angry.	.908	15.996
ES 5. While working, I am concerned that I could do something wrong.	.932	17.947
Learning from Failure (α=.895; CR=.896; AVE=.635)		
LFF 1. I have learned to better execute a project's strategy.	1.000 [a]	
LFF 2. I can more effectively run a project.	.870	13.076
LFF 3. I have improved my ability to make vital contributions to a project.	.870	13.480
LFF 4. I can "see" earlier the signs that a project is in trouble.	.950	14.655
LFF 5. I realize the mistakes that we made that led to the project's failure.	.926	16.075
Model fit: χ^2 (74) = 84.675; CFI = 0.995; GFI = 0.950; TLI = 0.994; RMSEA = 0.025; p = 0.186.		

Note: N = 237. [a] Fixed factor loading.
α = Cronbach's alpha, CR = Composite Reliability, AVE = Average Variance Extracted.

learning" (learning related to individual's personal attributes) (Shepherd et al., 2011, p.1239). Thus, our study used the five items (i.e., LFF 1–5 in Table 2) relating to project-related learning developed by Shepherd et al. (2011) to measure learning from failure. This dimension of learning has been independently employed and empirical verified in the context of business failure in China (i.e., Liu et al., 2019); lending support to our decision to focus on the project-related aspect of learning.

Control variables. NPD project leaders' gender (0 = Female, 1 = Male), age (1 = 29 or less, 2 = 30 to 40, 3 = 41 to 50, 4 = 51 and above), educational level (1 = Below bachelor, 2 = Bachelor, 3 = Master, 4 = PhD), organizational tenure (measured in years as the duration between the start of employment at the current organization and the survey response date) and were included as control variables, as prior research (e.g., He et al., 2018; Shepherd et al., 2011) suggested that these individual factors could potentially affect individuals' subsequent learning.

We further used a validated scale developed by Shepherd et al. (2011) to control for the variable of negative emotions over project failures. This scale includes questions such as "I have difficulty remembering information important for successfully completing tasks" and "the project failures are ongoing sources of disappointment". The Cronbach's alpha value is 0.831.

Three variables concerning the last failed NPD project were also included: the time spent on the project before failure (in months), the relative importance that respondents assigned to the project (hereafter labelled as currently project importance), and the team size of the failed NPD project (i.e., using the number of team members as a proxy), as they could significantly affect learning from failure (Shepherd et al., 2011).

We also controlled two variables relating to current NPD projects, namely the total number of ongoing NPD projects in the respondent ventures (hereafter labelled as currently ongoing projects) and the number of NPD projects being currently managed by the respondents (hereafter labelled as currently managed projects), as they might affect the effect of failure on learning (Hu et al., 2017). Table 3 summarizes the statistics of the key constructs.

4.3. Reliability and validity

The measurement scales were validated following Hair et al. (2014). Confirmation factor analysis (CFA) results showed that all the items loaded onto their respective factors, showing no significant cross-loadings and overall satisfactory model fit indices (see Table 2). Reliability was assessed using both coefficient alpha and composite reliability. All coefficient alpha exceeded the accepted 0.7 thresholds (c.f. Kock and Gemünden, 2021). Composite reliability using Fornell and Larcker's (1981) procedure was over 0.7 – the recommended threshold (Hair et al., 2014). Average variance extracted (AVE) using the Fornell and Larcker's (1981) procedure was used to assess convergent validity. AVEs of all the main constructs were higher than the minimum threshold of 0.5 (Fornell and Larcker, 1981). Additionally, all items loaded significantly onto their corresponding latent construct, with the lowest t-value at 13.076 (see Table 2), providing evidence of convergent validity. Discriminant validity was assessed by comparing the squared correlations between pairs of constructs and the AVEs of the constructs. All the correlations were lower than the square root of AVEs, indicating satisfactory discriminant validity (Hair et al., 2014).

4.4. Common method variance

To mitigate the risk of common method bias (CMB), we integrated both procedural methods and statistical techniques: (1) Prior to the survey, we conducted a pilot study to eliminate the ambiguity of item wording and context and placed the independent variables away from the dependent variables. (2) During the survey, we assured the respondents that their answers were confidential and that there were no right or wrong answers to the questions in the survey, to reduce the respondents' evaluation apprehension and social desirability. (3) The Harman's one-factor test was performed in exploratory factor analysis, resulting in multiple factors with the first factor only accounting for 27.092%, suggesting that there was no dominant factor. (4) We also conducted a CFA. The result showed that the model fit of this measuring model with only one dominant factor (χ^2 (77) = 274.246, CFI = 0.903, GFI = 0.901, TLI = 0.885, RMSEA = 0.104, p = 0.000), with two factors (χ^2 (75) = 242.417, CFI = 0.918, GFI = 0.905, TLI = 0.900, RMSEA = 0.097, p = 0.000) were all worse than our research model (χ^2 (74) = 84.765, CFI = 0.995, GFI = 0.950, TLI = 0.994, RMSEA = 0.025, p = 0.186). (5) We further employed the marker variable approach to test for CMB (Lindell and Whitney, 2001). The marker variable should be theoretically independent of at least one key variable. We thus used promotion focus, measured by a 9-items scale (Tumasjan and Braun, 2012) with a high reliability (α = 0.957), as a marker variable, which is not theoretically related to the error strain. The results illustrated that the zero-order correlations and partial correlations among key variables kept statistically similar after adding the marker variable. Hence, CMB was not a serious concern in our study.

5. Results

5.1. Analytical method

We conducted hierarchical linear regression analysis to test our hypotheses (see Table 4). Multicollinearity was not a serious concern; we checked the variance inflation factor (VIF) for each variable and found that it was below the threshold of 5 (i.e., the largest VIF was 1.714).

Table 3
Descriptive statistics.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age															
2. Gender	0.021														
3. Educational level	0.069	0.038													
4. Organizational tenure [a]	−0.043	0.084	−0.001												
5. Team size	0.044	0.151*	−0.015	0.206**											
6. Currently ongoing projects	0.026	0.009	0.018	−0.066	0.222**										
7. Currently managed projects	−0.059	0.031	−0.063	−0.012	0.317***	0.603***									
8. Project importance	0.069	0.020	0.036	0.092	0.096	−0.094	0.012								
9. Negative emotions	0.09	0.32	0.40	0.001	−0.016	0.007	−0.049	0.032							
10. Time spent on project before failure [b]	0.004	−0.045	−0.049	−0.058	−0.099	0.009	−0.100	0.002	0.026						
11. Percentage of project failures	−0.001	−0.064	−0.011	0.036	0.121†	0.115	0.110†	−0.021	0.148*	−0.190**					
12. Time since project failure [a]	0.081	0.023	−0.008	0.051	0.021	0.002	−0.027	0.077	0.039	0.106	0.034				
13. Error competence	−0.018	0.025	0.047	0.077	0.165*	0.035	0.024	0.199**	−0.174**	0.016	−0.148*	0.182**	*0.799*		
14. Error strain	0.004	−0.030	0.147*	−0.067	−0.140*	−0.039	−0.105	0.099	0.354**	−0.021	0.063	−0.029	−0.209**	*0.837*	
15. Learning from failure	−0.031	0.118	−0.007	0.062	0.058	0.002	0.040	0.237**	−0.105	−0.050	−0.137*	0.132*	0.384***	−0.136*	*0.797*
Mean	2.414	0.540	2.288	6.304	12.219	6.004	2.443	4.729	4.095	5.882	0.343	6.203	5.499	4.166	5.515
Standard deviation	0.832	0.499	0.507	4.331	10.887	7.709	2.527	1.048	1.056	4.105	0.166	3.034	0.807	1.143	0.729

Note: N = 237.
†$p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Two-tailed tests.
[a] In years.
[b] In months. Italic figures on the diagonal are the square root of the AVEs for the constructs.

Before conducting regression, we mean-centered all interaction terms. To explore the patterns of the interaction terms and test the moderating effects, we utilized the Johnson-Neyman technique recommended by Bauer and Curran (2005).

5.2. *Hypothesis testing*

Model 1, referred to as the base model, included only the control variables. Notably, the coefficient of project importance was significantly positive (β = 0.138; p = 0.035). This suggests that the relative importance that individuals assigned to a given project could positively affect the NPD project leaders' learning from project failure, aligning with the research finding of Shepherd et al. (2011).

Model 2 included the two independent variables. The coefficient of the percentage of project failures was negative and statistically significant (β = −0.139; p = 0.038), supporting Hypothesis 1: NPD project leaders' percentage of project failures had a negative effect on their learning from failure. On the contrary, the coefficient of time since project failure was positive and statistically significant (β = 0.133; p = 0.041), supporting Hypothesis 2: NPD project leaders' time since project failure has a positive effect on their learning from failure.

Model 3 tested the moderating effects of error competence. The results show that the coefficient of the interaction term between error competence and percentage of project failures was statistically significant (β = 0.166; p = 0.008). This supports Hypothesis 3a: as error competence increases, the negative effect of percentage of project failures on learning from failure is weakened. However, the coefficient of the interaction term between error competence and time since project failure was not statistically significant (β = 0.061; p = 0.333). Thus, Hypothesis 3b was not supported.

Model 4 tested the moderating effects of error strain. The coefficient of the interaction term between error strain and percentage of project failures was not statistically significant (β = 0.033; p = 0.597). Thus, Hypothesis 4a was not supported. However, the coefficient of the interaction term between error strain and time since project failure was statistically significant (β = −0.230; p = 0.001). This supports Hypothesis 4b: as error strain increases, the positive effect of time since project failure on learning from failure is weakened.

Model 5 tested the four moderating effects together. Hypothesis 3a (β = 0.177; p = 0.005) and 4b (β = - 0.207; p = 0.001) remained supported while Hypothesis 3b (β = 0.016; p = 0.797) and 4a (β = 0.045; p = 0.468) were not supported.

To further assess the significance of the interaction effects, we used the Johnson-Neyman technique which employs confidence bands. Fig. 2a plots the confidence bands around the conditional effect (the dark line) of percentage of project failures on learning from failure across the distribution of error competence (on the horizontal axis). The vertical axis represents the coefficient of the relationship between percentage of project failures on learning from failure (i.e., the conditional effect). The dashed lines in the diagram represent the upper and lower bounds of a 95% confidence interval around the conditional effect. The points at which the confidence interval is wholly above or below zero depict the range of values of the moderator error competence for which there is a significant relationship between percentage of project failures on learning from failure across the distribution of error competence. Applying the 95% region to calculate the regions of significance, we calculated the lower bound estimate (i.e., the value of the moderator below which the coefficient of the relationships between percentage of project failures on learning from failure becomes significantly negative) to be 5.174, whereas the upper bound estimate (i.e., the value beyond which the coefficient becomes significantly positive) was 6.437. That means that when the score of error competence is 0.326 below the mean (i.e., 5.499, see Table 3) or smaller, the effect of percentage of project failures on learning from failure is significantly negative, whereas when error competence is at least 0.938 above the mean, this effect is significantly positive. In between these two values, the relationship between

Table 4
Results of regression analysis.

	Dependent variable: Learning from failure				
	Model 1	Model 2	Model 3	Model 4	Model 5
Control Variables					
Age	−0.042 (0.065)	−0.057 (0.064)	−0.034 (0.061)	−0.066 (0.063)	−0.043 (0.059)
Gender	0.118 (0.065)	0.098 (0.065)	0.085 (0.061)	0.104 (0.063)	0.092 (0.060)
Educational level	−0.013 (0.064)	−0.015 (0.064)	−0.020 (0.060)	0.003 (0.062)	−0.005 (0.059)
Organizational tenure [a]	0.031 (0.066)	0.024 (0.065)	0.009 (0.062)	−0.006 (0.063)	−0.014 (0.061)
Team size	−0.008 (0.072)	0.012 (0.071)	−0.044 (0.068)	−0.017 (0.070)	−0.058 (0.067)
Currently ongoing projects	0.024 (0.082)	0.033 (0.081)	0.028 (0.076)	0.040 (0.079)	0.034 (0.075)
Currently managed projects	0.001 (0.084)	0.013 (0.083)	0.019 (0.078)	0.015 (0.081)	0.025 (0.077)
Project importance	0.138* (0.065)	0.129* (0.064)	0.159* (0.062)	0.103* (0.064)	0.144* (0.062)
Negative emotions	−0.116† (0.064)	−0.096 (0.064)	−0.037 (0.061)	−0.033 (0.070)	−0.003 (0.066)
Time spent on project before failure [b]	−0.038 (0.065)	−0.081 (0.066)	−0.072 (0.062)	−0.078 (0.064)	−0.063 (0.061)
Independent Variables					
Percentage of project failure		−0.139* (0.067)	−0.057 (0.065)	−0.153* (0.065)	−0.072 (0.064)
Time since project failure [b]		0.133* (0.065)	0.052 (0.064)	0.112† (0.063)	0.051 (0.063)
Interaction Effects					
Error competence			0.352*** (0.065)		0.317*** (0.065)
Error competence × Percentage of project failures			0.166** (0.062)		0.177** (0.062)
Error competence × Time since project failure			0.061 (0.063)		0.016 (0.064)
Error strain				−0.081 (0.072)	−0.045 (0.070)
Error strain × Percentage of project failures				0.033 (0.063)	0.045 (0.061)
Error strain × Time since project failure				−0.230** (0.065)	−0.207** (0.062)
R-squared	0.086	0.118	0.232	0.177	0.274
Adjusted R- squared	0.045	0.070	0.179	0.121	0.214
Highest VIF	1.682	1.686	1.698	1.705	1.714
F change	2.120*	4.003*	10.875***	5.314***	4.220**

Note: N = 237.
†p < 0.1, *p < 0.05, **p < 0.01, ***p < 0.001. Two-tailed tests.
[a] In years.
[b] In months. Explanatory variables and interaction terms are standardized. Robust standard errors are provided in parentheses.

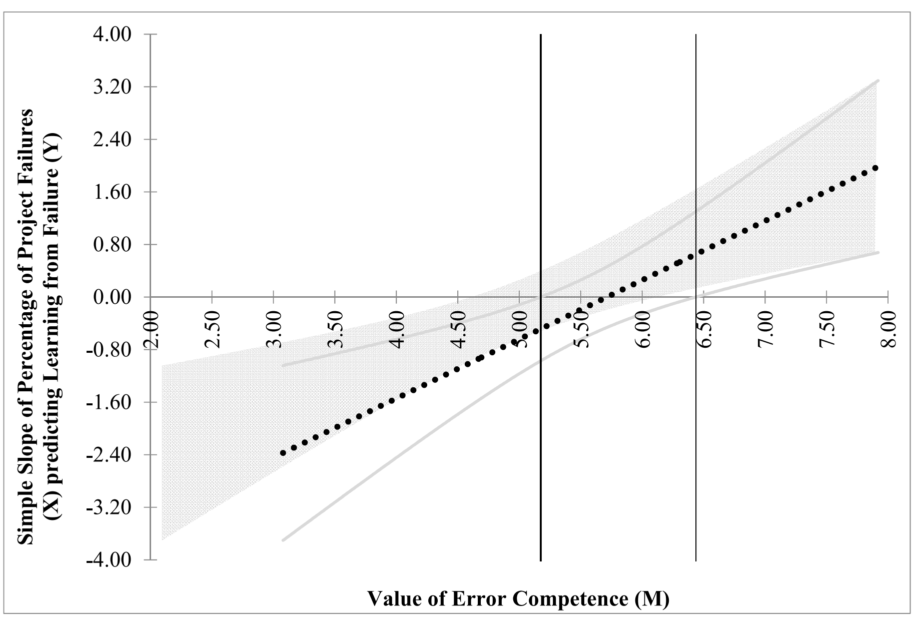

Fig. 2a. Johnson-Neyman regions of significance for the conditional effect of percentage of project failures at values of error competence.

percentage of project failures on learning from failure is not significant. These results further support Hypothesis 3a.

Similarly, Fig. 2b plots the confidence bands around the conditional effect (the dark line) of time since project failure on learning from failure across the distribution of error strain (on the horizontal axis). The vertical axis represents the coefficient of the relationship between time since project failure on learning from failure (i.e., the conditional effect). Applying the 95% region to calculate the regions of significance, we calculated the lower bound estimate (i.e., the value below which the coefficient becomes significantly positive) to be 3.964, whereas the upper bound estimate (i.e., the value beyond which the coefficient becomes significantly negative) was 6.009. That means that when the score of error strain is 0.202 below the mean (i.e., 4.166, see Table 3) or smaller, the effect of time since project failure is significantly positive, whereas when error strain is at least 1.843 above the mean, this effect is significantly negative. In between these two values, the relationship between time since project failure on learning from failure is not significant. Thus, these results further support Hypothesis 4b.

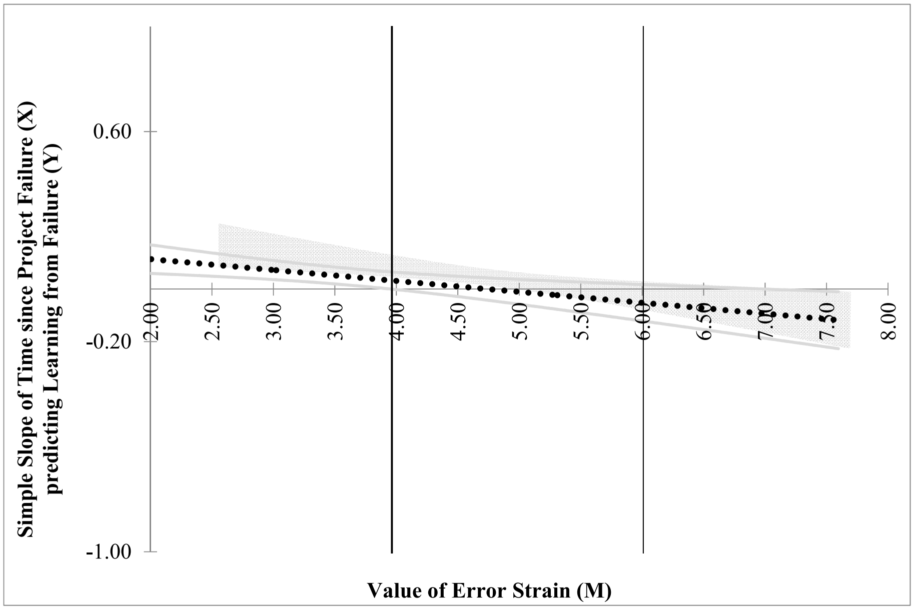

Fig. 2b. Johnson-Neyman regions of significance for the conditional effect of time since project failure at values of error strain.

5.3. Robustness tests

We conducted several tests to scrutinize our results. To account for the potential endogeneity of previous failures, we applied a two-stage Heckman procedure. First, we estimated a first stage probit model to assess the likelihood of a project failure. Absent better exclusion criteria, we generated two new variables, an industry percentage of project failures, and a district percentage of project failures - the ratios of the total number of NPD project failures to the overall number of NPD projects in an industry and in each of the 16 administrative districts of Shanghai in the sample respectively (Liu et al., 2019). Our sample for the first stage contains 262 observations including 25 NPD project leaders without failure experience. Second, we put the inverse Mills' ratio derived from the previous estimation, with other antecedent variables in the second-stage analysis of learning from failure. The results showed that all hypotheses remained consistent and the inverse Mills' ratio was insignificant ($\beta = -1.590$; $p = 0.141$). Thus, the selection bias was not an issue.

We further assessed the potential curvilinear relationship between percentage of project failures and learning from failure, as the previous research finds an inverted U-shape relationship between failure velocity (i.e., the ratio of the number of failed businesses to the number of years) and learning behavior (He et al., 2018). The results showed that percentage of project failures squared ($\beta = -0.023$; $p = 0.591$) had no significant relationships with learning from failure. Thus, the percentage of project failures did not have any curvilinear relationships with learning from failure.

Additionally, to assess the extent to which the current model accounts for potential moderators such as project characteristics (Shepherd et al., 2011) and contextual factors (Shepherd et al., 2013) in the relationship between project failure and subsequent learning,[1] we conducted additional tests. Considering the limitations of our data source, we specifically examined the potential moderating effects of variables including the number of ongoing projects, the number of projects managed, project importance, and the interaction between the percentage of project failure and time since project failure. The results indicated no significant moderating effects, thereby reinforcing the validity of our theoretically driven model.

Finally, although the current study conceptualizes error orientation as an innate individual difference, we could not eliminate the possibility that error strain and error competence might be changed by situational cues such as project failure. Therefore, based on a structural equation modelling (SEM), we empirically tested the mediating roles of error strain and error competence in the relationship between project failure and learning from failure. The insignificant mediators rule out such alternative model in our study.[2]

6. Discussion

6.1. Theoretical implications

The existing literature acknowledges that innovation failure can be a valuable learning experience (Baxter et al., 2023). However, research also highlights that not all project failures are equally effective in facilitating learning (Khanna et al., 2016), and individuals differ in their ability to learn from project failure (Shepherd et al., 2011, 2013). Our study expands upon this knowledge by investigates two factors that jointly affect whether project leaders learn from NPD project failure: their project failure experience (i.e., measured by the percentage of prior project failures and the time elapsed since last project failure) and their error orientation (i.e., error competence and error strain).

Our study emphasizes the significance of comprehending different facets of error orientation to elucidate how failure can be transformed into a learning opportunity. It's worth noting that we encountered unexpected results of the insignificant moderating effect of error competence on the positive relationship between time since project failure and learning from failure (i.e., Hypothesis 3b), and similarly the insignificant moderating effect of error strain on the negative relationship between the percentage of project failures and learning from failure (i.e., Hypothesis 4a). One possible explanation is that these variables may exhibit complementary interactions. For instance, while error competence positively affects learning from failure when time since project failure is low, its value may reach a plateau when the intensity exceeds a certain threshold. Similarly, error strain may not significantly moderate the relationship between the percentage of project failures and learning

[1] We thank an anonymous reviewer for suggesting this idea. The full report is available upon request.

[2] A table of the SEM results of the alternative model is available upon request.

from project failure because other factors, such as time since project failure, might hold greater important within this context.

Our study mainly contributes to the literature on learning from innovation failure. First, our study provides new insights into the nature of innovation failure by focusing on the heterogeneous effects of project failure experience on subsequent learning, as called for by Wang (2023). Specifically, we pay close attention to the role of different types of innovation failure in developing valuable knowledge, as highlighted by Rhaiem and Amara (2021). Our study differentiates between percentage of project failures and time since project failure and uncovers their opposing effects on learning from failure. These findings challenge prior research that has solely focuses on the specific project failure (Patzelt et al., 2021; Shepherd et al., 2011) or the overall project failure (Shepherd et al., 2013) and emphasize the importance of dissecting the nature of project failure. Our study brings clarity to the concepts and measures of project failure within the NPD process, which timely responses to the call of Baxter et al. (2023) for reconceptualizing failure innovation. Furthermore, our study sheds light on the intricate relationship between project failure and learning from such failures. Consequently, our research findings highlight the imperative of capitalizing on every failure to optimize the value derived from learning, as emphasized by Mueller and Shepherd (2016).

Second, our study makes a valuable contribution to the existing literature on learning from innovation failure by utilizing the error management perspective to elucidate the influence of individual differences affect the relationship between project failure and learning from failure. Recent research has empirically justified the moderating role of individual differences, such as emotional regulation (He et al., 2018) and error orientation (Funken et al., 2020), in the failure-and-learning relationship within the entrepreneurship context. However, limited research has been conducted to explore the mechanisms through which these differences facilitate the transformation of project failure into learning opportunities within the innovation process. In addition, the error management perspective has not been fully integrated into the innovation failure literature (Seckler et al., 2017). Our study addresses these gaps by examining the impact of error competence and error strain on the relationship between project failure and learning from project failure, thereby providing new insights into the application of the error management perspective in the field of learning from innovation failure. These findings contribute to a better understanding of how failure experience and error management can jointly affect learning from innovation failure (Rhaiem and Amara, 2021).

Finally, our study also contributes to the existing literature on learning from failure by investigating the learning opportunities that arise from project failures within the NPD process. While previous research on learning from failure has predominantly concentrated on the terminations of ventures (e.g., He et al., 2018; Liu et al., 2019; Ucbasaran et al., 2013) or entrepreneurial projects (e.g., Shepherd et al., 2009; Shepherd et al., 2013; Shepherd et al., 2014; Patzelt et al., 2021), we believe that NPD project failures occur more frequently and offer greater opportunities for learning. While a recent systematic review on learning from innovation failure (c.f., Rhaiem and Amara, 2021) fails to clarify the concept of innovation failure across various research contexts, our study specifically focuses on NPD project failures. Through the examination of project leaders' project failure experience and their error orientation, we hope to uncover more learning opportunities in the day-to-day management of the innovation process (Salerno et al., 2015).

6.2. Practical implications

Our study offers practical insights for NPD project leaders on how to learn from project failure. As Shepherd et al. (2011, p.1250) rightly point out, "project failure is a way of life for members in many organizations." It is therefore crucial for NPD project members to learn from project failure towards future success. However, NPD project leaders should acknowledge the fact that learning after experiencing project failure is not guaranteed, and such recognition is the starting point of the learning journey. The next step involves a thorough dissection of the nature of project failure and the error orientation of NPD project leaders involved. We suggest that, when a project failure occurs, NPD project leaders take a step back to reflect on the nature of failure (i.e., a series of events leading up to the failure and the intensity of these events) they experience, instead of simply focusing on the failure itself (i.e., the outcome of failure). NPD project leaders that consider the failed events solely can easily fall into the 'failure trap', which is mixed with negative emotions, such as grief, regret and stigma (Shepherd and Cardon, 2009). Conversely, project leaders that take a more in-depth, cool-headed and systematic reflection of the nature of project failure and their attitudes towards failure can optimize learning. For example, post-project reviews (Anbari et al., 2008), a fact-based method for applying the lessons extracted from prior experience to the next event or project, has been used in systematic inter-project learning (Von Zedtwitz, 2002). Overall, our study sheds light on the importance of embracing project failure as a learning opportunity in the NPD process.

6.3. Limitations and future research

Our study has several potential limitations. First, focusing on the individual level, our study aims to investigate whether and when project leaders learn from NPD project. However, prior research has discussed the variance in response to failure and learning from failure at multiple levels (e.g., Dahlin et al., 2018; Funken et al., 2020; Wilhelm et al., 2019). There may be differences and even competing interests between actors at different levels, such as perceptions of project failure likely differing between the primary decision-maker accountable for the outcome and project team members (Shepherd et al., 2014). Thus, future research could adopt a multilevel perspective to explore how learning from innovation failure occurs across different levels. For instance, Behrens and Patzelt (2016) incorporate factors at the portfolio, individual and firm level to explain manager's decisions to terminate projects.

Second, our study centers around error competence and error strain, as they are highly relevant to our research context and can provide insights into the research question. While error orientation is a multidimensional construct, other dimensions of error orientation have been conceptualized and measured, such as the eight subscales proposed by Rybowiak et al. (1999) or the two-factor structure of error mastery orientation and error aversion orientation identified by Funken et al. (2020). Future research may benefit from exploring the specific roles of these other dimensions of error orientation in relevant research contexts.

Thirdly, in addition to examining project failure and error orientation, we also conducted robustness tests to explore the potential moderating effects of project characteristics and contextual factors. However, we acknowledge that there are likely additional contingencies that should be considered in future research (Rhaiem and Amara, 2021), which will contribute to a more comprehensive understanding of the dynamics involved in fostering effective learning processes following innovation failure.

Fourth, although we collected data at two distinct time points, it might not entirely rule out reverse causality. Time plays a vital role in the process of learning from project failure (Patzelt et al., 2021; Shepherd et al., 2011; Wang, 2023). Future research may employ longitudinal studies and experience sampling studies, which can account for reverse causality and disentangle learning from failure over time (Seckler et al., 2017).

Lastly, as this is a single region study, future research can collect data from a wider geographical area to increase the generalizability. Emerging research has pointed out that various cultural factors can affect learning after failures, such as regional culture (Cardon et al., 2011) and social supports (Todt et al., 2018). Thus, examining the influences of cultural factors on post-failure events, such as public narratives (Kibler et al., 2021), is a promising direction.

7. Conclusion

Our study sheds light on the complex nature of learning from failure among NPD project leaders. The findings highlight that not all failure experiences have an equal impact on learning, and individual project leaders differ in their ability to effectively learn from failure. Specifically, the percentage of project failures, as a measure of failure experience, has a negative influence on learning from failure. As the percentage of project failures increases, the extent of learning decreases. This suggests that project leaders face challenges in extracting meaningful insights and learning from failure when they have encountered a higher number of failures. However, the negative relationship between failure experience and learning is mitigated by the presence of higher error competence. Project leaders with greater error competence possess the skills and knowledge necessary to navigate and interpret failure experiences, enabling them to derive valuable learning outcomes even in the face of multiple failures.

Our study also reveals that the time elapsed since the project failure positively affects learning from failure. As more time passes since the project failure, project leaders demonstrate a greater propensity to learn from failure. This temporal aspect provides project leaders with an opportunity for reflection, analysis, and sensemaking, which can contribute to enhanced learning outcomes. Nevertheless, the positive relationship between time since failure and learning is weakened when project leaders experience higher levels of error strain. Elevated levels of stress or negative emotions related to errors can hinder project leaders' ability to effectively utilize the temporal aspect for learning.

These findings contribute to the broader understanding of learning from failure in NPD contexts and provide practical implications for high-tech ventures and project leaders seeking to improve their innovation processes. Our study emphasizes the need for a customized approach that considers project leaders' failure experience and error orientation to optimize learning from failure. By recognizing the nuanced relationship between failure experience and error orientation, high-tech ventures can foster a culture of learning that effectively capitalizes on failure experiences to drive future success in NPD endeavors.

Declarations of interest

None.

Data availability

Data will be made available on request.

Acknowledgements

We thank Brian Anderson, Dan Kai Hsu, Gabriella Cacciotti, Jeffery McMullen, Saras Sarasvathy and Smita Srivastava, as well as participants at the Babson College Entrepreneurship Research Conference and Academy of Management Annual Meeting for their constructive comments.

References

Ahn, J.H., Kim, M.S., Lee, D.J., 2005. Learning from the failure: experiences in the Korean telecommunications market. Technovation 25 (1), 69–82.
Anbari, F.T., Carayannis, E.G., Voetsch, R.J., 2008. Post-project reviews as a key project management competence. Technovation 28 (10), 633–643.
Bandura, A., 1986. The explanatory and predictive scope of self-efficacy theory. J. Soc. Clin. Psychol. 4 (3), 359–373.
Baxter, D., Trott, P., Ellwood, P., 2023. Reconceptualising innovation failure. Res. Pol. 52 (7) https://doi.org/10.1016/j.respol.2023.104811.
Bauer, D.J., Curran, P.J., 2005. Probing interactions in fixed and multilevel regression: inferential and graphical techniques. Multivariate Behav. Res. 40 (3), 373–400.
Behrens, J., Patzelt, H., 2016. Corporate entrepreneurship managers' project terminations: integrating portfolio–level, individual–level, and firm–level effects. Entrep. Theory Pract. 40 (4), 815–842.
Byrne, O., Shepherd, D.A., 2015. Different strokes for different folks: entrepreneurial narratives of emotion, cognition, and making sense of business failure. Entrep. Theory Pract. 39 (2), 375–405.
Cardon, M.S., Stevens, C.E., Potter, D.R., 2011. Misfortunes or mistakes? Cultural sensemaking of entrepreneurial failure. J. Bus. Ventur. 26 (1), 79–92.
Chang, W., Taylor, S.A., 2016. The effectiveness of customer participation in new product development: a meta-analysis. J. Market. 80 (1), 47–64.
Dahlin, K.B., Chuang, Y.T., Roulet, T.J., 2018. Opportunity, motivation, and ability to learn from failures and errors: review, synthesis, and ways to move forward. Acad. Manag. Ann. 12 (1), 252–277.
DeRue, D.S., Wellman, N., 2009. Developing leaders via experience: the role of developmental challenge, learning orientation, and feedback availability. J. Appl. Psychol. 94 (4), 859–875.
Elmquist, M., Le Masson, P., 2009. The value of a 'failed' R&D project: an emerging evaluation framework for building innovative capabilities. R D Manag. 39 (2), 136–152.
Emby, C., Zhao, B., Sieweke, J., 2019. Audit senior modeling fallibility and audit juniors' responses to self-discovered errors: the mediating effects of error strain and error-related self-efficacy. Behav. Res. Account. 31 (2), 17–30.
Forsman, H., 2021. Innovation failure in SMEs: a narrative approach to understand failed innovations and failed innovators. Int. J. Innovat. Manag. 25 (9) https://doi.org/10.1142/S1363919621501048.
Frese, M., Keith, N., 2015. Action errors, error management, and learning in organizations. Annu. Rev. Psychol. 66, 661–687.
Fornell, C., Larcker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. J. Market. Res. 18 (1), 39–50.
Funken, R., Gielnik, M.M., Foo, M.D., 2020. How can problems be turned into something good? The role of entrepreneurial learning and error mastery orientation. Entrep. Theory Pract. 44 (2), 315–338.
Hair, J.F., Hult, G.T.M., Ringle, C.M., Sarstedt, M., 2014. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Sage, Thousand Oaks.
He, F., Sirén, C., Singh, S., Solomon, G., von Krogh, G., 2018. Keep calm and carry on: emotion regulation in entrepreneurs' learning from failure. Entrep. Theory Pract. 42 (4), 605–630.
Heggestad, E.D., Scheaf, D.J., Banks, G.C., Monroe Hausfeld, M., Tonidandel, S., Williams, E.B., 2019. Scale adaptation in organizational science research: a review and best-practice recommendations. J. Manag. 45 (6), 2596–2627.
Hetzner, S., Gartmeier, M., Heid, H., Gruber, H., 2011. Error orientation and reflection at work. Vocations Learn. 4 (1), 25–39.
Hu, Y., McNamara, P., Piaskowska, D., 2017. Project suspensions and failures in new product development: returns for entrepreneurial firms in co-development alliances. J. Prod. Innovat. Manag. 34 (1), 35–59.
Keith, N., Frese, M., 2005. Self-regulation in error management training: emotion control and metacognition as mediators of performance effects. J. Appl. Psychol. 90 (4), 677–691.
Khanna, R., Guler, I., Nerkar, A., 2016. Fail often, fail big, and fail fast? Learning from small failures and R&D performance in the pharmaceutical industry. Acad. Manag. J. 59 (2), 436–459.
Kibler, E., Mandl, C., Farny, S., Salmivaara, V., 2021. Post-failure impression management: a typology of entrepreneurs' public narratives after business closure. Hum. Relat. 74 (2), 286–318.
Kim, N., Lee, J., 2020. Who is leaping through failure? The influence of innovation characteristics on learning from failure. Ind. Innovat. 27 (9), 1014–1039.
Kock, A., Gemünden, H.G., 2021. How entrepreneurial orientation can leverage innovation project portfolio management. R D Manag. 51 (1), 40–56.
Lindell, M.K., Whitney, D.J., 2001. Accounting for common method variance in cross-sectional research designs. J. Appl. Psychol. 86 (1), 114–121.
Liu, X., Hodgkinson, I.R., Chuang, F.M., 2014. Foreign competition, domestic knowledge base and innovation activities: evidence from Chinese high-tech industries. Res. Pol. 43 (2), 414–422.
Liu, Y., Li, Y., Hao, X., Zhang, Y., 2019. Narcissism and learning from entrepreneurial failure. J. Bus. Ventur. 34 (3), 496–512.
Maslach, D., 2016. Change and persistence with failed technological innovation. Strat. Manag. J. 37 (4), 714–723.
Minniti, M., Bygrave, W., 2001. A dynamic model of entrepreneurial learning. Entrep. Theory Pract. 25 (3), 5–16.
Morais-Storz, M., Nguyen, N., Sætre, A.S., 2020. Post-failure success: sensemaking in problem representation reformulation. J. Prod. Innovat. Manag. 37 (6), 483–505.
Mueller, B.A., Shepherd, D.A., 2016. Making the most of failure experiences: exploring the relationship between business failure and the identification of business opportunities. Entrep. Theory Pract. 40 (3), 457–487.
Nolen-Hoeksema, S., Wisco, B.E., Lyubomirsky, S., 2008. Rethinking rumination. Perspect. Psychol. Sci. 3 (5), 400–424.
Patzelt, H., Gartzia, L., Wolfe, M.T., Shepherd, D.A., 2021. Managing negative emotions from entrepreneurial project failure: when and how does supportive leadership help employees? J. Bus. Ventur. 36 (5) https://doi.org/10.1016/j.jbusvent.2021.106129.
Pierce, J.L., Kostova, T., Dirks, K.T., 2001. Toward a theory of psychological ownership in organizations. Acad. Manag. Rev. 26 (2), 298–310.
Puliga, G., Urbinati, A., Franchin, E.M., Castegnaro, S., 2023. Investigating the drivers of failure of research-industry collaborations in open innovation contexts. Technovation 119. https://doi.org/10.1016/j.technovation.2022.102543.

Qin, J., van der Rhee, B., 2021. From trash to treasure: a checklist to identify high-potential NPD projects from previously rejected projects. Technovation 104. https://doi.org/10.1016/j.technovation.2021.102259.

Rhaiem, K., Amara, N., 2021. Learning from innovation failures: a systematic review of the literature and research agenda. Rev. Manag. Sci. 15 (2), 189–234.

Rybowiak, V., Garst, H., Frese, M., Batinic, B., 1999. Error orientation questionnaire (EOQ): reliability, validity, and different language equivalence. J. Organ. Behav. 20 (4), 527–547.

Salerno, M.S., de Vasconcelos Gomes, L.A., Da Silva, D.O., Bagno, R.B., Freitas, S.L.T.U., 2015. Innovation processes: which process for which project? Technovation 35, 59–70.

Schell, K.L., Conte, J.M., 2008. Associations among polychronicity, goal orientation, and error orientation. Pers. Indiv. Differ. 44 (1), 288–298.

Seckler, C., Funken, R., Gielnik, M.M., 2017. A psychological model of learning from entrepreneurial failure: integrating emotional, motivational, and cognitive factors. In: Ellingson, J.E., Noe, R.A. (Eds.), Autonomous Learning in the Workplace. Routledge, New York, pp. 54–77.

Seckler, C., Fischer, S., Rosing, K., 2021. Who adopts an error management orientation? Discovering the role of humility. Acad. Manag. Discov. 7 (4), 461–481.

Shepherd, D.A., Cardon, M.S., 2009. Negative emotional reactions to project failure and the self-compassion to learn from the experience. J. Manag. Stud. 46 (6), 923–949.

Shepherd, D.A., Covin, J.G., Kuratko, D.F., 2009. Project failure from corporate entrepreneurship: managing the grief process. J. Bus. Ventur. 24 (6), 588–600.

Shepherd, D.A., Haynie, J.M., Patzelt, H., 2013. Project failures arising from corporate entrepreneurship: impact of multiple project failures on employees' accumulated emotions, learning, and motivation. J. Prod. Innovat. Manag. 30 (5), 880–895.

Shepherd, D.A., Patzelt, H., Williams, T.A., Warnecke, D., 2014. How does project termination impact project team members? Rapid termination, 'creeping death', and learning from failure. J. Manag. Stud. 51 (4), 513–546.

Shepherd, D.A., Patzelt, H., Wolfe, M., 2011. Moving forward from project failure: negative emotions, affective commitment, and learning from the experience. Acad. Manag. J. 54 (6), 1229–1259.

Spreitzer, G., Sutcliffe, K., Dutton, J., Sonenshein, S., Grant, A.M., 2005. A socially embedded model of thriving at work. Organ. Sci. 16 (5), 537–549.

Steele, L.M., Watts, L.L., 2022. Managing technical innovation: a systematic review of 11 leader functions. Technovation 115. https://doi.org/10.1016/j.technovation.2022.102539.

Tao, X., Wang, C.L., Robson, P.J., 2023. Regulatory focus, ambidextrous learning, and opportunity recognition in new product development. IEEE Trans. Eng. Manag. https://doi.org/10.1109/TEM.2023.3240029.

Thomas, J.B., Clark, S.M., Gioia, D.A., 1993. Strategic sensemaking and organizational performance: linkages among scanning, interpretation, action, and outcomes. Acad. Manag. J. 36 (2), 239–270.

Todt, G., Weiss, M., Hoegl, M., 2018. Mitigating negative side effects of innovation project terminations: the role of resilience and social support. J. Prod. Innovat. Manag. 35 (4), 518–542.

Tumasjan, A., Braun, R., 2012. In the eye of the beholder: how regulatory focus and self-efficacy interact in influencing opportunity recognition. J. Bus. Ventur. 27 (6), 622–636.

Ucbasaran, D., Shepherd, D.A., Lockett, A., Lyon, S.J., 2013. Life after business failure: the process and consequences of business failure for entrepreneurs. J. Manag. 39 (1), 163–202.

Urbig, D., Bürger, R., Patzelt, H., Schweizer, L., 2013. Investor reactions to new product development failures: the moderating role of product development stage. J. Manag. 39 (4), 985–1015.

van Dyck, C., van Hooft, E., de Gilder, D., Liesveld, L., 2010. Proximal antecedents and correlates of adopted error approach: a self-regulatory perspective. J. Soc. Psychol. 150 (5), 428–451.

van Gelderen, M., van de Sluis, L., Jansen, P., 2005. Learning opportunities and learning behaviours of small business starters: relations with goal achievement, skill development and satisfaction. Small Bus. Econ. 25 (1), 97–108.

Von Zedtwitz, M., 2002. Organizational learning through post–project reviews in R&D. R D Manag. 32 (3), 255–268.

Wang, T., 2023. Toward an understanding of innovation failure: the timing of failure experience. Technovation 125. https://doi.org/10.1016/j.technovation.2023.102787.

Weick, K., 1979. The Social Psychology of Organizing. Addison-Wesley, Readon, MA.

Weick, K.E., Sutcliffe, K.M., Obstfeld, D., 2005. Organizing and the process of sensemaking. Organ. Sci. 16 (4), 409–421.

Wilhelm, H., Richter, A.W., Semrau, T., 2019. Employee learning from failure: a team-as-resource perspective. Organ. Sci. 30 (4), 694–714.

Wolfe, M.T., Shepherd, D.A., 2015. What do you have to say about that? Performance events and narratives' positive and negative emotional content. Entrep. Theory Pract. 39 (4), 895–925.

Zhang, L., Wang, B., Feng, X., Zhang, Y., Wang, W., 2022. Exploring the influence of failure aversion on learning from project failure: a Sensemaking perspective. Front. Psychol. 13 https://doi.org/10.3389/fpsyg.2022.794390.