How managers' cognitive frames affect the use of process improvement approaches in new product development

ABSTRACT

Purpose: Despite the numerous implementations of process improvement approaches (PIAs) in new product development (NPD), the espoused benefits of PIAs are rarely realized in practice. This paper explores how managers' cognitive frames provide knowledge structures that affect the use of PIAs in the development of new products.

Design/methodology/approach: A qualitative multiple case study method was used to elaborate theory in relation to the use of PIAs in NPD. Four large multinational companies were selected. Interviews with informants from different functional specialisms were conducted, and internal and online documents were collected and analyzed.

Findings: Two main findings emerge. First, we identify three types of managers' cognitive frames: conflicting, paradoxical, and supporting. Second, these cognitive frames are found to influence managers' decisions over whether to promote, adapt or prevent the implementation of PIAs, sometimes in contrast with their organization's strategic intent.

Originality/value: This study helps explain conflicting findings in the literature regarding the implementation and effects of PIAs in NPD by identifying managers' cognitive frames as a key factor. Moreover, it highlights managers' roles in shaping an organization's approach for managing contradictory goals and shows how an organizational frame may conflict and sometimes be displaced by individual managers' cognitive frames.

Practical implications: This paper generates insights into the importance of managerial decision-making in determining the scope and depth of implementation of PIAs in NPD.

Keywords: Process improvement, new product development, cognitive frames, paradox, lean.

Paper type: Research paper.

1. INTRODUCTION

While process improvement approaches (PIAs), such as lean, Six Sigma, and total quality management, originate in manufacturing contexts, over time they have been deployed in other functions and processes, often to make them more efficient and effective (Collins and Browning, 2019). The application of PIAs in new product development (NPD) has been particularly diffused but also contested (Netland and Powell, 2017) and recent research argues that our understanding of the types of process improvement approaches and tools exceeds our understanding of how to implement them (Collins and Browning, 2019). On one hand, some researchers state that PIAs negatively affect an organization's capacity to innovate, because of their aim of reducing variation in processes (Benner and Tushman, 2002) and their reliance on standardization and formalization (Zeng *et al.*, 2015), which conflict with the need for variation-increasing activities, flexibility and slack resources that are necessary for product innovation (Atuahene-Gima, 2005; Sethi and Sethi, 2009). On the other hand, some scholars suggest that the introduction of PIAs in NPD can be beneficial as they can support learning and lead to improvements in both quality and flexibility (Leon and Farris, 2011; Marodin *et al.*, 2018).

Considering the ways in which PIAs have been applied in NPD, studies have tended to focus on specific tools and practices - including value stream mapping (Schulze *et al.*, 2013) product modularization and standardization (Karlsson and Ahlstrom, 1996; Marodin *et al.*, 2018), 5Ss (sort, set in order, shine, standardize, and sustain), 5 whys, DMAIC (Define, Measure, Analyze, Improve, Control) (Carleysmith *et al.*, 2009), and waste reduction (Liker and Morgan, 2006) - their adaptation to the NPD context (Collins and Browning, 2019), and their effects on innovation performance (Dalton, 2009; Tuli and Shankar, 2015). However, some scholars have emphasized that behavioral aspects play a crucial role and are inseparable from the implementation

of PIAs. In other words, the effectiveness of these approaches does not depend solely on the types of tools deployed, but also on how these are perceived and used (Jones, 2014; Bortolotti *et al.*, 2015). For example, Maalouf and Gammelgaard (2016) highlight the importance of understanding the impact of lean implementation on individuals and organizations in order to avoid setbacks in the lean transformation process. Canato *et al.* (2013) report how the misfit between organizational culture and PIAs (in this case, Six Sigma) may result in mutual adaptation of organizational practices and culture in the long run.

While these and other studies examine relevant behavioral and cultural issues, little is known as to the role of individual managers in shaping the use of PIAs in NPD (Cho and Linderman, 2019). This is a major problem as managers' cognition and engagement with process improvement has been found to play a key role in determining the success of PIAs' implementations (Camuffo and Gerli, 2018; Cho and Linderman, 2019; Jones, 2014). Therefore, this study investigates the following question: *how do managers' cognitive frames affect the introduction and use of PIAs in NPD?*

To address it, this research draws on the cognitive frame and paradox management literatures. A cognitive frame refers to a "mental template that individuals impose on an information environment to give it form and meaning" (Walsh, 1995; p. 281). Individuals tend to generate these frames by associating certain attributes to various situations and objects. A cognitive lens can help understand the determinants of managerial decisions and responses to various situations, particularly in presence of competing goals (Hahn *et al.*, 2014). Indeed, research on tensions and paradoxes has focused on individuals' cognitive frames to unpack the process of managing divergent and contradictory goals in organizations such as exploration and exploitation or flexibility and standardization, and the simultaneous pursuit of economic, social, and

environmental goals (Andriopoulos *et al.*, 2018; Hahn *et al.*, 2014; Zehendner *et al.*, 2021). Studies on paradox management suggest that the achievement of contradictory goals in organizations requires managers to cognitively relate to contradictions in ways that allow them to embrace rather than deny or avoid these tensions (Tarba *et al.*, 2020).

To explore the role of managers' cognitive frames in the deployment and use of PIAs in NPD, a multiple case study research design was used, and interviews with informants from different functional specialisms (R&D, design, engineering, manufacturing, and marketing) were conducted. The analysis leads to three main findings, which have important implications for both theory and practice: first, managers' interpretations of the role of PIAs at different NPD stages were found to be of three types - conflicting, supporting, and paradoxical. Second, often because of their cognitive frames, managers acted to promote, adapt, or prevent the use of PIAs. Third, when there was a misalignment between managers' cognitive frames and the company's intention towards the implementation of PIAs, managers' actions became dominant and led to situations that conflicted with the company's strategy, most notably to the lack of deployment of a PIA even though the firm had identified this as a priority.

This paper is organized as follows: the next section reviews studies in the areas of process improvement, NPD, cognitive framing, and paradox. Section three presents the research methodology and data collection and analysis procedures. Subsequently, the findings are reported, emphasizing the roles of managers' cognitive frames. The paper concludes by highlighting the contributions and implications of the research.

2. LITERATURE REVIEW

2.1 Process improvement and the new product development process

In this study, we follow Collins and Browning (2019; p. 216) and define PIAs as "organizational initiatives intended to improve the efficiency, effectiveness, and consistency of work—such as improving product designs, reducing errors, and decreasing requirements for time, money, and other resources." The main PIAs, with examples of related tools and practices, are reported on Table I (see also Collins and Browning, 2019).

Insert Table I about here

Over the past three decades, academics and practitioners have discussed the applicability of various PIAs in different areas and processes within an organization such as new product development (Netland and Powell, 2017). Overall, the literature on the use of PIAs in NPD can be divided into three streams. The first one discusses the use of *specific process improvement tools and practices* in the NPD context (Hines *et al.*, 2006; Leon and Farris, 2011). The second stream examines *the effects of PIAs on innovation outcomes* in the context of NPD. Overall, these studies are often based on contradictory theoretical arguments and lead to conflicting empirical results. On one hand, innovation and strategy scholars suggest a negative impact for PIAs implementation in NPD, as these approaches are said to hinder the flexibility and creativity that are needed for innovation. For instance, in their theoretical examination of the productivity dilemma, Benner and Tushman (2003) argue that PIAs impede the exploration that is needed for innovation as PIAs reduce the variation and slack resources that are required for experimentation and creativity.

Empirically, one of the main criticisms for Six Sigma's use in NPD has been that it "creates a culture of command and control, which may stifle employee creativity and innovation" (Sony *et al*., 2020; p. 955).

On the other hand, operations management scholars highlight the positive role of PIAs in NPD. For example, Prajogo and Hong (2008) find that TQM can be implemented effectively in an R&D environment and it has a positive impact on both product quality and innovation. Similarly, Carleysmith *et al.* (2009, p. 104) conclude, "while not catalysing creativity directly, Lean Sigma methods and tools can be used to improve knowledge management and teamwork, and to improve all routine aspects of the overall operation. The result is more time for scientists to innovate, and reduction of cycle times, which increases the speed of development". Also, Schulze *et al.* (2013) reveal that value stream mapping facilitates "feed-forward learning" in NPD. Sethi and Sethi (2009) conclude that quality orientation does not negatively impact product novelty in cross-functional teams. Similarly, Pekovic and Galia (2009) emphasize the importance of a "well-established quality system" to improve innovation performance. Other scholars have considered the effect of PIAs on the speed and performance of NPD. For example, Dalton (2009) argues that a theory of constraints approach could help improve NPD processes by creating a culture of continuous innovation and by helping identify bottlenecks in the innovation process. Also, Tuli and Shankar (2015) claim that lean can improve NPD process performance in terms of quality, time to market, and risk management by aligning people and processes towards a common goal. Gutierrez-Gutierrez *et al.* (2020) find a positive impact of Six Sigma on flexibility.

The third stream of research investigates *how PIAs could be more effectively introduced in NPD* (Collins and Browning, 2019). Browning and Sanders (2012) propose ways to facilitate the implementation of lean in R&D suggesting four paths to lean product development. Others

stress the importance of behavioral aspects in the implementation of PIAs (Modig and Ahlstrom, 2012). Karlsson and Ahlstrom (1996) emphasize the role of top management and employees' competencies in supporting lean usage in product development. Likewise, Award and Shanshal (2017) propose a framework to adopt a combined approach that includes kaizen and design for Six Sigma in product development, highlighting the relevance of management support and buy-in. In a similar vein, Liker and Morgan (2006) stress the importance of using an integrated framework that combines technology, people, and processes when using lean outside manufacturing environments such as NPD. Recent research also shows that the implementation of PIAs rarely follows a sequence of "turn-key" steps and instead consists of practices that are often constructed via adaptive and dialectical learning (De Mast *et al.*, 2022).

While these studies discuss various managerial and behavioral aspects, little attention has been paid to the role of individuals' perspectives in the adoption of PIAs (Camuffo and Gerli, 2018; Cho and Linderman, 2019). This is a major issue as research on both process improvement and innovation adoption shows that individual managers' cognitive frames substantially affect the deployment and use of new practices (Andriopoulos *et al.*, 2018; Canato *et al.*, 2013). Indeed, studies on cognitive frames suggest that the way in which individuals view certain practices, especially new ones, guides how they use them (Benkert, 2021) and "both scholars and practitioners frequently cite human behavior as a primary reason that [PIAs] fail to achieve their intended results" (Collins and Browning, 2019; p. 219). Thus, this study draws on the cognitive frames and paradox literatures to understand how individuals' mental frames affect the deployment and use of PIAs in NPD.

2.2 Cognitive frames and paradox

Cognitive frames, also known as mental frames or schemas (Longoni et al., 2019), form "the foundation of individual and collective human reasoning, decision-making and behaviors" (Moosmayer *et al.*, 2020; p. 176). Individuals tend to impose mental frames on the information they have, especially when they are confronted with making decisions (Walsh, 1995). Frames are key resources for cognition (Cornelissen and Werner, 2014) as they enable individuals to "comprehend, understand, explain, attribute, extrapolate, and predict" (Starbuck and Milliken, 1988; p. 51).

When pursuing different and potentially conflicting objectives, managers may adopt two types of frames (Smith and Lewis, 2011). The first is a unitary frame whereby managers deal with ambiguity by trying to eliminate tensions (Hahn *et al.*, 2014), for example by attempting to reconcile conflicting goals related to efficiency and flexibility (Eisenhardt *et al.*, 2010) or productivity and adaptability (Adler *et al.*, 1999). In this case, a specific goal may be prioritized, and the others considered only to the extent that they are aligned with it (Hahn *et al.*, 2014; Miron-Spektor *et al.*, 2018). For instance, in the context of NPD, experimentation and adaptability may be perceived to be the most salient goals, and standardization and efficiency only relevant if they support the organization's capacity to experiment and adapt. The second is a paradoxical frame whereby individuals attempt to manage tensions and inconsistencies, rather than to resolve them (Andriopoulos *et al.*, 2018; Davies *et al.*, 2021; Smith and Lewis, 2011). In the context of NPD, it could be argued that flexibility, freedom, and autonomy are required to push boundaries and facilitate innovation (Benner and Tushman, 2003). Yet maintaining a certain amount of control, through standardization, is necessary to foster efficiency and reduce lead times (Andriopoulos et

al., 2018). For example, Beltagui (2018) proposes structural separation between business units to help manufacturing firms that offer services deal with tensions in NPD.

Although difficult to develop, the ability of NPD managers to cope with such tensions has been identified as a crucial antecedent of innovation performance (Sethi and Sethi, 2009). According to Gibson and Birkinshaw (2004), achieving ambidexterity in organizations depends on individuals' ability to manage alignment and adaptability. Smith and Tushman (2005) suggest that paradoxical frames could help managers deal with the contradiction of exploitation and exploration. In a similar vein, O'Reilly and Tushman (2008) emphasize the role of top management teams in dealing with contradictory goals. Adler *et al.* (1999) propose switching as a mechanism that employees in production units could use to perform either systematic or flexible tasks. Recent research adopts a paradox lens to examine the diffusion of PIAs. For example, Maalouf *et al.* (2016) identify organizing, performing, and belonging as lean implementation related paradoxes. Erthal *et al.* (2021) build on this study and suggest that lean associated practices such as the adoption of a continuous improvement mindset and a focus on value creation could help manage these paradoxes. In an NPD context, Andriopoulos *et al.* (2018) find that the adoption of paradoxical cognitive frames in NPD teams foster the cognitive comfort necessary to deal with innovation tensions. Also, Lin *et al.* (2014) suggest that ambidextrous cognitive frames enable strategic business units' leaders to manage innovation-related tensions (e.g., exploration and exploitation). Also, Miron-Spektor *et al.* (2018) focus on employees' mindsets and note that a paradox mindset can help improve their innovative and in-role job performance.

2.3 Conclusions from the literature

Despite the numerous implementations of process improvement approaches in new product development processes, the espoused benefits of PIAs in NPD are rarely realized in practice (Collins and Browning, 2019). Studies have focused on which process improvement tools and practices are most suitable in an NPD context and on what effect they have on innovation outcomes. Considering how to effectively introduce PIAs in NPD, recent research has identified managers' cognitive frames as potential enablers or barriers to PIAs' successful deployment (Cho and Linderman, 2019). However, while several studies have advanced our understanding of the role of individuals in managing tensions in NPD, how managers' individual frames influence the use of PIAs in NPD has remained largely unexplored. The implementation of PIAs in NPD entails paradoxes that need to be managed, such as standardization and flexibility, autonomy and control, and innovation and efficiency (Benner and Tushman, 2003; Carleysmith *et al.*, 2009; Erthal *et al.*, 2021; Maalouf and Gammelgaard, 2016). Studies on paradox suggest that managers' cognitive frames shape how they perceive and manage contradictory goals within organizations (Smith and Tushman, 2005; Hahn *et al.*, 2014) including in the context of NPD (Andriopoulos *et al*., 2018). Therefore, examining managers' cognitive frames from a paradox perspective could be a promising avenue to enrich our understanding of the implementation of PIAs in the NPD context. Figure 1 graphically depicts the main elements of this study's conceptual framework.

Insert Figure 1 about here

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3. METHODOLOGY

3.1 Case selection and research context

To elaborate theory in relation to the use of PIAs in NPD, this research adopts a qualitative multiple case study method (Voss *et al.*, 2002) where the selected firms were purposefully sampled to

achieve maximum variation (Denzin and Lincoln, 2011). Following previous research that considered the role of managers' cognitive frames in managing paradoxes in NPD (e.g., Andriopoulos *et al.*, 2018), we sampled various companies and then collected data from managers within different functions that play a key role in product development. Specifically, we identified four large international manufacturing companies from three industries (aerospace, automotive, and pharmaceutical) that could shed the light on our research question. We selected firms that are similar in terms of sector, size, and location, but vary in the extent of PIAs usage and the degree of product innovativeness. While these criteria were identified at the beginning of the sampling phase, further validation of the initial assessment was sought during the data collection and analysis process.

The characteristics of PIAs deployed at each site were derived in three ways: first, data were collected up front on awards received by the organization in relation to process improvement. Second, the breadth and the depth of PIAs usage across the organization was evaluated during initial interviews and gathering of documentary evidence, both internal and external (Marodin *et al.*, 2018, Netland and Ferdows, 2016). Third, to validate our initial assessment, key informants were explicitly asked regarding the types of uses of PIAs in the organization. The degree of product innovativeness was gauged in relation to both market and technology, consistently with extant research (Chandy and Tellis, 2000). A product that displays new technology, knowledge, or capability and satisfies new customers was identified as a radical innovation. Conversely, instances where current technology, knowledge, or capability were used, and the product satisfied existing customers were identified as incremental innovations. To derive this, the existence of innovation awards as well as external documentary evidence were considered, and informants were asked to provide examples of recent products to classify them as incremental or radical.

3.2 Data collection

Data were acquired through semi-structured interviews and internal documents (the interview protocol is reported in Appendix 1). Also, the first researcher kept a diary throughout the data collection and analysis phases (Voss *et al.*, 2002). Over 15 months, a total of 44 semi-structured interviews were conducted and 55 relevant documents were collected. The interviews were carried out with senior managers from different functional specialisms (e.g., R&D, manufacturing, engineering, design, and marketing). A snowballing technique was used to ensure key informants were included. Each interview lasted an average of one hour and field notes were taken throughout the research (Eisenhardt, 1989). The interviewing process continued until theoretical saturation was achieved both within and across organizations (a minimum of eight interviews and 10 documents were collected per company). The main characteristics of the research sites are reported in Table II[1]. Table III provides examples of process improvement tools and practices in the case organizations.

Insert Table II and Table III about here

3.3 Data analysis

Data were analyzed within and across cases through a multi-stage iterative process which included several rounds of coding, categorization, and refinement using the NVivo software. While the

[1] For confidentiality reasons, organization names have been anonymized.

process is described in a linear way for simplicity, it was iterative in practice. The analysis was broadly conducted in two stages.

Stage 1: Within-case analysis

The first round of analysis was initiated by in-depth reading of the documents and the interview transcripts for each case organization separately to allow "the unique patterns of each case to emerge" (Eisenhardt, 1989; p. 540). Initially, the main characteristics of PIAs in each organization - where they were being used, by whom, and how – were derived. This includes identifying which process improvement tools and practices were used in each organization and in which function. Several product innovation aspects, including the types of products and the main stages and features of the new product development process were considered as well. Managers' cognitive frames were identified by examining their views on the applicability and effects of PIAs in NPD. The first-order codes reported on Figures 2 and 3 summarize these. In this round of coding, in-vivo codes or descriptive sentences were used to adhere to the informants' terms (Gioia *et al.*, 2013). After identifying the main characteristics of PIAs, innovation, and managers' cognitive frames and actions through first-order coding, a detailed description was written for each case.

Stage 2: Cross-case comparison

The second stage of analysis was to identify the main similarities and differences between managers' cognitive frames and the process improvement approaches adopted by each organization. While the four companies were similar in their intentions and willingness to implement PIAs in NPD, managers' frames were found to vary across both the case organizations and the various NPD stages (e.g., discovery and selection, development, and deployment). In some

instances, managers appeared to view PIAs as supporting innovation whereas in others they regarded them as conflicting with it; in others again, they appeared to adopt a paradoxical view whereby they recognized the tensions between process improvement and innovation but argued that both were important. During the analysis, first-order codes such as "PIAs reduce creativity" and "PIAs drive a sequential process" were initially derived from the data (see Figure 2). First-order codes were then aggregated into second-order ones: for example, "PIAs reduce creativity" and "PIAs drive a sequential process" were regarded as "barriers." Subsequently, aggregate dimensions (e.g., "conflicting frame") were derived from second-order codes (e.g., "barriers" and "inapplicable"). A similar process was followed in relation to the varied uses of PIAs at different NPD stages across the case organizations. In some instances, PIAs appeared to be embedded in the NPD process; in others, they were confined to the back end of NPD. First-order codes (e.g., "Encouraging employees to use process improvement tools" and "Promote PIAs' diffusion in line with corporate guidelines") emerged from the data and were then aggregating into second-order codes ("Support PIAs use"). These latter were then used to form the aggregate dimensions ("Promotion") (see Figure 3). The coding structure and illustrative quotes are reported in Appendix 2.

Insert Figures 2 and 3 about here

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4. FINDINGS

4.1 Within-case analysis

This section describes the main findings within each case organization. Each sub-section is divided into three parts: the company's intended approach, managers' cognitive frames, and deployment of PIAs.

4.1.1 Fast-CarCo

Company's intended approach

Data gathered through documents and interviews show that process improvement is an essential component of the Fast-CarCo way of working. The company has an annual internal business excellence award that requires evaluating performance in various areas including strategy, operating processes, responsiveness, and customer-centricity. As part of this assessment, Fast-CarCo has introduced the LEAP program (Leadership in Efficiency, Agility, and Performance) to drive performance improvements "across six major work streams: (1) market equation, (2) product design cost, (3) material cost, (4) manufacturing cost, (5) quality/warranty cost, (6) fixed cost containment and IT, with each workstream having multiple initiatives" (Excellence and strategic priorities document, 2016, p. vii).

Additionally, Fast-CarCo uses different process improvement tools and practices such as PDCA, DMAIC, FMEA, SPC[2], process mapping/flowcharting, Kaizen and lean methods. In general, "Continuous Improvement methodology is used throughout the business to improve operating efficiency and remove non-value-added work" (Excellence and strategic priorities document, 2016, p. 27). Fast-CarCo communicates and shares best practices across the company

[2] PDCA: Plan, Do, Check, Act; DMAIC: Define, Measure, Analyze, Improve, Control; FMEA: Failure Modes and Effects Analysis; SPC: Statistical Process Control

through different portals such as the 'Fast-CarCo Way', which is a business-wide initiative that was established in 2014. Its main purpose is to "bring together and improve the business excellence mechanisms which establish and control our ways of thinking, behaving and working. It includes all Fast-CarCo corporate and operational policies, key work systems, processes, procedures, templates, standards, etc., and it is accessible globally via the Fast-CarCo Portal" (Excellence and strategic priorities document, 2016, p. vii). The Fast-CarCo portal acts as a library that collects various codified processes from various parts of the organization, including processes for strategy, technology development, and product creation. Each process at Fast-CarCo has an owner who is responsible for its improvement.

Managers' cognitive frames

Informants across Fast-CarCo expressed fairly varied views toward the applicability of PIAs approaches in NPD. The majority of interviewees considered PIAs as enablers of innovation, a few saw them as paradoxically related to innovation, and only one talked about PIAs as barriers to the creativity and flexibility needed to innovate. Managers belonging to the first group described PIAs as compatible with creativity. For instance, the Director of Business Excellence stated:

> Standardized work is important so that you go through a certain mechanism of: let's do this, let's do this, let's do this. And you will get the outputs. So standardized work is important. Can we say standardized work causes problems in creativity? Yes and no, because in every piece of that standardized work, which is so much, there could be pieces out here that say: okay, think creatively in this box.

Similarly, some informants associated PIAs with efficient and faster innovation processes. For example, the Lead engineer explained: *"I would say that at those early stages, yes, [PI] would be important. As I said earlier, if you find out [waste] at these stages … you can reduce your costs by finding errors by almost 70%".*

Other informants stressed the importance of managing opposing forces that are associated with PIAs usage and other activities in NPD. For instance, the Marketing Communication Manager

stated: "*You're always trying to do the combination of optimizing and then innovating. I don't think those two things are in tension. For me it's just always about just ensuring you get a balance*". Likewise, the Competitive and Market Intelligence Manager talked about pursuing innovation by bringing new products to market and optimizing the organizational processes that facilitate the launch of these innovations: *"In the corporate strategy we have two arms. One is to pack down the operations to make them more efficient, and the reason for doing that is partly to free up money that we can use to explore new things at the front end. And we need to do both".*

On the other hand, the Business manager of global CRM and Customers' insights talked about PIAs as conflicting with innovation. This was evident in his description of PIAs as incompatible with the flexibility needed to innovate:

> Sometimes I wonder if you're only ever going to make small changes as a result of following that Plan, Do, Check, Act, you know? Well, we did it like that, we could perhaps tweak it here and there, and it would be better. Okay, well, we've done that, and now it's fine [but] it's not necessarily going to bring major innovation.

Deployment of PIAs in NPD

Overall, there is substantial alignment at Fast-CarCo between the company's intention and the actual adoption of PIAs in NPD. The use of PIAs is promoted also during the early stages of NPD to facilitate problem-solving rigorously, as explained by the Head of Research: "*If we look at Six Sigma, some of the techniques like DMAIC, etc., in terms of giving us statistical analysis in order to make some of these decisions, they're incredibly useful."*

Managers who view PIAs as supporting mechanisms for innovation tend to adapt them to their areas, particularly design, engineering, and product creation. The Product Creation Delivery System Project Manager explained this approach:

> We've used lean techniques within the business processes as well for looking at opportunities to reduce the length of processes by taking out, you know, unnecessary process steps and stuff like that. In terms of the process improvement projects that we do, we have an in-house project management process, but it largely follows the same steps that you go through for kind of DMAIC projects.

4.1.2 Value-CarCo

Company's intended approach

Value-CarCo aims to implement and use PIAs widely in the organization. To do so, it first created an operational excellence team to "facilitate a culture of continuous improvement and transformation in the areas of Enterprise Process Management, Supply Chain Management, Enterprise Project Management, Production Efficiency Management, and Continuous Improvement Programs" (Strategic plan). Second, it introduced an excellence award called the "Value-CarCo Business Excellence Model Assessment" which "provides comprehensive, analytical feedback [on] strategy deployment, operational processes, market responsiveness, customer-centricity. All systems and processes of Value-CarCo are checked during the assessment. The exercise aims to understand areas of strength and identify the opportunities for improvement". Third, lean facilitators were appointed in the product development, design, and engineering areas. At the beginning of this study, we interviewed the newly recruited Lean Facilitator in the Advanced Product Creation area who elaborated on his role:

> In terms of this advanced product creation area, that will be me, and I will be bringing some of this [lean] methodology to it, and that's one of the reasons that I've been, kind of, engaged in this space, because typically in advanced product creation usually you hire somebody to do that role from either the engineering community or the design community. I'm neither of those, I'm not a designer or an engineer, I'm a lean [facilitator].

Also, the engineering and design departments have several people trained in various PIAs. According to the Head of Propulsion and Innovation:

> We do have some Six Sigma specialists. We've actually had a certain amount of training going on over the last few years because we are helping to analyze product data, and that's where I think the typical disciplines help.

Managers' cognitive frames

Despite the company's intention to use PIAs in NPD, most managers expressed a negative view of PIAs. Essentially, they described these approaches – particularly lean and Six Sigma - as rigid barriers to the creativity and flexibility that are needed in NPD, particularly in the early stages of discovery and development. Rather unexpected in an automotive company, resistance to PIAs' use in NPD was clearly voiced by several interviewees such as the Chief Program Engineer:

> The processes need to be very flexible in an innovation environment, so that's very different from an operational lean or Six Sigma environment where you're trying to take the creativity out, you're trying to actually make it consistent and repeatable every single time.

The introduction of the lean facilitators was intended to accelerate the diffusion of PIAs. In his first interview, after just being appointed, the Lean Facilitator in Product Creation and Development stated:

> We try to use lean methodologies to get problems solved at the lowest level in the organization. So, what we want to try and do, we want to try to get the problems or challenges and opportunities addressed at the lowest point in the organization so that not everything comes all the way up, and that's very much a lean way of doing things.

However, during his second interview, after almost a year, this lean facilitator stressed the challenge of adopting PIAs in NPD, arguing that this depends on people's perspectives:

> [I've come] to the conclusion and realization that actually just because [lean] is logical and to a large degree proven in certain areas of industry, [it] doesn't mean that everyone's going to run away and do it. Because of either the environment they've grown up in or their skepticism or whatever else it is. So, on the one hand, you've got a bunch of people saying this is good and it's logical and why wouldn't you do it? And a whole bunch of people who've been in the world actually have to work with the community to actually change that behavior [of resisting the implementation of lean] to get them to accept it.

Consistent with this view, the Head of Propulsion and Innovation stated:

> I think it depends on the background and the thought process in individual departments, and we've got one of the teams, which is only half a dozen people, but a lot of the guys in there have worked previously in environments where … they use visual management tools and they track the progress of things through their department in a very process-oriented way, and I think they do perhaps a rather more disciplined job.

Deployment of PIAs in NPD

Our analysis of documents and interview data shows a clear misalignment between Value-CarCo's intention for deploying PIAs and the cognitive frames of managers and, eventually, their actions. Which tools and approaches are used appears to depend upon an individual manager's experience, background, and views of PIAs. Cases of entire rejection of PIAs were evident even in instances where managers had received process improvement certifications, and recounting stories of failure at other firms were also common. For example:

> "I actually discourage it because I find it's too engineering-based and it stifles creativity I feel. If you just Google "Six Sigma and design", there is a whole argument, for instance like an example of 3M, when they applied actually and it kind of, you know, killed the creative development of new ideas, new products and all that. So, there is a lot of examples of that and not just in the automotive industry." (Head of Design)

However, there were some efforts to adopt PIAs at later stages in NPD, although to a limited extent. The Head of Propulsion and Innovation explained:

> In terms of Lean and Six Sigma, I think the principles of it are applied in some of… the areas of automotive that actually lend themselves to measurement. In a way, you can say design releases, e.g., where you're actually in the engineering process but you're producing a product, an output, which is a drawing release, you can take that little part of the process and you can measure the rate of progress through it and you can measure delivery times and you can look for delays and you can optimize that little piece of the process.

4.1.3 AeroCo

Company's intended approach

Over the past decade, AeroCo has launched formal process improvement transformation programs that aim at "simplifying the organization, streamlining senior management, reducing fixed costs and adding greater pace and accountability to decision making" (Strategic Report, p.10). One of these is a business-wide engineering efficiency program called E3 ("embedded engineering excellence") that was introduced in 2016. This program wants to enhance efficiency and

effectiveness, provide additional capacity with minimal cost, and leverage existing programs around high-performance culture and lean (AeroCo full-year results presentation). These formal transformation programs are managed by different dedicated teams such as the lean transformation enterprise which has *"a strategic and coaching role with the intention that [w]e support the organization to transform more towards what I would describe as a true lean"* (Head of Lean Enterprise Transformation, AeroCo). Additionally, AeroCo runs different PI training programs such as Six Sigma master black belts, kaizen, etc. PI training is usually followed by projects and coaching activities to ensure that trainees can practically apply process improvement tools.

Managers' cognitive frames

Informants across AeroCo tend to have a positive attitude toward PIAs and view them as supporting new product development. Several interviewees described PIAs as facilitating creativity by embedding an improvement mindset in the innovation process. For example, the Head of the Production System explained:

> I don't see how you can be innovative if you don't have that improvement mindset. I think they go hand-in-hand because you're kind of doing exactly the same thing. You're looking for a better way. You know, innovation is we're looking for a better way to do it or a different way of working. And an improvement mindset, again, you're looking for exactly that same thing. Is there a better way of us doing it? Is there a different way of us doing it? Can we do it with less waste? Can we do it cheaper? Can we do it to a higher quality level? You know, can we do it faster?

Others suggest that PIAs in NPD provide a structure to the innovation processes and do not constrain ideation. Essentially, PIAs were described as mechanisms that improve the speed and the efficiency of product introduction without hindering the organization's capacity to innovate. The Global Head of Continuous Improvement asserted:

> I don't see process improvement limiting innovation [of our products]. It just provides a structure for allowing those ideas and revolutions to progress quicker, not to say … can't use innovation… because it should not cut the ideas, it should just provide a structure of those ideas to progress through the regulations that are required.

Also, informants emphasized the compatibility of PIAs usage with creating an environment that encourages learning and openness that are needed at various stages of NPD. At the same time, a few informants were against the use of PIAs at the front end of NPD such as the discovery stage since PIAs were seen to minimize the failures that are needed for creative idea generation. The Technology Lead argued:

> If you were trying to minimize waste, you'd have to quantify that in terms of R&D. What is the waste? You know, it's not the same as if you were making a component and you've got to produce 50 components out of each piece of metal. Well, can you make it 53? Within R&D, no, and actually, if we're honest, with respect to innovation, we don't want to be in a culture where we're minimizing failures, because actually, you've got to try these things, and knowing something doesn't work has value, so just trying to make things successful all the time can actually have a negative effect.

Deployment of PIAs in NPD

Overall, PIAs are widely used across the NPD process at AeroCo. However, even in this setting, some differences in PIAs adoption appeared to be due to divergent managerial cognitive frames. For instance, the Technology Lead who regarded PIAs as rigid sets of tools discouraged their use in R&D. At the same time, the Head of the Product Development System, who viewed PIAs as supporting mechanisms, encouraged and promoted their use at the early stages of the NPD process, albeit in a modified way: *"So we do apply it, but the concept of Six Sigma in the earlier stages has been an approach we've had to adapt a little bit".*

4.1.4 PharmaCo

Company's intended approach

PharmaCo's intended approach towards process improvement has changed substantially over time. During most of the 2000s, lean and Six Sigma were deployed from R&D to manufacturing. The goal of introducing PIAs in R&D was first formalized in 2003 with the intention of reducing cost

and time to market, and of improving productivity. Various process improvement approaches and tools were implemented including lean thinking, Six Sigma, theory of constraints, kaizen, five-whys, and value stream mapping (published paper on PharmaCo[3]). PI expertise was shared from the manufacturing units by using PI training materials and by moving PI experts (e.g., master black belts) from manufacturing to R&D. Between 2003 and 2007, PIAs implementation in R&D was supported by senior management.

However, in 2008, a new R&D leadership team was appointed with the aim of driving innovation by allowing employees the flexibility to generate and develop their ideas. As a result, the use of PI stopped in that unit and PI specialists in R&D left the company. As the Director of Strategy, Operations and Finance in Rare Diseases recalls: *"It goes in trends, right? So, I remember when I first joined [in 2004] everybody wanted to be a lean sigma person, and then it kind of faded away".*

In recent years, while its strategic intention towards the diffusion of PIAs has not been entirely formalized, PharmaCo has sought to improve its operations through "restructuring, investment, and modernization to improve profitability and efficiency" (annual report). The focus of its senior management team is to increase the number of successful new products while eliminating non-value-adding programs that are unlikely to generate sufficient returns. This intention has been supported by several initiatives that aim to accelerate the drug development process by combining "approaches derived from project management as well as organizational development and lean Six Sigma" (published report about PharmaCo, 2014). Other significant programs include the PharmaCo production system, which is an internal system focusing on *Gemba* with the purpose of reducing waste and becoming more efficient in the manufacturing area.

[3] Reference to this article is not explicitly made to preserve the anonymity of the organization.

In addition to the production system, quality insurance procedures were introduced in product development processes to maintain product quality. Moreover, there are teams at PharmaCo that assess each site's maturity in relation to various production system aspects.

Managers' cognitive frames

Informants across PharmaCo expressed consistently negative views regarding PIAs' usage in NPD. Essentially, most managers described PIAs as reducing creativity, flexibility, and risk tolerance that are essential at various NPD stages. For example, some managers highlighted the inapplicability of PIAs to the front end of NPD. The New Product Introduction Lead explained:

> I see a lot of processes and systems; they are very rigid … you have to do it that way. It's very hard to think outside of that way. And that drives the culture; it drives a certain behavior. For me, innovation… I don't want to say it sits outside of that; you still need people that are doing the actual day-to-day stuff to become part of the innovation. I don't think having stable systems will actually help that. I don't, no.

At the same time, other managers highlighted the importance of not investing excessively in projects that may appear innovative but that eventually will not deliver sufficient returns. As the Director of Portfolio Management stated:

> It does cycle between the two [PI and innovation]; it's a very imperfect science. It's very difficult because there are many examples probably where, you know, commercial got it hopelessly wrong and said there wasn't going to be a market and then it turned out to be a blockbuster, and vice versa. And there are times when with hindsight, you think: why did we work on this? It was never going to go anywhere commercially. So, I can't really give you an answer in terms of the best way to do it. I think you just have to have a mindset where you're looking at both ends of the spectrum and trying to have a light touch but having time to reflect and drawback and say: is this the time now to, you know, enough is enough on this, we shouldn't go further. Or is it to say that actually this has got huge potential?

Deployment of PIAs in NPD

Currently, at PharmaCo, PIAs are virtually not used at all in the discovery and development stages of NPD, but they are deployed in manufacturing. Despite the programs and initiatives mentioned

above, the company has struggled to re-introduce PIAs at the front end of innovation, especially because of managers' resistance due to their negative framing of these approaches.

Table IV summarizes the findings of the within-case phase of the analysis.

Insert Table IV about here

4.2 Cross-case analysis

The cross-case analysis reveals that, despite the intentions of the four case organizations towards the diffusion of PIAs in NPD, managers demonstrated a variety of cognitive frames: conflicting, supporting, or paradoxical. These frames ultimately influenced where and how PIAs were used. Table V summarizes the different uses of PIAs at different NPD stages in the case organizations.

Insert Table V about here

4.2.1 Discovery stage of NPD

Cognitive frames

This stage involves the generation and selection of ideas that will eventually become a product. This includes the technology development process in the two automotive companies and AeroCo, and the early stages of drug development in PharmaCo. By analyzing the informants' responses on the role of PIAs in NPD, it becomes clear that views vary considerably. For example, while at Fast-CarCo PIAs are mostly seen as important mechanisms for *supporting* the flexibility that facilitates innovation, at PharmaCo and Value-CarCo, PIAs are considered inapplicable, especially in the R&D function, as they are regarded as barriers to creativity. In these two companies, PIAs

are seen to conflict with innovation at the discovery stage. As the Fund Director, Immunology Innovation Fund at PharmaCo described: "*Earlier in discovery, [PIAs] become less relevant and actually they just become a hindrance because it's all about the creative spark and the creative spark doesn't get very well with structured template and process".* On the contrary, the Head of the Lean Transformation Team at AeroCo argued that PIAs help in generating creative ideas by using more rigorous and efficient processes:

> Then why wouldn't you want to try and efficiently answer the question of the hypothesis in your mind as an innovator, as opposed to just randomly testing it and then maybe actually finding later down the line that it's not a statistically significant result, or you misled yourself with some kind of belief, yes… I don't think [Six sigma] should stifle creativity at all.

PIAs use

Managers acted to prevent, promote, or adapt PIAs in NPD depending on their cognitive frames. For example, in the research function at Fast-CarCo, PIAs such as Six Sigma are introduced to maintain rigorous processes, facilitate collaboration, and create a trusting environment by encouraging employees to participate in improvement-related decisions. However, PIAs are not imposed and they are used only when managers deem so appropriate, as noted by the Head of Research: *"Will [employees] use DMAIC on every project? No. It's where it's appropriate to use it. And it's the same with lean tools."*

On the contrary, at Value-CarCo and PharmaCo, the use of PIAs is actively prevented from the early stages of NPD. For example, the Head of Digital at Value-CarCo asserted: "*I have to be very flexible and very open because I'm dealing with different people, different types of technology, potentially different marketplaces. So, to try and impose a process, a structured process is not a great idea."*

At AeroCo, the views over PIAs' applicability at the discovery stage vary between idea generation and selection. For example, at the idea generation stage, PIAs are considered as conflicting with innovation. The Technology Lead explained:

> Because you're dealing with new technology, new products, new ideas, they are less constrained by the process. In many cases, they don't exist or are new to the business, and it's not until they get taken into the mainstream that more rigorous processes get applied to them. By which time, they're out of R&D, so we're not affected by that.

On the other hand, at the idea selection stage, PIAs help filter ideas to select the most rigorous ones to be developed. The Head of Engineering Strategy and Enterprise Architecture elaborated:

> We have an innovation website and we may get hundreds of ideas coming in every day. Where lean plays a part in spotting the good ideas and moving them efficiently to a product. Where waste comes out is spotting the wrong one or spotting the right one and implementing it purely.

4.2.2 Development stage of NPD

Cognitive frames

This stage involves departments like product creation, product development, design, and engineering. People's responses regarding the use of PIAs tend to vary across the case organizations. While PIAs are seen supporting innovation at this stage at Fast-CarCo and AeroCo, at PharmaCo and Value-CarCo they are considered to be conflicting. For instance, the New Product Introduction Lead at PharmaCo expressed his views on the use of PIAs in product development: *"I would view [lean] as a hindrance rather than something that will actually help people [to think in a different way]".* Also, the Chief Program Engineer at Value-CarCo elaborated:

> I think you've got to choose the right processes. If you try and force operational Six Sigma into a development organisation, there will be problems … in the development of technology projects, if you apply an operational Six Sigma approach to that, you will stifle the innovation and development of new ideas.

Conversely, the supporting frame was based on the view that PIAs help provide a structure for the product development process and foster both flexibility and rigor. As the Head of the Production System at AeroCo explained:

> There's no harm in having standards because it just makes sure that nothing's missed. So even if you're doing a radical innovation, it might say, check this, check that, check the other, have you spoken to so-and-so, have you explored in this area? And it might just be making sure that you've not missed anything.

In a similar vein, the Lead Engineer at Fast-CarCo explained the benefits that organizations get from adopting PIAs in the design and engineering areas:

> Your engineers, if they have the mindset of Lean or Six Sigma, when they're designing that vehicle … they will design for efficiency. They will also design with creativity but taking into account efficiency and quality in mind. So… that will save you a lot of money and cost and heartache. … So, yes, you do have to use these right from the outset, during the design stages.

PIAs use

Differences in cognitive frames resulted in different uses of PIAs. For example, at AeroCo and Fast-CarCo, PIAs were promoted and adapted to product development, design and engineering. This adaptation was evident by mixing lean with agile, using standardization only when deemed appropriate, and translating the meaning and types of waste to these environments. The Head of Continuous Improvement in Engineering at AeroCo described her department's experience with PIAs:

> I would like to talk about it within engineering… we can make the processes as easy and as simple and you can take out as much waste you can from that… you can take away the time that is spent on rework or waiting time, all the wasteful time, and focus that on the interesting innovation so you can spend more time designing… more time thinking about what could new concepts be and what new radical ideas.

On the other hand, even though PharmaCo and Value-CarCo wanted to apply PIAs more widely, managers tended to consider them as barriers to innovation, and inapplicable in the design and product development areas. As a result, PIAs were discouraged or even eliminated at the

development stage in both companies. For instance, the Head of Design at Value-CarCo expressed his disagreement with PIAs' implementation in his area: *"I've gone to the training for it myself and, the more I thought about it, I felt like it's far too compartmentalized and far too, you know, it's like this is the process, it's A, B, C, D, E. And I felt like once you apply that, it becomes too regimented".* At the same time, the Chief Program Engineer at Value-CarCo, who stressed the importance of balancing standardization with flexibility, tended to use PIAs occasionally depending upon the type of project and individual's knowledge: "*It's more down to individuals' ability just to follow their own instincts or training."*

4.2.3 Deployment stage of NPD

This stage involves the late engineering and production areas, which are characterized by high measurability and process orientation. In all the studied companies, PIAs are seen as applicable and essential to maintain rigor in these areas. Therefore, PIAs are consistently interpreted as supporting mechanisms rather than conflicting ones. For example, in the manufacturing units at PharmaCo, PIAs are used to standardize the production process, meet regulations, and foster learning by providing employees with the autonomy to pursue their ideas and participate in improvement decisions. The Chief Program Engineer at ValueCarCo described how Six Sigma and lean fit in the operational environment:

> The purpose of many operational processes, particularly problem resolution processes, is to define things very clearly, to define processes very clearly, to avoid noise factors and error states, and minimize the risk of things not happening. … In the deployment process, you don't want innovation. What you want is delivering an output within the specified timescale within a specified budget, without any error states, and then precisely meeting your customer requirements. So, you don't want new innovation, new ideas, and creativity creeping in. You actually want to remove those sorts of error states so that you have a clean delivery.

At AeroCo and Fast-CarCo, PIAs are seen as applicable at this stage as well. Here, PIAs are used as controlling mechanisms that help ensure quality and eliminate errors.

5. DISCUSSION AND CONCLUSIONS

Research on the implementation of PIAs in NPD has discussed the design, deployment, and use of various types of process improvement tools and practices (Collins and Browning, 2019). While insightful, extant research does not provide conclusive evidence on what determines the uses and effects of PIAs in NPD. This study focused on the role of managers' cognitive frames in shaping the diffusion of these approaches. Through an in-depth study of four organizations, we show that the (mis)alignment between the organization's strategic intention and managers' frames concerning the applicability of PIAs in the development of new products plays a very important part. Essentially, whether PIAs were implemented or not in the discovery, development, and deployment stages of NPD often depended on managers' views over whether PIAs were conflicting or supporting innovation or in a paradoxical relationship with it.

This paper makes several contributions to theory. First, it extends existing theory by highlighting the role of managers' cognitive frames in facilitating or hindering PIAs implementation and use (Netland and Powell, 2017; Cho and Linderman, 2019). Extant literature has identified the characteristics of successful implementation of PIAs in a production context; however, what makes the implementation of PIAs in NPD successful has received less attention and has led to inconclusive results (Collins and Browning, 2019). Our study identifies the role of managerial mental frames as a key factor which affects the deployment of PIAs, as individuals' views of PIAs' effects in NPD may explain the reasons behind the success or failure of process improvement programs. These findings suggest that the pervasiveness and effectiveness of PIAs' deployment can be due to individual managers' views of PIAs rather than to the nature of the approaches themselves.

Second, this study highlights managers' roles in shaping an organization's approach for managing contradictory goals – in this case, efficiency and innovation. Paradox management studies have drawn on the cognitive framing lens to explore tensions that emerge in organizations and the various actions that can be taken to deal with these tensions (Andriopoulos *et al.*, 2018; Smith and Tushman, 2005). Essentially, these studies highlight the role of individuals' interpretations in identifying and managing competing goals and dynamics (Papachroni *et al.*, 2016). In our research, managers sometimes demonstrated a clear intention of managing the paradox of efficiency and innovation, for example by adapting PIAs to the area in which they were used. At Fast-CarCo, for example, the Head of Research viewed PIAs as applicable to NPD and promoted the adaptation of tools to the research area and the deployment of DMAIC in a fairly unstructured way. In other cases, such tension was resolved by prioritizing one goal (typically innovation) at the expense of the other (efficiency), for example by preventing the use of PIAs at the front-end stages of NPD. At Value-CarCo, the Design Manager, despite being a certified Six Sigma black belt, discouraged the use of PIAs in his area, because he viewed them as means to introduce an overly rigid process. This line of argument suggests that functional managers can shape the overall way in which contradictory goals are managed at the organizational level, by preventing or promoting the introduction of a certain approach (Cho and Linderman, 2019). This finding also leads to advocating a horizontal approach for managing contradictory goals (Kassotaki *et al.*, 2018) and builds on the proposed multi-level perspective for managing tensions in organizations (Papachroni *et al.*, 2016).

Third, this paper contributes to the process improvement literature by identifying three ways in which managers can deal with the tensions associated with the implementation of PIAs in NPD (i.e., promoting, preventing, or adapting). Studies have identified the reconceptualization of waste

and value-adding activities as an important practice to increase the fit of PIAs within NPD (Browning and Sanders, 2012; Collins and Browning, 2019). In line with these studies, this research indicates *promotion* and *adaptation* as intentional mechanisms that could be used by managers to tailor their deployment of PIAs rather than pursuing a standard approach across NPD. This, in turn, could support the transformation and diffusion of PIAs across the organization.

Fourth, a company's intended approach towards the deployment of PIAs may be a reflection of the organization's cognitive frame (Rerup and Feldman, 2011). While important, this study demonstrates that this organizational frame may conflict and sometimes be displaced by individual managers' cognitive frames. While this was not the explicit focus of this study, this finding calls for a much deeper understanding of the interplay between cognitive frames at different levels and on the very notion of dominant cognition about a firm's strategy and objectives (Grewatsch and Kleindienst, 2018).

This research has also implications for practice. First, to facilitate the implementation of PIAs across the organization, leaders should explore and interrogate managers' and employees' perspectives. As our findings suggest, the way PIAs are used and implemented in organizations is affected by individuals' cognitive frames and these should not be underplayed. Second, while the failure of implementing PIAs in NPD may depend on the approaches themselves or on their inappropriate use, this research shows that managers need to pay more attention to understanding the different ways in which PIAs can be used at different stages of NPD. For example, greater consideration should be given to the flexibility with which certain approaches may be deployed – as in the case of Six Sigma in R&D at FastCarCo – and on how certain concepts or practices could be adapted to the local context, as in the definition of what constitutes "waste."

5.1 Limitations and future research

This study is not without limitations. First, findings are drawn from multiple case studies and are therefore limited in their generalizability. While this study aims to generalize to theory, a quantitative study could test the existence of the identified cognitive frames and their effects on the implementation of and use of PIAs. Second, this research investigated managers' interpretations of organizations from various industries. Selecting different types of firms may limit the possibility of drawing causal relationships between the identified mental frames and the usage of PIAs in NPD. Thus, future research could test what was found in this study in more homogenous settings. Third, further studies could investigate the factors that shape managers' cognitive frames. For example, interviewees argued that employees' functional specialism, background, and experience may play an important role. Future research could formally explore these and other aspects and investigate how cognitive frames can be modified. Indeed, scholars have suggested that frames are not static, but "are essentially dynamic and socially situated processes of meaning construction" (Cornelissen and Werner 2014; p. 183). Therefore, we encourage longitudinal studies that focus on the evolution of managers' cognitive frames over time.

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