Unintended cascading effects of expanding organizational limits for resilience: lessons from the nuclear industry

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The recent COVID pandemic revived the interest in resilience as the ability to absorb strain and preserve (or improve) functioning despite the presence of adversity. To increase resilience, organizations must articulate both the ways to deal with predictable and unpredictable events. We use the theory of organizational limits with the aim to understand how to develop resilience capabilities by getting closer to the organizational limits and what are the consequences of exceeding limits in day-to-day activities. Through a qualitative case study of a European nuclear power operator, we uncover the existence of the negative cascading effects of the limits of managerial actions. Our results show that instead of increasing resilience through formalization, quantification and specialization, these cascading effects constrain resilience. Exceeding the limits of managerial actions has unintended consequences on cognition and on the efficiency of managerial actions, which negatively impact resilience development.

Keywords: resilience, organizational limits, safety, uncertainty, mindfulness, nuclear industry

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INTRODUCTION

While undeniably resilience has for a long time occupied an important place in the organizational literature (Boin & van Eeten, 2013; Hillmann & Guenther, 2020; Linnenluecke, 2017; Sutcliffe & Vogus, 2003; van der Vegt et al., 2015; Vogus & Sutcliffe, 2017; Williams et al., 2017), the ongoing COVID-19 crisis dramatically renewed scholarly interest in this topic (Barton et al., 2020; Christianson & Barton, 2020; Rouleau et al., 2020). The different streams in the abundant literature (Hillmann & Guenther, 2020; Linnenluecke, 2017), consider resilience as the ability to "*absorb strain and preserve (or improve) functioning despite the presence of adversity*" (Sutcliffe & Vogus, 2003, p. 96). While all resilience definitions include the notion of the adversity, many ambiguities persist. The first concerns the nature and the scale of adversity. While traditionally resilience was seen as the capacity to recover after crises, more recently scholars underline the importance of precursor resilience aiming to prevent their occurrence (Boin & van Eeten, 2013). Also, there is no consensus whether resilience aims to deal with big disruptive external events only, or can it involve daily adaptations to challenging conditions?

The second ambiguity concerns whether adversity is expected and anticipated. Some scholars oppose anticipation and resilience (Morel et al., 2008; Wildavsky, 1988). This ambiguity echoes the tension in the safety science literature between regulated (organization's technical systems and procedures to deal with predictable events) and managed safety (organization's capacity to proactively deal with unexpected situations) (Amalberti, 2021; Besnard et al., 2017; Morel et al., 2008; Nascimento et al., 2014). Recent, more integrative, approaches to resilience suggest that resilience be considered as a wider ability to adapt and adjust through the customization of responses in face of adversity (Andersson et al., 2019; Duchek, 2020; Lengnick-Hall et al., 2011; Williams et al., 2017). Therefore, the interaction between the ways to deal with expected and unexpected situations is not clearly conceptualized.

However, disregarding the measure of anticipation and adaptation, there is a consensus that both behavioral and cognitive dimensions are crucial for resilience, and should be coherently connected (Duchek, 2020; Hillmann & Guenther, 2020; Williams et al., 2017). In particular, resilience scholars agree that organizations need to develop cognitive capabilities of mindfulness and sensemaking (Fiol & O'Connor, 2003; Sutcliffe & Vogus, 2003; Weick et al., 1999; Weick & Sutcliffe, 2007).

Resilience researchers underline the necessity to better understand "*how organizations actually prepare for unexpected events, accept problems, and learn from them*" (Duchek, 2020, p. 238) in daily organizing (Andersson et al., 2019). The existing research focused on the enabling role of structure. In particular, HRO studies explored resilience from the perspective of developing capabilities. However, the capabilities are not without limits. By attracting attention to the existence of the limits to organizational capabilities and to the danger of violating these limits, the theory of organizational limits (Farjoun & Starbuck, 2007) sheds new light on possible unwelcome side effects on reliability when organizations exceed limits, which could become a source of organizational accidents (Oliver et al., 2017, 2019; Starbuck & Farjoun, 2005). Farjoun and Starbuck (2007) theorize that limits may originate from cognition, managerial actions (control) and from external environment. However, these limits are not always directly visible or related to resilience (Farjoun & Starbuck, 2007) leaving many unanswered questions, especially regarding the cascading consequences of exceeding limits (Farjoun & Starbuck, 2007) while trying to improve resilience (Oliver et al., 2017, 2019).

Approaching resilience from the perspective of capabilities and limits represent two sides of the same coin. Understanding the influence of organizational limits in day-to-day activities allows to better understand how capabilities develop.

Following a recent call for further research on organizing for resilience (Linnenluecke, 2017, p. 26), in this paper we take up the challenge to explore constraining and enabling role of the managerial control structuring collective actions to guarantee resilience. The aim is to better understand the development of resilience capabilities close to organizational limits and the consequences and cascading effects of exceeding endogenous limits in day-to-day activities.

Making a parallel between paradoxes in safety science and in organization theory is an fruitful area for future organizational research (Oliver et al., 2017). High-risk nuclear power industry,

which implies the necessity to proactively face high level of uncertainty and emergence (Hällgren et al., 2017), constitutes an interesting context to study resilience. Notwithstanding a considerable technological and regulatory efforts to control risk and face uncertainty, high-risk organizations such as nuclear power plants, need make daily additional efforts to develop an ability to prepare for ambiguous and unexpected situations (Morel et al., 2008). We conducted a qualitative case study at a European power plant, ATOM, to explore how the implementation of practices designed to reinforce resilience capability is affected by the organizational limits of managerial actions.

Getting closer to organizational limits by increasing managerial control through formalization, quantification and specialization has a positive impact on resilience up to a certain level beyond which it produces negative unintended effects. Our findings show that some practices intended to develop resilience produce unexpected negative results. Not only they do not help increase resilience but they also create new difficulties. More particularly, our paper highlights the negative side effects of exceeding managerial control limits, its impact on cognition and other cascading effects.

This paper contributes to the resilience literature by uncovering mutual interaction by recombination, enriching Grote's (2019) adaptative switches between regulated and managed safety modes. Our results suggest that the effects of exceeding managerial limits impacts resilience capability to deal with both predictable and unpredictable events on daily basis. Moreover, mobilizing a theory of organizational limits (Farjoun & Starbuck, 2007) allows to explore a key role of structure in building resilience (Andersson et al., 2019; Busby, 2006; Duchek, 2020). By focusing on the three managerial action mechanisms that structure collective action, this paper underlines their enabling (capabilities development) and constraining (capabilities restriction through limits effects) role (Farjoun, 2010). This paper also advances knowledge on the organizational limits (Farjoun & Starbuck, 2007) by specifying managerial limits, by exploring cascading effects of exceeding limits originated from managerial actions and cognition in day-to-day activities (Andersson et al., 2019).

The paper is structured as follows. First, we review the literature on organizing for resilience and organizational limits. Second, we present our qualitative case study methodology. Third, we briefly describe main findings. Finally, we discuss the contributions and limitations of our research.

LITERATURE REVIEW

1.1. ORGANIZING FOR RESILIENCE IN HIGH-RISK ENVIRONMENTS.

Studied by multiple disciplines, resilience has often been presented as "umbrella concept" (Hillmann & Guenther, 2020; Linnenluecke, 2017). In organization theory, resilience is defined as the organizational ability to "*absorb strain and preserve (or improve) functioning despite the presence of adversity*" (Sutcliffe & Vogus, 2003, p. 96). Resilience studies started with the interest on the capacity to react to and recover from extreme, disruptive external chocs (Geoffroy et al., 2016). The analysis of major accidents highlights the necessity for organizations to prepare for emergent and unpredictable events (Hamer et al., 2021), to develop resilience to ensure high level of safety and reliability (Boin & van Eeten, 2013; Hollnagel et al., 2006; Sutcliffe et al., 2016; Sutcliffe & Vogus, 2003; Weick et al., 1999; Weick & Roberts, 1993; Weick & Sutcliffe, 2007). Therefore, subsequent development of the resilience research focused on small internal daily variations of organizational reliability as a capability to avoid accidents. For example research on High-Reliability Organizations (HROs) (Weick et al., 1999; Weick & Sutcliffe, 2007) represent this "resilience as reliability" stream (Andersson et al., 2019; Linnenluecke, 2017; Zolli & Healy, 2012). More recent approaches to resilience tend to be more integrative. They focus on the coping mechanisms and response strategies under conditions of great environmental uncertainty (Linnenluecke, 2017).

While all resilience definitions include the notion of the response to the adversity, resilience literature remains marked by ambiguities about 1) the type and the scale of adversity and 2) about the degree to which this adversity is expected and anticipated.

The first ambiguity relates to the fact that resilience may be seen as a capability to deal with rare disruptive events, with a wider range of budding disruptions and disturbances (Boin & van Eeten, 2013; Williams et al., 2017). While some authors explore resilience as preparedness for dealing with unforeseen disruptive adverse events (van der Vegt et al., 2015), others underline that resilience is built through daily organizing (Andersson et al., 2019; Lengnick-Hall et al., 2011; Linnenluecke, 2017; Weick & Sutcliffe, 2007). In particular, research on HROs (Weick et al., 1999; Weick & Sutcliffe, 2007) underlines the importance of paying attention to organizational capabilities and mechanisms in dealing with unexpected events to avoid accumulation and escalation of problems. More recent research tends to be more inclusive in their definition of

resilience and includes all types of "challenging conditions" (Vogus & Sutcliffe, 2007, p. 3418). Williams et a (2017, p. 742) defines resilience as a broad process by which "*an actor (i.e., individual, organization, or community) builds and uses its capability endowments to interact with the environment in a way that positively adjusts and maintains functioning prior to, during, and following adversity*", highlighting its three temporal dimensions. In the same vein, Duchek (2020) identifies three stages of resilience: anticipation, coping and adaptation. In this paper we focus on the precursor resilience, before the occurrence of adverse events (Boin & van Eeten, 2013). Precursor resilience refers to the capacity to recognize and handle unanticipated perturbations (Morel et al., 2008) preventing budding problems from escalating (Boin & van Eeten, 2013).

The notion of precursor resilience echoes the second ambiguity regarding the degree to which the adversity is expected and anticipated. Some scholars make an analytical separation and clearly distinguish resilience from anticipation (Morel et al., 2008; Vogus & Sutcliffe, 2007; Wildavsky, 1988). Resilience is considered as the response through the limited capabilities of risk management to totally anticipate potential dangers, despite existing prevention and preparation mechanisms (Douglas & Wildavsky, 1982). In particular, risk management practices remain principally based on the probabilistic view of risk, leading to the definition of rules to follow in adverse situations and the reinforcement of rigid technical and regulatory barriers to cover the risk (Scheytt et al., 2006). By contrast, resilience allows to deal with uncertainty based on adaptative mechanisms to cope with unanticipated dangers (Wildavsky, 1988). This echoes the tension between regulated and managed safety that organizations must continuously articulate and jointly develop (Amalberti, 2021; Besnard et al., 2017; Morel et al., 2008; Nascimento et al., 2014). While regulated safety refers to the organization's technical systems and procedures to deal with predictable events by relying on compliance, managed safety corresponds to organization's capacity to proactively deal with unexpected situations. For other scholars anticipation and resilience are not polar opposites. They suggest a more integrative resilience approach (Andersson et al., 2019; Duchek, 2020; Lengnick-Hall et al., 2011; Williams et al., 2017) without making a clear distinction between anticipated and non-anticipated situations. Nowadays, in organizational studies resilience makes bridges between the two forms of safety by requiring the capacity to understand current specific situations to adaptively switch (Grote, 2019) between customized responses (Lengnick-Hall et al., 2011), to accept (Duchek, 2020) and to adjust (Williams et al.,

2017), and to **proactively adapt** to an abnormal and unexcepted disturbance (Boin & van Eeten, 2013). In the same vein, if "anticipation" is viewed by Wildawsky (1988) as an opposition to resilience and refers to "*knowing what to expect*" (Hollnagel et al., 2006, p. 349); for other scholars (Andersson et al., 2019; Duchek, 2020; Weick & Sutcliffe, 2007) this term includes preparing for unexpected events, avoiding the unexpected by early sensing of upcoming events. Therefore, contradictory recommendations for how organizations should build resilience emerges from literature pointing to the unresolved tension between organizational stability (prediction, control, low deviation) and change (adaptation, openness, variety) (Andersson et al., 2019; Grote, 2019; Hillmann & Guenther, 2020; Linnenluecke, 2017). As a result, the interaction between the ways to deal with expected (regulated safety) and unexpected (managed safety) situations is not clearly conceptualized.

However, disregarding the measure of anticipation and adaptation (disruptive new responses or adjustment to current situations) required to build resilience, there is a consensus that both behavioral and cognitive dimensions are crucial for resilience, and should be coherently connected (Duchek, 2020; Hillmann & Guenther, 2020; Williams et al., 2017). In particular, concerning the cognitive capabilities, resilience scholar agree that organizations need to develop mindfulness and enhance sensemaking in daily practices and routines (Fiol & O'Connor, 2003; Vogus & Welbourne, 2003; Weick et al., 1999; Weick & Sutcliffe, 2007). Mindfulness refers to an individual capacity to focus attention on one particular object, while remaining attentive to the weak cues signaling potential future problems (Weick & Sutcliffe, 2006). Collective mindfulness represent social processes of organizing (attention, action, communication) in a particular context and "*the collective capability to discern discriminatory detail about emerging issues and to act swiftly in response of these details*" (Sutcliffe et al., 2016, p. 56). Mindfulness refer to cognitive processes to detect appropriate signals, to make sense of their cues and to develop appropriate responses (Levinthal & Rerup, 2006). The idea is to construct meaning from a panel of relevant signals relative to the object in question and its immediate context, and then to imagine appropriate, innovative, responses, often outside the established procedures (Langer & Moldoveanu, 2000). Thus, "mindful" individuals and organizations can manage unexpected events in an adaptive and flexible manner (Levinthal & Rerup, 2006). Therefore, mindful organizing for resilience requires sensitivity to operations and reluctance to simplify interpretations, which requires preoccupation

with failure and deference to expertise/underspecified structuring (Weick et al., 1999; Weick & Sutcliffe, 2007).

Resilience authors underline the necessity to gain more insight by exploring "*how organizations actually prepare for unexpected events, accept problems, and learn from them*" (Duchek, 2020, p. 238) in daily organizing (Andersson et al., 2019). Therefore, the essential role of structure on the development of resilience is an interesting area for research (Andersson et al., 2019; Barton & Sutcliffe, 2009; Duchek, 2020). As emphasized by Giddens (1984), structure can be enabling and constraining. Research up to date focused on the enabling role of structure, in particular in HROs studies, explored resilience from the perspective of the development of capabilities (see Duchek's (2020) capability-based resilience). However, capabilities are not limitless. This idea invites further research on resilience from the perspective of limits where capabilities and limits to resilience are seen as two sides of the same coin.

1.2. ORGANIZATIONAL LIMITS AND RESILIENCE

Theory on organizational limits (Farjoun & Starbuck, 2007; Oliver et al., 2017) provides a new perspective to frame the development of capabilities. Some goals and capabilities are out of organizational reach and theory highlights the danger of this "overreach" (Oliver et al., 2017, p. 5). After exceeding existing limits, organizations face unintended consequences, both dangers and opportunities. However, in the resilience perspective, the idea that organizations have limits and sometimes exceed them, alerts to a systemic source of accidents and the importance of organizational factors (Farjoun & Starbuck, 2007). Exceeding limits may lead to undesirable outcomes. However not all limits are directly visible and not all are directly related to safety, while *"most limits depend upon decisions about goals, policies, or resource allocation*" (Farjoun & Starbuck, 2007).

Theory on organizational limits (Farjoun & Starbuck, 2007; Oliver et al., 2017) identifies three types of limits originated in cognitive capabilities, managerial action or external environments. First, cognitive limits are linked to the difficulty of paying attention to many things simultaneously. This constrains the capacity to recognize, interpret and conceive appropriate responses to events. Cognition limits echo sensemaking and mindfulness processes for resilience and require developing the ability of its members to make sense of an ongoing experience (Weick & Roberts, 1993; Weick & Sutcliffe, 2007). Second, limits produced by managerial actions and polices

(budgets allocation, planning, policies) rigidify resource allocation. Managerial control is not purely enabling or constraining by itself. On the one hand, by redirecting organizational attention, managerial control contributes to a higher control and predictability. On the other, rigid resource allocation impedes the development of certain capabilities and the overall organizational performance. Hence, managerial control may negatively affect fundamental organizational processes such as learning, innovation, coordination, and decision making (Oliver et al., 2017). This echoes Farjoun (2010) stability and change duality that suggests the possibility of mutual enabling (change for stability and stability for change). The relationship of opposition or of mutual enabling between stability and change depends on the way organizations implement managerial control mechanisms. Third, limits may originate from constraints on the organizational environment (legislation, governmental regulation and norms).

While cognition and managerial control are endogenous limits, environmental laws and regulation are exogenous. As emphasized by Oliver et al. (2017, p. 3), endogenous limits refer to the limits of what an organization is able to do, given its characteristics and capabilities. Organizations may directly influence only the endogenous limits of cognition and managerial control, even if the way organizations deal with endogenous limits is obviously influenced by the exogenous limits. By developing resilience capabilities, organizations stretch or expand their endogenous limits (Starbuck & Farjoun, 2005).

Interestingly, Farjoun and Starbuck (2007) highlight the difficulties to anticipate the cascading consequences of exceeding endogenous limits, especially in a particular complex environment of high-risk organizations looking to develop resilience. A recent study explored (Oliver et al., 2017) the limits of cognition and technology in a high risk contexts and invited to further extend case studies on other high reliability environments. Limits originated from managerial control may underpin attention, sensemaking, and many fundamental organizational processes. In their research on the Columbia shuttle accident Starbuck & Farjoun (2005) provide the examples of dangers due to time pressure (i.e. deadlines becoming dysfunctional when they turn into ends in themselves, rather than serve the coordination); fragmentation (becoming disordered and destroying the connections between actions and their outcomes); blind compliance to the rules, which may become inappropriate (Weick, 1993). Therefore, managerial control actions influence

both behavioral (definition of roles, coordination) and cognitive (attention quality, sensemaking) capabilities. Existing studies adopting the limits perspectives focused on the post-accident analysis of the systemic sources of catastrophes. However, understanding the influence of the organizational limits in normal daily activities offers the opportunity to better understand how capabilities develop.

In this paper we take up the challenge to explore constraining and enabling role of managerial control structuring collective actions to guarantee resilience. The aim is to better understand **how to develop resilience capabilities by getting closer to the organizational limits and what are the consequences and cascading effects of exceeding endogenous limits in day-to-day activities.**

2. METHODOLOGY

2.1. RESEARCH CONTEXT

We conducted a qualitative case study within a European nuclear operator (we name ATOM for confidentiality reasons), operating in a complex, high-risk environment. The complexity of the operational activities and structures, the coupling with natural environment and the variable energy demands create a high-level of uncertainty. The high impact of potential accidents makes the nuclear energy industry strongly regulated and controlled. It is also characterized by a complex ecosystem of stakeholders (front-line agents, managers and experts in firms operating in the nuclear sector, external experts as well as national and international regulatory institutions). Many continuous improvements allow to consider the nuclear energy industry as reliable. Indeed, the nuclear sector continuously enhances safety by integrating research advancements (Hamer et al., 2021) and by developing internationally shared industrial practices such as peer reviews, audits, controls and dialogues with regulatory bodies (Kudesia et al., 2020). Managers in the nuclear sector are fully aware of the tensions between regulated and managed safety. The common answer to cope with uncertainties and to enhance managed safety has been to develop safety culture (e.g. Pidgeon, 1991; Reason, 2000). However, managers highlight the difficulty of translating safety values into effective behaviours.

Recently, to enhance safety and resilience, ATOM introduced several organizational changes, such as reliability enhancing practices (REPs), an integrated management system (IMS) and the

weak signals management system (OPEX). First, REPs are designed to secure human intervention actions in real-time situations and aim to keep agents attention focused on the essentials matters. Since, according to the top management's view, operators' actions remain the source of risk uncovered by technical barriers and standardizations, ATOM stresses the application of concrete behavioral-focused practices, such as for example, pre-job briefings (analyzing risk and procedures, and declaring readiness to act) or self-checking (pronouncing aloud the references of installations by pointing the finger on them). These practices aim to improve mindfulness of the individuals and small teams by simultaneously enhancing stability and vividness of the operators' attention. Second, the IMS was imposed by the nuclear industry legislation "*to ensure that the requirements relating to the protection of the referred interests are systematically taken into account in all decisions concerning the plant"* (Legislation document). It involved the implementation of a more coherent and global view on all activities to enhance coordination through a transversal management process. This change aimed to coordinate attention to enhance shared sensemaking. The third change involved the implementation of the weak signals management system to allow feedback of the operating experience (OPEX). OPEX aims to develop collective learning. It implies registration, classification, and quantification of anomalies and gaps with the aim to identify and analyze incidents. All these changes were intended to push organizational limits to improve managed/regulated safety articulation to increase resilience.

2.2.DATA COLLECTION

We collected data through a case study of two of the ATOM's business units (nuclear power plants) in two stages. The first stage involved the immersion by taking part in a group of internal safety culture review. This allowed the familiarization with the research context, clarification of the safety culture vision and the understanding of on-going organizational processes for safety. The second stage involved an in-depth case study. During these two stages data was collected via non-participant observation (10) and semi-structured face-to-face interviews lasting from 60-90 minutes (33 individual and 9 collective interviews) across multiple hierarchical (field agents, control room operators, first-line, middle and top-level managers) and functional layers (independent safety engineers, leadership support, quality and safety, training). In each interview we asked respondents to tell us about their perceptions of risks, uncertainty and safety, organizational values, and the efficacity of existing organizational practices. We also observed

organizational and managerial practices through meetings, audio-conferences, briefings, evaluation, and training. In addition, we collected a rich retrospective data from internal documents on reliability practices and documents with international organisms' recommendations, which provided useful contextual information. We chose to focus on perceptions and day-to-day safety practices at ATOM. The results of our study have been presented and discussed during two on-line sessions: first, with the representatives of the about twenty difference ATOM business units (nuclear operator) and second, with the representatives of the country ATOM's regulatory body.

2.3.DATA ANALYSIS

We used a case analysis methodology (Tsoukas, 1989). Our data analysis followed the conventional grounded theory coding process as methodology (Charmaz, 2006, 2009, 2014; Gehman et al., 2018; Gioia et al., 2012; Glaser, 2004; Glaser & Strauss, 1967, 2009; Strauss & Corbin, 1990, 1998) to capture human organizational experience and provide a rich description of the context. Data was coded using the qualitative data analysis software N'Vivo 12. Following Gibbert et al. (2008) and Gioia et al. (2012) guidelines for a qualitative case study rigor, data were analyzed through an abstraction process of categorical analysis using constant comparison techniques, which helped to delineate themes, key concepts, and aggregate dimensions. Open coding was used to identify initial relevant codes then grouped into increasingly abstract and conceptual categories, through successive levels of abstraction (Clark et al., 2010; Gioia et al., 2010). Emerging conceptual categories identified were linked together through a theoretical coding. The latter is about how concepts relate to each other in order to form an analytical framework helping to understand the studied phenomenon (Charmaz, 2006). First-order terms, second-order themes and aggregate dimensions allowed to build a data structure (see Figure 1). Two sessions presenting and discussing results, first, with several employees from ATOM (representing around twenty units that have not been studied in this research project) and, second, with experts for the ATOM regulatory institution , reinforced the internal validity of the findings. In data analysis, we triangulated between primary and secondary data. In our analysis, we constantly iterated between triangulated data, our emerging theory, and the literature.

3. RESULTS

In this research at ATOM we aimed to better understand the link between the implementation of safety practices (REP, IMS, OPEX) for building resilience capabilities through the lens of the organizational limits theory. Our findings show that some practices intended to develop resilience produced unexpected negative results; not only they did not help achieve the goal of improving resilience but they created new difficulties. ATOM's business units we studied have recently experienced problems of safety performance degradation for which the top-level management recognized, analyzed, and assumed responsibility. A head of service confessed: "*we have difficulties, we are not at the expected level. This means that the organization does not allow everyone to be in the best dispositions to act safely ... There are things in the organization that are really difficult to take into account"* (IntB6).

The recognition of cognitive and managerial actions limits resulted in cascading effects with unwelcome outcomes for resilience. An in-depth analysis allowed to identify three organizational mechanisms of managerial action that structure collective actions and that intervened in ATOM's efforts to increase its resilience, namely: formalization, quantification, and specialization. Interestingly, ATOM's endeavors to develop resilience through the above-mentioned mechanisms, produced undesired effects: instead of extending organizational limits, they reduced them and produced emerging negative cascading effect between cognition and managerial control (see data structure Figure 1).

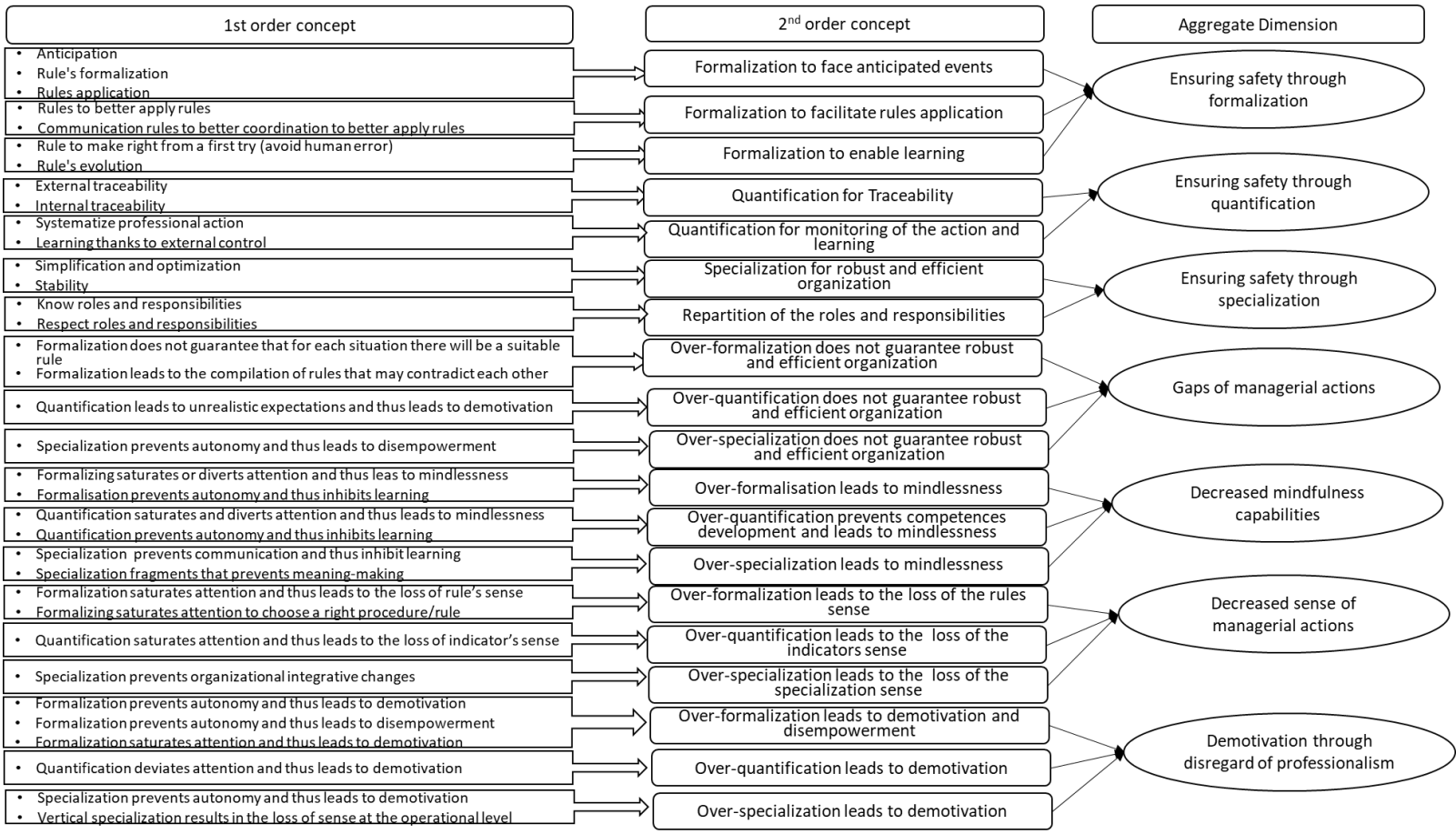

Figure 1. Data structure

3.1. MECHANISMS OF MANAGERIAL ACTIONS

Our first results identify three organizational mechanisms of the managerial control that structure collective actions for resilience in ATOM, namely: formalization, quantification, and specialization.

3.1.1. Ensuring safety through formalization

The interviewees highlighted that formalization play a crucial role in ensuring safety, particularly through three processes: facing anticipated events, facilitating rule application, enabling learning. **First, formalization aims to help face anticipated events**. Despite the recognition of the inherent uncertainty and risk, interviewees brought to surface an idea of the strength of anticipation: "*to attenuate the risks - there is no such thing as zero risk, but we can reduce the probability of risk*" *(Int07)*. Hence, most desired responses to situations are formalized

through rules and procedures to regulate interventions in day-to-day activities. Respondents acknowledged: "*we want to respond to technical faults or any significant safety event systematically by the paper" (Int11), "we made safety gaps and behind, we compensated these gaps with a procedural system" (Int15).*

The role of the written word is important at ATOM. However, employees highlight that it is not enough to simply formalize, but, it is equally important to apply all formalized rules. The following quote illustrates ATOM's employee belief in the role of rules: "*if we respect the doctrine, normally one does not deviate*" *(Int10).*

Second, **formalization aims to facilitate rule application**. Respondents pointed to the exitance of rules aiming to guide and facilitate the application of other rules. The fact that these application-enabling rules exist highlights that the application of some rules is not obvious. For example, the REPs include a formalized pre-job briefing practice, aiming to prepare agents to their intervention. An interviewee recognized:

> *"New reliability practices help us in terms of safety to think a little better about what we do. We better appropriate the documents and the activities that we have to do… It is important to be sure that a person has understood what you are asking to do" (Int02).*

Third, **formalization aims to enable learning**. For example, REPs are launched with the objective to avoid human error by *"reducing the gap between what is planned and what is actually done, to ensure that every action taken, every method, every communication is the right one." (Document Human Performance).*

3.1.2. Ensuring safety through quantification

Our results highlighted that ATOM creates many indicators to control the implementation of procedures such as for example, the number of managerial visits to encourage field presence, the percentage of implemented recommendations or the number of reported weak signals. Quantification allows control through traceability and monitoring.

First, **quantification aims to ensure internal and external traceability**. For example, ATOM "*is committed to meeting a certain percentage of WANO (World Associate of Nuclear Operators) recommendations each year" (Int01).*

Second, **quantification aims to monitor action through indicators, thus enabling learning.** For example, a respondent explained why IMS requires to establish indicators for each process: *"The idea is to make these processes move forward and be sure that there are always people to make them move forward. Hence the interest of these indicators"(Int01).*

3.1.3. Ensuring safety through quantification

Our findings showed that due to the complexity of the nuclear power plant industrial activities, the work of managers and operators at ATOM is highly specialized. Multiple silos exist, for example, between the different services, executive managers and operational agents, functional and operational activities. ATOM respondents acknowledge the importance of the specialization in ensuring safety.

First, **specialization aims to contribute to robust and efficient organization through simplification and stability**. Simplification and optimization are highlighted as particularly important:

> *"We have to keep things simple, to optimize things every time. Because the more we optimize things, the more time we will have to work on concrete things, on technical skills, for example" (Int01).*

Second, **a clear repartition of roles contributes to place "*right skills at the right time*"** (Int 14). The following quotes illustrate the importance for safety to respect the role repartition:

> *"I try as hard as I can to make sure people are in their defined place, even if it's painful for some. There's an operator who has to stay on monitoring, because the control room has to always be monitored". (Int16)*

The managerial control mechanisms are implemented with the objective to ensure safety and develop resilience. However, the way formalization, quantification and specialization are implemented is qualified by the respondents as 'excessive'. This points to the existence of limits of managerial actions. Exceeding these limits produced unintended effects on ATOM's organizational and its ability to further increase resilience.

3.2. CONSEQUENCES OF LIMITS OF MANAGERIAL ACTIONS

3.2.1. Gaps of managerial actions

Our findings highlight that the development of managerial control capabilities is not limitless. This suggests gaps of managerial actions, pointing to the threshold of the limit.

First, abundant formalization does not guarantee robust and efficient organization. As highlighted by one of the respondents, the abundant documentation describing the procedures to follow does not guarantee that rules allow to deal with all situations:

"We have frames of rules that tell us black or white, but we find ourselves in a gray situation, where we are not sure we can hold on to. There is interpretation, interpretation to be done" (Int 09).

Moreover, the multiplication of problem-specific procedures often leads to their incoherence and results in operators' confusion. As one of the interviewees recounted*: "you can find documentation flaws: since documents are made for very specific situations and sometimes, you're in a different situation - and you're a little bit lost" (Int 01).* In addition, the accumulation of more or less detailed rules and procedures may inhibit their clear understanding, which is crucial, especially in operational activities: "*The clarity of the documents is also to ensure that they are not too fragmented; because in real time activity we need to have the information quickly to understand it quickly*" (Int 09).

Second, quantification does not guarantee either robust or efficient organization. Ubiquitous use of indicators becomes counterproductive by setting only unrealistic expectations that demotivate rather than motivate. An interviewee explained:

"We're in a gap culture with the idea that 'the benchmark is there' ... And in reality, we have a tremendous amount of constraints. In fact, it's just not feasible. In fact, we don't know how to do it. And so, that means that at some point, you have to be reasonable "(Int04)

Third, specialization does not fulfill to its initial goal to make the organization robust and efficient. Excessive specialization prevents autonomy and leads to disempowerment. An interviewee highlighted :

" There is a loss of efficiency, because necessarily when you go up - there is the funnel effect, and instead of having, I don't know, 5 people making the decisions, you're going to have one, so you're going to wait for him to make the decision." (Int14)

Despite initial objective to develop resilience, if pushed too far in their implementation the three mechanisms of managerial actions provoke unintended consequences. The onset of unwelcome effects points to the exceeding of limits.

3.2.2. Decreased mindfulness capabilities

It appears that the tendency towards excessive managerial control at ATOM produces unintended effects and negatively impacts cognitive capabilities, namely mindfulness and sensemaking abilities.

First, excessive formalization interferes with mindfulness to detect, analyze, and respond to unpredictable events. Instead of guiding operators' attention, excessive formalization prevents the assimilation of information and the construction of meaning. It results in attentional overload. Instead of focusing on problem analysis and the resolution, the operators' attention is focused on problem formalization. This deviates the attention from the deep understanding to accurate formalization. A respondent recounted:

> *"We get asked a lot of small tasks. We don't spend an hour doing one thing, we do more like 10 things, but every time, we have to go to the computer: we'll enter an activity on schedule, as soon as there's a periodic test that ends, we have to go into an application to say, here it is, it's over, I checked it. There are a lot of little things, which means that sometimes, we detach ourselves a little from the head-up monitoring…Sometimes, the risk is that we put ourselves in a tunnel, we put blinders on, and then we do our work. And then something happens - we didn't see it". (Int10)*

In addition, at ATOM formalization prevents autonomy and impacts learning necessary for understanding of weak signals and small incidents. A control room operator explained:

> *"Regulated safety is very important, but it robotizes and kills initiative... In fact, what is caricatural to be locked into your rule, without having a tiny bit more hindsight" (Int11).*

Second, when excessive, managerial quantification actions also inhibit competence development and the development of mindfulness. ATOM tends to value indictors *per se* more than the efficiency of the measured practice, what can impede safety. For example, talking about the mandatory meeting subjected to presence indicators, a proximity manager admitted:

> *"We get asked to do a lot of representation in seminars and meetings. Thus, it's complicated to manage our schedule – we're not left to our core business." (Int09)*

Indeed, the inefficient use of time through meetings only increases the load on the already tight schedule. This deviates attention from the important safety-related problems employees must face in their every-day activities. Our results highlight that such frequent and mandatory meetings fail

to play their role in promoting joint attention leading to individual and collective cognitive flexibility.

It appears that the excessive quantification impedes sensemaking because it focuses agents' attention on 'ticking the boxes', rather than on the development of a deep understanding of situations and learning. An interviewee highlighted:

> *"What bothers me and saddens me is that we've put a lot of things in place, a lot of new requirements to mask the lack of respect for what we could assimilate to the safety culture of the agents… To monitor all the parameters of the installation, we have implemented a powerful practice that says, depending on the conditions, every x minutes you have to go and check this parameter, every y minutes this parameter, etc. I think we've lost something fundamental because that's normally an acquired skill."(Int04)*

Third, excessive fragmentation appears to impede cognitive capabilities. Specialization prevents communication and inhibits learning. Some silos exist even inside services between people responsible for the detection of anomalies and those responsible for deciding how to deal with them. Because of these silos in the OPEX system, the person who reports the anomaly is not systematically informed about its follow-up and resolution. A field agent explains: "*For us, on the side of the field agents, it means detecting anomalies, reporting the anomaly, and then it is up to them to decide… We notice something abnormal - afterwards, it's beyond us" (Int03).* This situation contributes to the disempowerment of agents and blocks learning. Operational actors acknowledge this fragmentation effects and ask for more fluidity in information and decision sharing: "*It bounces back very little and …that was, by the way, the request of one of the operators: they have a lot of alarms in the control room, they don't have feedback on how the alarm is processed or how it was processed*" (Int07). It appears that fragmentation prevents effective meaning-making. For example, a proximity manager stated that *"given the complexity of everything that has to be planned: activities, interactions with the business lines, etc. it's very difficult to have an accurate and global representation "(Int16).*

Through formalization, quantification, and specialization managers aspire for more control to increase safety and resilience. However, as we have seen, when excessive, these managerial mechanisms may result in unintended effects and deviate attention and decrease mindfulness. The

danger of excessive quantification relates to the fact that it may lead to the loss of sensemaking and to the destruction of competencies.

3.2.3. Decreased sense of managerial actions

Exceeding the limits of managerial actions leads to the loss of their initial sense. First, formalization saturates attention, particularly necessary in choosing the right procedure or rule. One interviewee acknowledged that countless detailed documentation is difficult to exploit to find out which rule to apply in a relevant situation.

> *"Everything is written! ... That is to say that there are writings that are not read, you don't know where to find them… It's incredible how much information we have. However, when it comes to using it, when you need information - you can't do it. We are not able to exploit it to the extent that it should be. " (Int04).*

Respondents mark the loss of sense behind the rules by denouncing that a strict rule application takes on the initial meaning to apply this rule: *"It starts from the same ambition to reduce the risks, to control them, except that we enter the discourses which are on the wording sometimes, not at all on the meaning" (Int14)*

Second, excessive quantification highlighted that the main aim of the multiplication of indicators is to make sure certain practices exist, rather than checking if they are efficient. For example, ATOM multiplies interface meetings to improve coordination, specifically by IMS process meetings. Some meetings are mandatory, and the participation of each service is controlled through reporting using dedicated indicators. However, many interviewees believe these meetings are ineffective because of they are too frequent and not well-prepared. These meeting are time consuming and fail to create a context for effective problem solving.

> *"Everyone in the service knows about the meetings that are more or less useful: those that are going to be really important, those that are a little less, but that are subject to an attendance indicator. An indicator is still an indicator. But we still try to respect them, our indicators. And in fact, we may end up having to ... pardon the expression, 'heat up the place'" (Int01)*

Since meetings are mandatory, the participants pay more attention to the attendance follow-up, rather than to the goals of the meeting. The loss of sense regarding the usefulness of these meetings demotivates the operators. Moreover, rigidity in the control prevents people from making sense out of it and, if necessary, questioning it.

Third, specialization prevents integrative changes. By implementing IMS, ATOM superimposed a process-based management onto the existing complex matrix structure, rendering the division and coordination of activities opaque. The following quote illustrates how the implementation of this superposition of the two structures meant to improve coordination, produced the opposite effect. Instead of encouraging integration and synergy, the new organizational design led to a greater segmentation of activities (with corresponding measurable indicators), suggesting that the successive but not integrated implementation of top-down and cross-functional processes complicate sensemaking and amplify existing ambiguities and tensions. As recounted by two interviewees:

> *"Culturally, we only know the pyramidal system. This means that every time we finally develop something that should be integrative, whose objective is to be integrative, in fact, we reproduce the patterns we know, we make the pyramidal" (Int04C).*
>
> *"In our service, we operate on a vertical action plan. And our pilots of the macro-processes who are not in the right posture, who stay in a vertical posture, also give the action plans. So, in our power plant, the process-based projects are managed as the departments: 'you do this to us, you do that" (Int 04B)*

In sum, our results suggest that at ATOM managerial actions have become the ends by themselves, rather than means to develop resilience. This deviates a sense of the managerial actions.

3.2.4. Demotivation through disregard of professionalism

Another effect of exceeding limits of managerial actions is linked to the decrease of motivation. Excessive managerial control mechanisms created a perception of the disregard of field actors' professionalism.

First, by preventing autonomy, formalization leads to demotivation and disempowerment. For example, several interviewees mentioned organizational "slowness": "*the slowness on everything - to change things, to do maintenance, to implement software - you have to go through meetings of I don't know how many hours, but it doesn't actually go forward, and people are demotivated" (Int03).* Moreover, excessive formalization results in disempowerment. A top manager admitted:

"Here, we have added layers and layers of paperwork...while they have an expectation of simplifying the procedures. In fact, we keep adding to it. We don't help them, we don't make them responsible. (TOP_Int07)

Second, excessive quantification also demotivates by deviating attention. A quantitative reporting of the identified gaps during field visits is perceived by the field actors as a personal sanction: *"They don't understand that. It's more about policing them" (Int07).*

Third, specialization inhibits motivation by preventing autonomy. As one interviewee explained, *"there are more and more layers of responsibility. So, it's kind of chopped up, so people, to me, are taking less and less responsibility " (Int16).* Moreover, a vertical specialization results in the monopolization of decision-making by the upper levels of management on the basis of the data reported from the field. If this decision-making is not accompanied, this may provoke a loss of sense at the operational level and even lead to the social tensions. A field agent acknowledged:

" There is a real separation between managers and others... It's very complicated. ..We're made to do things we shouldn't even be doing, we're told to 'shut up', it's very, very confrontational" (Int03).

The described effects of the limits of managerial actions question the acknowledgment of the field actors' professionalism in the highly formalized, quantified, and specified environment.

3.3. CASCADING EFFECTS OF THE MANAGERIAL ACTION AND COGNITION LIMITS

Our results alert about multiple undesired effects appearing because ATOM exceeds the limits of the managerial actions. Figure 2 presents the model of cascading effects of the endogenous limits and their impact on resilience.

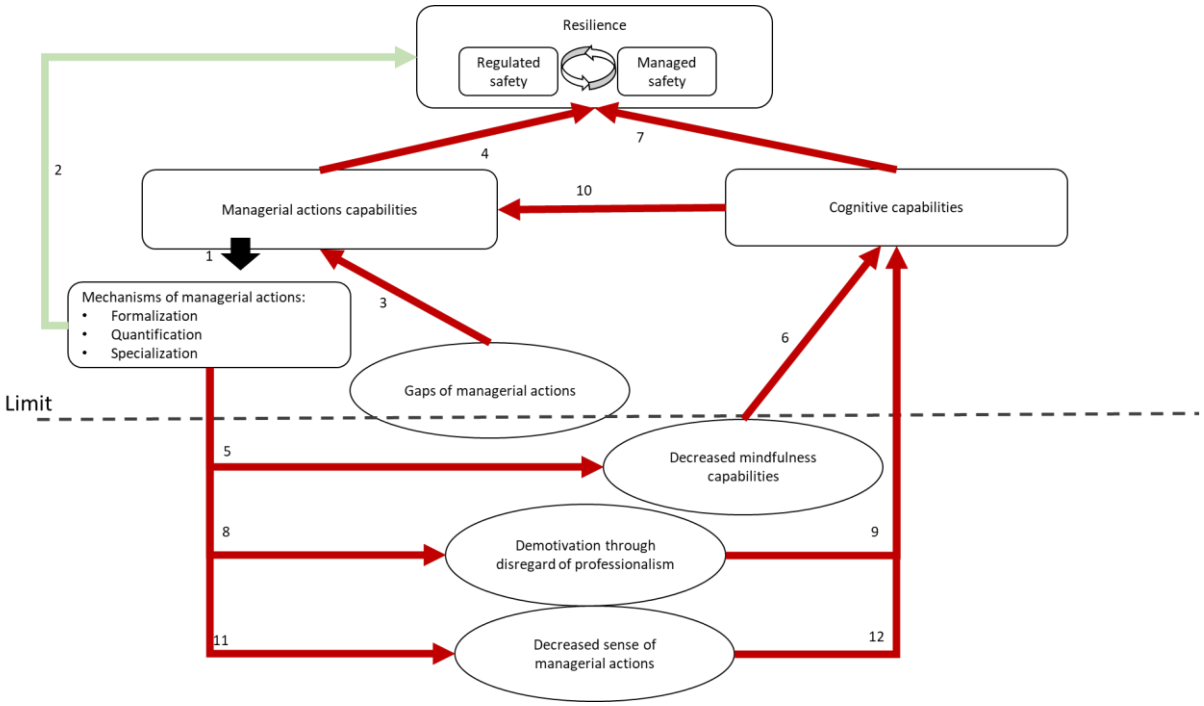

Figure 2. Model of cascading effects of the endogenous limits and their impact on resilience

Managerial actions unfold through three mechanisms structuring collective actions (arrow 1, Figure 2). These mechanisms aim to improve resilience (arrow 2) through the simultaneous development of regulated and managed safety. However, despite ATOM's continues to push formalization, quantification, and specialization, our finding suggests the presence of the gaps of these managerial actions. Even continuously developed, these managerial actions do not guarantee organizational robustness and efficiency for resilience, which mark their limits. These gaps contribute to diminish the efficiency of managerial actions and impede further development of managerial capabilities (arrow 3) negatively impacting resilience objective (arrow 4).

Moreover, there is a cascading effect of limits of managerial actions on cognitive limits. Excessive formalization, quantification and specialization emerge as an obstacle in developing mindfulness (arrow 5), constraining cognitive capabilities (arrow 6) and further development of resilience (arrow 7).

Our results also suggest two more complex cascading effects. First, exceeding limits of managerial actions results in demotivation through disregard of professionalism (arrow 8). This

affects motivation and sensemaking, affecting cognitive capabilities (arrow 9). Therefore, the efficiency of managerial actions is constrained (arrow 10) which has a negative impact on resilience (arrow 4). Second, exceeding limits to managerial action results in the decreased perception of sense of these actions (arrow 11). The formalization, quantification, and specialization's focus on obligation of means (e.g., procedure to follow or control) comes in tension with the obligation of result (e.g., reliable practice or transversal synergy). This approach to exert managerial control does not allow to enhance mindfulness and sensemaking (arrow 6). Instead of pushing cognitive limits and improving attention quality, it leads to the deviation of attention or its overload. Excessive formalization, reliance on many different metrics and fragmentation became barriers to sensemaking, leading to the loss of autonomy and motivation. Then, following the same path (arrows 10 and 4), this creates additional difficulties related to the articulation between regulated and managed safety for resilience.

ATOM introduces practices (REP, IMS, OPEX) to increase resilience capabilities and implements them by mobilizing the mechanisms of managerial control (formalization, quantification, specialization). Approaching organizational limits by increasing managerial control up to a certain level has a positive impact on resilience. However, it also produces negative unintended effects when the limits are crossed. Our findings show how two endogenous limits (cognition and managerial control) cascade through the implementation of organizational process such as REP, SMI or OPEX. Exceeding limits has unwelcome cascading effects on managerial and cognitive capabilities, impacting both behavioral and cognitive dimensions. These side-effects impact the ability to simultaneously deal with expected (regulated safety) and unexpected (managed safety) events in daily work.

CONCLUSION AND DISCUSSION

The objective of this paper was to better understand how organizations develop resilience capabilities in day-to-day activities by getting pushing organizational limits and the consequences of exceeding the limits. Our analysis showed that despite the objective of building resilience capabilities, ATOM's practices and processes implemented through managerial actions actually constrain the development of resilience because of cascading effects of organizational limits.

Exceeding limits of managerial actions has unintended consequences on cognition and on efficiency of managerial actions, which negatively impact the development of resilience.

Our findings have several important implications for organization theory and practitioners. First, our study provides new insights into the dynamics of building resilience by providing a better understanding of the interaction between managed and regulated safety. The literature treats the ways to deal with predictable and unpredictable disturbances separately (Morel et al., 2008; Wildavsky, 1988), ignores one side (Weick et al., 1999; Weick & Sutcliffe, 2007) or simply does not make a clear distinction between them, reinforcing the ambiguity (Andersson et al., 2019; Boin & van Eeten, 2013; Duchek, 2020; Sutcliffe & Vogus, 2003; Williams et al., 2017). Our study explores the mutual interaction between regulated and managed safety by combining them, rather than by focusing on their 'adaptative switches' (Grote, 2019). Our results uncovers how ATOM's effects of exceeding managerial limits impacts resilience capability to deal on daily basis with both predictable and unpredictable events.

Moreover, mobilizing a theory of organizational limits (Farjoun & Starbuck, 2007) allowed to shed a new light on the difficulties to implement generic guiding principles of resilience capabilities development offered by the literature (Boin & van Eeten, 2013; Sutcliffe & Vogus, 2003; Weick et al., 1999; Weick & Sutcliffe, 2007). In particular, applying organizational limits theory allowed to explore a key role of structure for resilience (Andersson et al., 2019; Busby, 2006; Duchek, 2020). By focusing of three mechanisms of managerial actions that structure collective action, this paper underlines their enabling (capabilities development) and constraining (capabilities restriction through limits' effects) role. This echoes Farjoun's (2010) alert on the impact of the way organizations implement control mechanisms. Our research shows the cascading effects of exceeding endogenous limits. When organizations aim to stretch the limits to enhance resilience, managerial control may deviate the implementation of safety practices and produce negative effects on cognition and managerial action efficiency. This unintentionally may lead to additional safety problems.

We advance knowledge on the organizational limits (Farjoun & Starbuck, 2007). First, this paper specifies managerial limits by identifying three mechanisms – formalization, quantification, and fragmentation – that intervene in organization's efforts to push organizational limits and increase its resilience. Second, while prior literature (Oliver et al., 2017, 2019) explores the

interaction between cognition and technology with the focus on the role of automation and its constraining influence on cognition, our study shed new light on cascading effects of exceeding limits originated from managerial action and cognition. Third, while prior organizational limits research is mainly focused on retrospective analysis of accident (with a clear limit violation), our paper studies less visible limit violation in day-to-day practices, which responds the call from resilience authors (Andersson et al., 2019).

A better understanding of organizational limits to develop resilience may offer managers the opportunity to consider the cascading effects originated in managerial actions, to explore the role of leadership for resilience and to adapt training programs. Future research on resilience may investigate how organization could be identity threshold of the managerial actions limit in order to prevents unintended effects of exceeding limits.

Our findings have several limitations. First, our study was conducted in a single organization in the nuclear energy industry. Data collection would have benefited from being conducted in multiple organizations of different sizes and from different industries. Finally, our investigation could have gone further in studying the underlying mechanisms impeding the development of resilience inside of the organizational limits.

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