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Organizational resilience in the oil and gas industry: A scoping review

Fabio Bento [a,*], Luciano Garotti [b], Marina Prado Mercado [c]

[a] Department of Behavioral Science, Oslo Metropolitan University, PO box 4 St. Olavs plass, 0130 Oslo, Norway
[b] Petrobras Research and Development Center – Cenpes, Av. Horácio Macedo, 950, Cidade Universitária – Ilha do Fundão, Rio de Janeiro, RJ 21941-915, Brazil
[c] Department of Production Engineering – PEP/COPPE, Federal University of Rio de Janeiro – UFRJ, Centro de Tecnologia - Rua Horácio Macedo, Bloco G, 2030 – 101, Cidade Universitária, Rio de Janeiro, RJ 21941-450, Brazil

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ABSTRACT

Resilience derives from the study of socio-ecological systems and refers to the dynamical capacity to adapt to internal and external perturbations by changing its mode of operation without losing its ability to perform. The present article offers a scoping review of organizational research discussing the concept of resilience in the oil and gas industry. Rather than approaching a narrowly defined question as in systematic reviews, scoping reviews produce an overview of a body of knowledge covering broad questions. It reviews organizational research on resilience in the oil and gas industry by covering five main categories: conceptualizations; article type/methods; context/unit of analysis; relation between resilience and safety; and, central topics highlighted in the literature. The review of both empirical and conceptual literature reveals that the concept of resilience tends to be researched in terms of system capabilities or outcomes rather than processes. Integrated operations has provided new scenarios to discuss and investigate resilience in oil and gas production. However, findings demonstrate how resilience is often presented as a normative construct and there is little development in terms of understanding the dynamics of adaptive processes in the industry. The overall goal is to contribute to the study of organizational resilience by identifying areas for further study and by producing new knowledge that can permeate practices in organizations.

1. Introduction

The present article offers a review of organizational research literature focused on the application of the concept of resilience in the oil and gas industry. Resilience is a concept that derives from socio-ecological studies (Folke, 2006) and refers to a system's capacity to absorb and return to a stable state after a disruption. In this regard, Barabási's (2016, p. 303) definition of system resilient provides a good starting point: "a system is resilient if it can adapt to internal and external errors by changing its mode of operations, without losing its ability to function. Hence, resilience is a dynamical property that requires a shift in the system's core activities". The conceptualization of organizational resilience presented by Hollnagel and Woods (2017) highlights the system's capacity to anticipate, to synchronize, to be ready to respond and to proactively learn. Hollnagel (2009) presents four cornerstones of resilience: (1) responding to what is happening; (2) a flexible monitoring of to identify critical problems; (3) anticipating potential problems, and; (4) learning from experience. Folke (2006) presents a historical overview showing how research on the concept gradually moved from an initial assumption of single equilibrium in socio-ecological systems to an understanding of multiple equilibrium states and an increasing recognition of uncertainty, variation and learning. This is in many ways a recognition of complexity in living systems.

Resilience has implications for different organizational settings. However, there are internal and external factors making resilience particularly interesting for the oil and gas industry. At the operational level, there are the complexity and risks of oil production. Bearing in mind that research on organizational resilience has largely focused on safety (Bergström et al., 2015) which is an area of concern in the oil and gas industry. However, there are also external changes that raise a concern with organizational resilience. Externally, the oil and gas industry is characterized by cycles and a reactive approach to fluctuations in the price of raw materials and derivatives (Capello and Passalacqua, 2018). One important external factor is the increasing social and political pressure to a change in profile from oil and gas to energy companies expanding their portfolios to renewable sources (Pickl, 2019; Zhong and Bazilian, 2018). This transition will certainly require adaptation and learning at different levels. At the time, this study was in its last stages,

* Corresponding author.
E-mail addresses: fabio.bento@oslomet.no (F. Bento), luciano.garotti@petrobras.com.br (L. Garotti), marinapmercado@gmail.com (M.P. Mercado).

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the industry was suffering the effects of the 2019–20 coronavirus pandemic which brought safety, health and economic concerns. It was at this point too early to evaluate learning emerging in this crisis. However, unexpected events as such raise concerns about adaptation processes and how organizations “bounce back”.

Integrated operations refer to not only technical but mainly organizational changes in oil and gas production introducing parallel collaborative practices in which processes and agents are temporally interdependent rather sequentially structured (OLF, 2005). The implementation of integrated operations represents a major change in the business model of oil and gas companies enabled by the use of real data-sharing through ICT developments and increasing collaboration across disciplines, companies and geographical areas (Skarholt et al., 2009). Integrated operations derive from a recognition of complexity in oil and gas production moving from a once consolidated assumption that processes could be divided, modelled and fully understood isolated from other processes (Lochman, 2012). Hepsø (2006) claims that integrated operations are forms of common information spaces that enable multidisciplinary collaboration and knowledge creation. Integrated operations work forms have in many ways changed the web of interactions in production processes by facilitating interaction among professionals in different sectors. There is then the need to understand the relations between integrated operations and system resilience.

Both internal and external complexity raises questions about knowledge, communication and information flow associated to with resilience at the system level. As presented in more detail in the next section, our central assumption is that resilience can indeed be conceptualized as an emergent property of complex systems (Barasa et al., 2018; Pariès, 2017). However it is important to bear in mind that not all complex systems exhibit resilience. In some systems, the structure and content of interaction many indeed restrain resilience making the system less adaptive to environmental changes and more susceptible to internal failures. From a management perspective, the main challenge seems to be to design interventions that facilitate the emergence of resilience in organizations. Complex systems are constituted of webs of interactions among interdependent agents (Holland, 1995). Such webs are characterized by emergent outcomes, sensitivity to initial conditions and feedback loops, and therefore difficult to predict and model. In organizational settings, there is a complex relation between formal structures and emergent webs of interactions (Bento and Garotti, 2019; Clement and Puranam, 2018).

The article offers a scoping review aiming at identifying how organizational literature in the oil and gas industry has approached such questions. The goal of a scoping review is to produce an overview of relevant literature in a field of study. Scoping reviews differ from narrative and systematic reviews in the sense that they cover broader topics encompassing different kinds of studies and thereby “mapping” a research field rather than providing answers to narrowly defined questions (Arksey and O’Malley, 2005). The main goal here is to look at the diversity of studies of resilience in the oil and gas industry in order to identify gaps and possibilities for further research.

This paper has the following structure. First, a review the relation between resilience and emergence in a complex system. This relation will inform the analysis and discussion of findings. Then the presentation of the methods and techniques used to search and select articles. The presentation of findings explore the following topics: definitions of resilience, context of resilience/units of analysis and main topics related to resilience. Among the main findings, it is observed that the literature about resilience in the oil and gas industry often assumes a normative character and does not investigate evolutionary adaptive processes that are characteristics of complex systems.

2. Organizational resilience

It is possible to observe a concern with resilience in a variety of fields of organizational research such as individual and organizational psychology, supply chain management, strategic management and safety engineering (Bhamra et al., 2011). As demonstrated by Denyer (2017, p. 8), research on organizational resilience has evolved over the last forty years raising questions about the adaptive capacity of organizations to respond not only to internal failures but also to a variety of external challenges ranging from natural disasters to major socio-political trends. The increasing academic interest in organizational resilience has not derived from or led to a consensus of what the concept means.

2.1. Conceptualizations of resilience

Duchek’s (2020) review of research on organizational resilience identifies three main categories of definitions. The first and broadest category comprises studies that regard *resilience as an outcome*. In such studies, the main interest is on identifying characteristics of resilient organizations such as resources, strategies and behaviors that strengthen organizational resilience. Empirical studies often retrospectively investigate cases of organizations responding to the crisis in order to identify factors that may have a positive or negative impact on resilience. Duchek (2020) states that although those studies bring important contributions in identifying attributes of organizations that effectively respond to change and crises, they provide little insight on the internal dynamics of resilience.

The second conceptualization sees *resilience as a process* and brings a time perspective and often aims at identifying stages of resilience. Duchek’s (2020) study itself can be seen as being partially informed by such an approach by offering the following components of resilience in a time perspective: anticipation, coping and adaptation. Although the label and number of suggested stages vary, those studies have in common the emphasis on the dynamic nature of resilience. Duchek (2020) suggests that conceptualizations of resilience contribute to understanding the process from resilience resources and resilience outcomes.

The conceptual interest in *resilience capabilities* looks at specific organizational abilities that underlie resilience rather than attributes. Such studies differ in research methods, contexts and problems (Duchek, 2020). The capabilities can be broadly defined as operational and strategic, but also sometimes specifically identified as routines and practices that embed organizational resilience. The capability-oriented approach has an intrinsic interest into how resilience can be achieved in practice.

However, some of those conceptualizations contrast with Hollnagel and Woods’ (2006) claim that resilience is not a property of a system or organization, but rather a characteristic that is developed or nurtured, using knowledge, competence and resources: “resilience cannot be engineered simply by introducing more procedures, safeguards, and barriers. Resilience engineering instead requires a continuous monitoring of system performance, of how things are done. In this respect resilience is tantamount to coping with complexity (Hollnagel and Woods, 2005), and to the ability to retain control” (Hollnagel and Woods, 2006, p. 348). Therefore, the next section consists of a discussion about the relation between resilience and complexity.

2.2. Organizational resilience and complexity: An overview

The systematic review presented by Bergström et al. (2015) about resilience in the safety domain demonstrates how resilience is usually embedded by an assumption of complexity. However, the authors observe that complexity is not always explicitly defined or developed in the literature about resilience in the safety domain. In this regard, the recognition of the relation between the concepts of emergence and resilience in complex systems informs the formulation questions addressed in this scoping review. From the perspective of complexity sciences, it is important to identify the unit of analysis of resilience from the individual to the system level and interaction process within organizations.

If resilience is a possible emergent property of complex systems (Bar-

Yam, 2019; Dahlberg, 2015; Folke, 2006; Pariès, 2017), it is important to review the concept of emergence (Heylighen, 1989; Padgett and Powell, 2012). The most common and perhaps straightforward definition of emergence can be expressed as such: "the whole is more (or different) than the sum of its parts". This means that complex systems cannot be understood only by observing properties of its parts, but there is a need to look at the outcomes of processes of interaction in a temporal dimension. What happens at the macro-level is not a sum but an emergent outcome of various processes of interactions at the micro-level. Complex systems are process-dependent entities with feedback among multiple levels and agents (Holland, 1995) leading to multiple rather than single equilibria points. In this sense, resilience in complex systems is not a single static state but an emerging and process-dependent outcome at the system level. For instance, research in socio-ecological systems have highlighted the importance of diversity for the emergence of new structures (Folke, 2006). Research in complex systems is usually based upon an evolutionary logic that highlights interaction as the main unit of analysis. Different from what occurs in Cartesian science, complex systems cannot be fully understood by breaking them in parts and studying those in isolation.

Resilience is often the outcome of local interactions at different layers of the system. The different parts and clusters of the system exhibit their own behaviors and structures but that are not enough to assess resilience at the system level. Emergence is indeed this functional mechanism of complex systems through which the outcome of local interactions is observed at the system level. However, among the different behaviors and properties observed at the micro level, not all are selected as emergent at the macro level. Out of many properties observed at the micro level only some emerge to the level of systems properties. Resilience may or not surface as a property depending on the existence of feedback loops and network structures that facilitate its emergence.

As demonstrated by Woods (2015), the recognition of complexity among resilience researchers have brought an increasing attention to the risk of brittleness and sustained adaptability. Brittleness relates to the risk of systems failures taking the systems beyond its limits to absorb perturbations and unexpected variation. Sustained adaptability refers to the architectural characteristics of networks at different levels and their capacity to adapt to unexpected events. In some organizational settings, this bottom-up process may occur in a spontaneous and evolutionary way, but in some other cases it needs to be facilitated by management practices. Management interventions can either enable or constrain the exploration of new opportunities brought by disturbances in term of recombination of structures and new trajectories at the system level (Folke, 2006). The resilience of complex system may depend upon an optimal adaptation balancing emergence and hierarchical interventions (Zarboutis and Wright, 2006).

The publication of Holling's (1973) work on resilience and stability in ecological systems raised the interest in the concept of resilience in organizational studies. Holling described two contrasting viewpoints regarding the behavior of ecological systems leading to different management approaches. Whilst a stability approach assumes equilibrium and the persistence of a predictable world, resilience indicates a qualitative capacity to absorb unexpected events. Holling (1973, p. 21) sums up the resilience viewpoint and its implication for management practice in the following terms:

A management approach based on resilience, on the other hand, would emphasize the need to keep options open, the need to view events in a regional rather than a local context, and the need to emphasize heterogeneity. Flowing from this would be not the presumption of sufficient knowledge, but the recognition of our ignorance; not the assumption that future events are expected, but that they will be unexpected. The resilience framework can accommodate this shift of perspective, for it does not require a precise capacity to predict the future, but only a qualitative capacity to devise systems that can absorb and accommodate future events in whatever unexpected form they may take.

Holling's seminal work paved the way for further development in the field moving from a strict focus on the capacity to absorb shocks and maintain functions to a recognition of the adaptive aspect of resilience. This means the qualitative capacity to renewal, recombination of structures and processes. Rather than returning to an initial equilibrium state, resilience has increasingly been understood as a concern with how to maintain continuous development, innovate and transform into new configurations in the face of internal and external perturbations (Folke, 2006).

Most studies about resilience in the safety domain highlight the challenge to cope with risky variability in complex systems (Bergström et al., 2015). As claimed by Weick and Sutcliffe (2001), in resilience engineering, safety does not mean the absence of accidents but a dynamic non-event and the system ability of dealing with unexpected events. At a first glance, it might seem that there is an intrinsic contradiction between resilience and safety. Pariès (2017) resolves this apparent contradiction by claiming that safety itself can be seen as a form of resilience. Hence, resilience becomes the emergent outcome of the robustness of all processes that maintain the system safe in relation to risks and threats. However, as pointed by Morel et al. (2008, p. 3): "the relationship between resilience and safety is much more complex than a simple, cumulative way of improving safety". Resilience has to do with the experiential knowledge constructed by encountering unexpected, but also open communication across agents and units beyond a cumulative logic.

2.3. Bayesian networks

Another important approach in the study of resilience is the application of Bayesian networks that are probabilistic models that have often been used for decision-making and risk assessment in areas such as software development, safety management and traffic accidents (Hosseini and Barker, 2016; Hossain et al., 2019). Bayesian models facilitate the analysis of the relationship between available information and uncertainty in complex systems. The models usually consist of networks of causes and effects. The nodes represent sets of variables while the edges represent relation among variables (Fenton and Neil, 2012). The goal then is to present causal relationships in terms of conditional probabilities. This is a quantitative approach but the data can derive from different sources such as historical information or expert knowledge (Hosseini and Barker, 2016). Bayesian network models have been applied to quantitatively assess the resilience of engineered systems (Yodo and Wang, 2016). It is important to determine if Bayesian network models have been used to investigate organizational resilience in the oil and gas industry.

3. Methods

Arksey and O'Malley (2005) stress the potential of scoping reviews in mapping and highlighting gaps in the existing knowledge base. Furthermore, they present the different stages of scoping reviews: (i) Identifying the research question; (ii) identifying relevant studies; (iii) study selection; (iv) charting the data, and; (v) summarizing and reporting results.

3.1. Identifying the research question

The initial question raised in this study is the following: how is resilience conceptualized and researched in the oil and gas industry? This main question was operationalized according to five main categories of findings under which the selected articles were analyzed. The below listed categories derive from the conceptual discussion about resilience and complexity in the second part of this paper and further refined as selected literature was being analyzed:

1. Conceptualization of resilience
2. Article type and empirical research methods
3. Context (the object of resilience) and units of analysis (individual/system)
4. The relation between resilience and safety
5. Central topics in the articles

3.2. Identifying relevant studies

In order to answer the main research question, a literature search of both conceptual and empirical articles was conducted using the following databases: Academic Ultimate Search and Scopus. On Scopus, the search was restricted to the following areas: Engineering, Social Sciences, Business, Economy, Decision Sciences, Humanities and Psychology. The choice of research terms was "resilience" AND "oil" OR "petroleum" in the abstract of the articles. This search was conducted in September 2019 and was restricted to academic peer-reviewed articles in English published since 2006. This starting point of the publication period was defined because 2006 is the year of publication of the first edition of "Resilience Engineering: concepts and precepts" (Hollnagel et al., 2006). Since then, there has been an increasing attention in resilience in the safety domain in organizational research. However, one purpose here is to assess to what extent the concept has been applied to other organizational domains beyond safety in the oil and gas industry.

3.3. Study selection and exclusion criteria

The first search gave access to n = 617 abstracts that were screened with the help of Rayyan (Ouzzani et al., 2016) which is an online platform that supports knowledge synthesis projects. The platform initially identified 113 duplicated abstracts which were removed. One article was found through online search. The next phase consisted of analyzing the 505 remaining abstracts looking for studies in the oil and gas industry from an organizational perspective. This step was conducted by all three authors and consisted of a peer review process in which the selection and exclusion criteria was discussed and refined along the way. Most studies (n = 467) were eliminated at this phase under the following exclusion criteria:

- Articles that did not focus on the organizational dimension of resilience;
- Articles that presented global and national market analysis which did not approach organizational challenges were also excluded;
- Articles that approached resilience in the context of energy distribution system (post-refinery) were excluded as these were regarded as outside the boundaries of oil and gas production, and;
- A relatively large number of articles investigated community resilience in response to the impacts of major accidents such as the Deepwater Horizon oil spill. Although this is an interesting area to be investigated from a resilience perspective, those abstracts were excluded since they did not focus on oil and gas companies from an organizational perspective.

The number of full text articles assessed for eligibility was thirty-eight (n = 38). In this phase, eighteen (n = 18) articles were excluded. In most cases, a closer reading of the full texts beyond the abstract revealed that those articles matched the above described exclusion criteria. In other cases, although the abstract mentioned the word resilience, the concept was not further operationalized, researched or even discussed in the text. As a result, twenty (n = 20) articles were assessed as eligible for qualitative analysis. The following flowchart is an adaptation of PRISMA (n.d.) and depicts the search and selection process (Fig. 1).

3.4. Analyzing and charting the data

The analysis of findings assumed a combination of both theory-driven and data-driven approaches (Gibbs, 2002). In units of analysis, data was categorized using the following codes: individual and systems. This coding strategy was embedded and driven by the conceptualization of resilience as a possible emergent property of complex systems and previous observation of different levels of resilience (Bergström et al.,

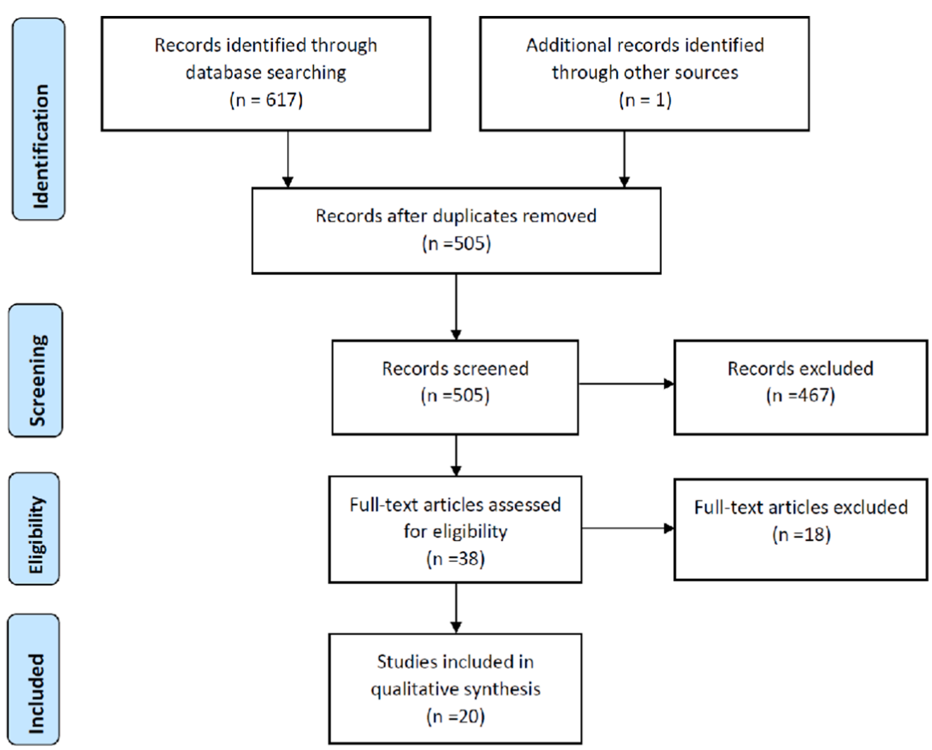

Fig. 1. Flowchart of search strategy for literature review.

2015). In definitions of resilience, the selected articles were coded in three categories of conceptualization as suggested by Duchek: (1) resilience as an outcome, (2) resilience as a process, and (3) resilience capabilities. On the other hand, the categorization of the context of resilience was essentially data-driven. The next step consisted of identifying recurrent themes that emerged from the data and creating categories according to these rather than guided by any previous theoretical framework. The following categories emerged: drilling, production, transportation, petrochemical plants and recovery from oil spills.

4. Findings

Table 1 provides an overview of findings in terms of conceptualizations of resilience, central arguments and contexts/units of resilience.

4.1. Conceptualization of resilience

The analysis of findings reveals a variety in terms of conceptualization of resilience in organizations studies in oil and gas. The studies conceptualize resilience either as an outcome of different organizational strategies (n = 8) or as sets of specific capabilities (n = 9). It is important to highlight that three articles (n = 3) (Andersen and Mostue, 2012; Hansson et al., 2009; Tveiten et al., 2012) conceptualize resilience as both capabilities and processes. These explicitly approached resilience as a process usually referring to Hollnagel's (2009) four cornerstones of resilience.

Fig. 2 shows the share of articles in terms of conceptualization of resilience:

4.2. Article type and empirical research methods

Six (n = 6) articles had a conceptual character. On the other hand, the majority of the selected studies (n = 14) had an empirical character either by focusing on necessary conditions or the implications of already existing strategies for resilience. Among the empirical articles, six (n = 6) followed a quantitative approach mostly relying on data gathering through surveys; seven articles (n = 7) followed a qualitative approach by applying methods such as action research, basic interpretive studies and participant observations, and; one (n = 1) mixed quantitative and qualitative methods. Fig. 3 shows the distribution of articles in terms of article type and research methods:

4.3. Context and unit of analysis

The selected articles approached resilience in a variety of organizational contexts in the oil and gas industry. The largest group (n = 9) focused primarily on organizational aspects of production processes but also on drilling and/or integrated operations. Among those, there is a concern with the implications of integrated operations to resilience (n = 4). Fig. 4 shows the quantity of articles addressing each context of resilience:

Other studies investigated resilience in petrochemical plants (n = 4), only drilling (n = 2), interorganizational collaboration in response to recovery spills (n = 1), environmental sustainability (n = 1), transportation systems (=1) and undefined (n = 1). It is important to observe that although the selected studies had an empirical character (n = 14) and focused on a variety of organizational contexts, none of the articles investigated practices that were explicitly informed by the concept of resilience. In all studies, resilience was presented as parts of conceptual frameworks suggested by the authors rather than explicitly permeating organizational practices or strategies. Resilience is presented as an abstract construct guiding both empirical and conceptual studies but not as organizational principles informing practices in an articulated manner.

Most studies (n = 13) looked at resilience as a system property while only one (n = 1) looked at resilience as individual property. Five (n = 5) articles presented a more mixed character look at resilience as a system property at investigating in terms of individual behaviors. In one article, it was not clear to identify the analytical level of resilience (n = 1). The following figure depicts the distribution of articles in terms of unit of analysis: (See Fig. 5).

4.4. Relation between resilience and safety

Most studies (n = 16) approach safety and explicitly assume that there is a relation between safety and resilience. The majority of these articles (n = 13) develop the assumption that resilience contributes to safety in the oil and gas industry. This is the case of Shirali, Shekari and Angali (2018), Azadeh et al., 2016; Azadeh and Salehi (2014) which claim that the concept of resilience engineering promotes safety in organizations.

On the other hand, a smaller group (n = 3) present safety and resilience as related concepts without explicitly claiming that resilience contributes to safety. Those articles discuss the challenges of integrated operations to safety and resilience (Grabowski and Roberts, 2016; Johnsen, 2012) or the negative effects of poor focus on human factors in the design process to safety and resilience (Johnsen et al., 2017). Moreover, four articles (n = 4) did not discuss safety. Fig. 6 shows the distribution of articles according to the relation between resilience and safety:

4.5. Central topics in relation to resilience

The review of selected articles reveals a wide variety in terms of topics related to resilience. However, there were several gaps that need to be researched in order to further develop our knowledge of theoretical and industrial implications of the concept. One way of analyzing such findings is to place the selected studies in a continuum ranging from formal and more technological approaches to informal and relational aspects of resilience. Examples of the first kind of study are the articles by Azadeh et al. (2016), Rabbani et al. (2019) and Thorogood (2013; 2014). Azadeh et al. (2016) operationalizes the concepts of resilience engineering in terms of human and equipment redundancy as a factor contributing to improving system efficiency. Rabbani et al. (2019) present an algorithm for performance evaluation of resilience engineering by identifying self-organization, teamwork and awareness as decisive for system safety. Thorogood (2013; 2014) argues that the cultivation of resilience demands formalizing processes of operational decision-making and change; making sure that workers are trained and suitable for their roles; and, maintaining skills in dealing with unexpected events by promoting training and exercises.

However, most studies discuss resilience beyond formal organizational structures. For instance, Albrechtsen (2015) presents a conceptual discussion about major accident prevention and highlights the importance of resilience-based approaches in supplementing formal management approaches. As the author discusses, integrated operations bring both positive and negative implications for system safety. Formal management practices have limitations in grasping tacit dimensions of knowledge. There is thus the need for a better understanding of practices that enable adaptation processes:

"there is a need for adaption to cope with complex, unanticipated, interleaved and conflicting tasks. As a result, management systems need to balance compliance and resilience. More research is needed in this regard: how to change the formal systems to match reality and how to facilitate adoption among sharp-end operators" (Albrechtsen, 2015, p. 90)

Andersen and Mostue, 2012 develop much of the same perspective. They apply a mixed method approach to investigate the implications of integrated operations to operational risk analysis and recommend resilience-based approaches to system safety. This case study describes how workers rely on various practices such as local plant knowledge, experience and common sense to monitor processes, adapt and anticipate possible outcomes. In many ways, their practice resembles the four system

Table 1
Presentation of findings.

Authors/Year	Article type/research methods	Central Topic	Unit of Analysis	Context of Resilience	Conceptualization of Resilience	Relation between Resilience and Safety
Albrechtsen (2015)	*Conceptual*	Resilience-based approaches as supplement to formal management approaches. The need for more research on how to change formal systems.	System and individual	Production andIntegrated Operations	Resilience capabilities	Resilience promoting safety
Andersen and Mostue, 2012	*Empirical*Mixed	Changes towards integrated operations bring implications for risk analysis. Resilience-based approaches as supplement to formal management approaches.	Not identified	Production andIntegrated operations	Resilience as a process and capabilities	Resilience promoting safety
Azadeh et al. (2016)	*Empirical*Quantitative	Resilience engineering.Human and equipment redundancy as improving systems efficiency.	System	Petrochemical plant	Resilience as an outcome	Resilience promoting safety
Azadeh & Salehi (2014)	*Empirical*Quantitative	Reducing the gap between work as imagined by managers and work as actually done by operators strengthens system resilience. Resilience engineering.	System	Petrochemical plant	Resilience as an outcome	Resilience promoting safety
Bento and Garotti (2019)	*Conceptual*	A network analytic approach to resilience challenges brought changes in workplace demographics.	System	Production andIntegrated operations	Resilience capabilities	Not about safety
Carlson (2018)	*Empirical*Qualitative	Renewal discourse in post-crisis communication and emphasis on preparedness facilitates dialogues about interdependencies among stakeholders.	System	Oil Spill Recovery	Resilience capabilities	Not about safety
Gomes et al. 2009	*Empirical*Qualitative	Resilience as an emergent property related to variability at different levels. It investigates how the transport system is resilient and given the workload demands of and economic pressures to helicopter pilots.	System and individual	Transportation system	Resilience as an outcome	Resilience promoting safety
Grabowski and Roberts, 2016	*Conceptual*	The challenges that reliability-seeking virtual organizations (RSVOs) pose for high reliability and resilient organizations. Fluidity in organizational structures as characteristic of reliable organizations.	System	Production andIntegrated Operations	Resilience as an outcome	Factors facilitating resilience and safety
Hansson et al., 2009	*Empirical*Qualitative	The authors describe an intervention based on a model of resilience used to reduce occupational injuries. They describe several activities influencing anticipation, attention and response. Resilience engineering.	System	Production andDrilling	Resilience as a process and capabilities	Resilience promoting safety
Johnsen (2012)	*Empirical*Qualitative	Action research aiming at influencing knowledge of safety guidelines among different stakeholders may have improved system resilience by increasing focus, awareness, network segregation, disturbance planning and reporting.	System	Production	Resilience capabilities	Factors facilitating resilience and safety
Johnsen, 2012	*Empirical*Qualitative	Focus on human factors in design processes impacts work conditions for human operators, and thereby safety and resilience. The need for non-technical skills such as communication and decision-making.	System	Production	Resilience capabilities	Factors facilitating resilience and safety
Ndubisi and Al-Shuridah (2019)	*Empirical*Quantitative	Commitment to resilience at the individual level as a dimension of mindfulness at the organizational level.	System and individual	Environmental and resource sustainability	Resilience capabilities	Not about safety
Rabbani et al. (2019)	*Empirical*Quantitative	Presents an algorithm for performance evaluation of resilience engineering. Resilience engineering improving safety. Identifies self-organization, teamwork and awareness as the most effective resilience engineering factors.	System	Petrochemical plant	Resilience as an outcome	Resilience promoting safety
Reknes et al., 2018	*Empirical*Quantitative	Stress resilience at the individual level. Focus on individual hardiness in mediating the bullying-anxiety relationship.	Individual (mental health)	Not defined	Resilience as an outcome	Not about safety
Shirali, Shekari & Angali (2018)	*Empirical*Quantitative	An evaluation of reliability and validity of instruments in measuring Resilience Safety Culture (RSC) in sociotechnical systems. Resilience engineering.	System and individual	Petrochemical plant	Resilience as an outcome	Resilience promoting safety
Skjerve et al. (2012)	*Empirical*Qualitative	It investigates the potential of a coaching approach in promoting reflection about resilient collaboration.	System and individual	Production	Resilience capabilities	Resilience promoting safety
Thorogood (2013)	*Conceptual*	Resilience as a characteristic of high reliability organizations (HRO). It provides actionable steps to the cultivation of resilience.	System	Drilling	Resilience capabilities	Resilience promoting safety
	Conceptual	Resilience as a characteristic of HRO.	System	Drilling	Resilience capabilities	

(*continued on next page*)

Table 1 (*continued*)

Authors/Year	Article type/research methods	Central Topic	Unit of Analysis	Context of Resilience	Conceptualization of Resilience	Relation between Resilience and Safety
Thorogood and Crichton (2014)						Resilience promoting safety
Tveiten et al. (2012)	*Empirical*Qualitative	The need to be more proactive in emergence management and the possibilities enabled by integrated operations. It suggests principles for resilience emergency management principles: monitoring, anticipation, responding and learning.	System	Production	Resilience as a process and capabilities	Resilience promoting safety
Yang (2019)	*Conceptual*	Resilience engineering ensures the design of complex systems that can stand adverse conditions and recover from disruptions. Three dimensions of resilience in HSE regulation: flexibility; fully communication and cooperation reducing potential conflicts of stakeholders, and; consensus and mutual trust.	System	Production andDrilling	Resilience as an outcome	Resilience promoting safety

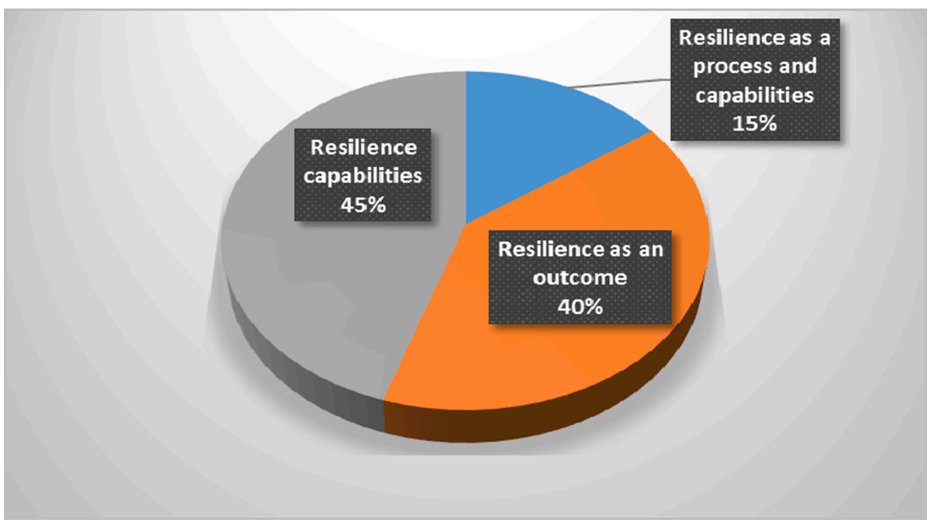

Fig. 2. Conceptualization of Resilience.

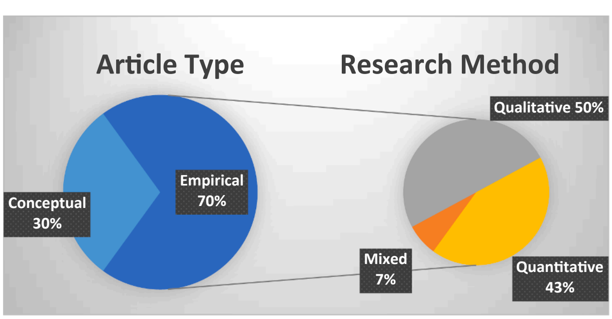

Fig. 3. Article Type and Empirical Research Methods.

capabilities of resilience as described by Hollnagel (2009). The authors observe a lack of formal risk analysis methods in daily operations that could be seen as a matter of concern. However, further formalizing risk analysis in operational processes could also lead towards a shift in focus towards requirement compliance without necessarily improving safety.

The focus on resilience beyond formal structures and procedures also permeates the study of Grabowski and Roberts (2016) when they discuss the need for organizational fluidity in reliability seeking virtual organizations such as integrated operations. Gomes et al. (2008) focus on transport system safety and conceptualize resilience as an emergent system property related to variability at different levels and subsystems. Bento and Garotti (2019) discuss the challenges in workplace demographics to the knowledge dimension of oil and gas companies and suggest a network analytic perspective seeing resilience in the context of loss of experiential knowledge in everyday interactions. It is possible to observe that in spite of a variety in terms of research methods, none of the selected articles used Bayesian network models to address organizational resilience in this industry. Although the initial screening of literature identified articles that discussed the use of Bayesian networks to study risk assessment in the oil and gas industry (Cai et al, 2015; Pasman et al., 2017), these did not focus on organizational resilience. Therefore, these were not included in this study.

As noticed earlier, some articles highlight resilience at the individual level. In such studies, the individual can be observed through different perspectives: collaboration, relationship, anxiety development and individual commitment. Skjerve et al. (2012) investigate the contribution of coaching in facilitating reflection about resilient collaboration. Reknes et al., 2018 looks at the individual hardiness in the context of bullying-anxiety relations in an oil and gas company in Norway. Ndubisi and Al-Shuridah (2019) approach commitment to resilience at the individual level as a dimension of mindfulness at the organizational level.

It is important to observe that among the twenty articles analyzed in

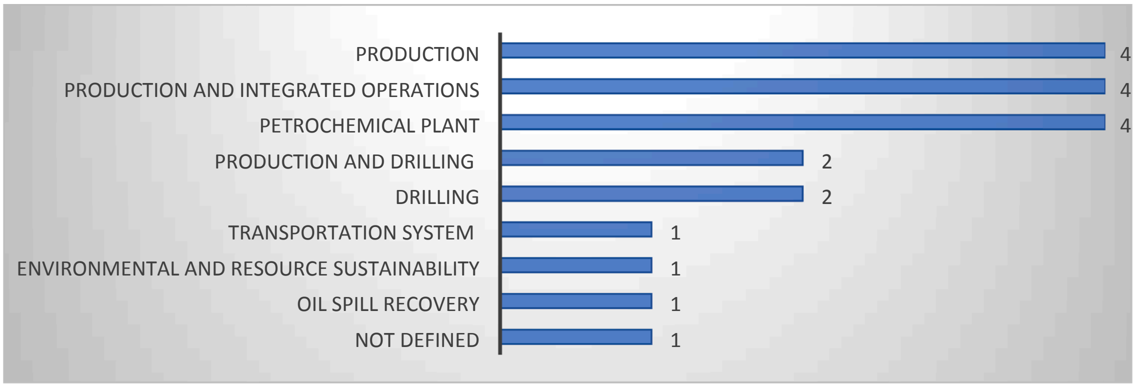

Fig. 4. Context of Resilience.

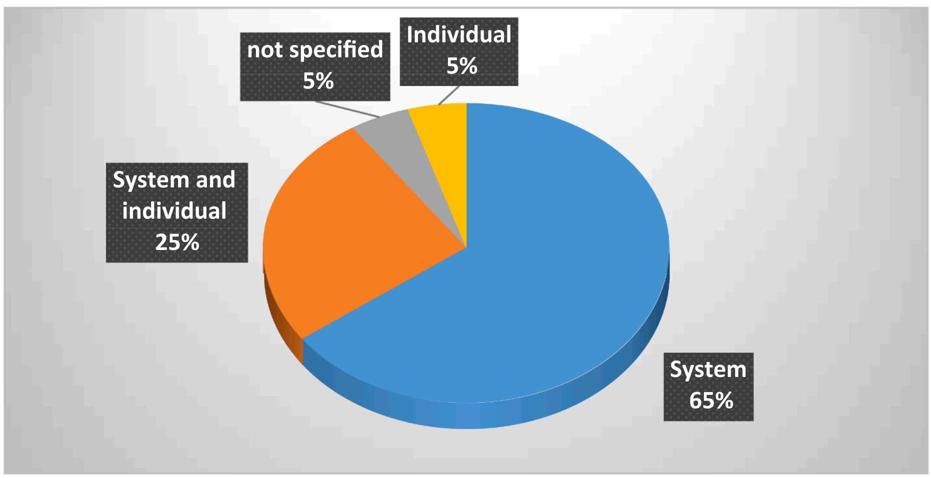

Fig. 5. Unit of Analysis.

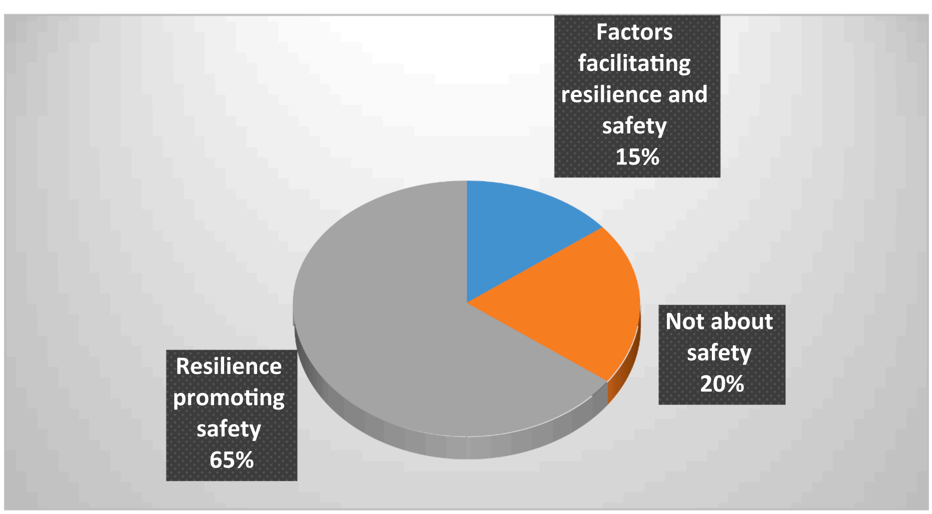

Fig. 6. Relation between Resilience and Safety.

this scoping review, only the article by Hansson et al. (2009) presented an evaluation of a management practice originally formulated based upon the concept of resilience. This article describes how the concept of resilience embedded the implementation of an intervention aiming at reducing occupational injuries. The authors identify organizational factors necessary to be able to anticipate, perceive and respond to different events: sufficient time, knowledge and competence, resources and including working environment (Hansson et al., 2009). However, all the other studies (n = 19) presented resilience as parts of conceptual frameworks developed by the authors rather than explicitly permeating organizational practices or strategies. In such studies, resilience is presented as an abstract construct guiding both empirical and conceptual studies but not as organizational principles informing practices in an elaborate manner.

5. Discussion

This section provides an interpretation of research findings under the light of the conceptualization of resilience as property of complex systems. Resilience is here understood not as something that organization possesses but may facilitate in a temporal perspective. From this perspective, further research on resilience in oil and gas production may be enriched by investigating adaptive processes beyond static system properties. Therefore, there is a need for more studies in processes and practices related to resilience which seem to be discussed by only 15% (n = 3) of articles.

The studies discussed the implications of different practices and/or tools aiming at evaluating resilience in different organizational contexts. For instance, the implications of integrated operations – a business model not originally embedded by a concern with resilience. However, it is important to observe that in most cases (n = 19), resilience was presented more as abstract constructs as part of the authors' analytical frameworks than being implemented in the organizational environment informing practices and interventions. This seems the main challenge ahead. As presented earlier, most analyzed articles looked at resilience at the system level while other studies looked at resilience as individual traits or skills. Both levels of resilience are important, but from a complex system perspective the analytical focus is always on interactions among agents and to what extent these interactions facilitate or restrain positive feedback loops of adaptation. The analytical focus on interactions may constitute an important starting point for the development of innovative practices towards promoting resilience at the system level. This means that there is a need to understand informal everyday processes of interaction that could not be fully grasped by looking at formal organizational structures. In this regard, social network analysis (Borgatti et al., 2009; Borgatti, et al., 2018) have provided important tools to identify barriers for communication and to analyze emergent changes in the structure of informal interactions in organizations.

Several questions for further study may be raised focusing on resilience beyond safety concerns. Adaptations processes related to environmental perturbations such as market fluctuations, workforce demographics and even the ongoing Coronavirus pandemics generate questions about learning and changes in interactions in oil and gas companies. There is a need to understand how new knowledge emerges from crisis situations and how management practices may facilitate adaptive processes. In complex systems, this usually involves a logic of facilitation rather than control (Sandaker, 2009).

In the development of the conceptual framework, resilience was presented as a possible emergent property of complex systems. From an evolutionary perspective, resilience is related to system capacity to reorganizing after internal or external disturbances (Folke, 2006). Adaptation in organizational settings usually means emergence of learning and new patterns of behavior, and changes in structure of the web of social interactions. Bearing that in mind, it is possible to enquire if the evolutionary perspective informs the understanding of resilience in the selected literature of this scoping review. In response to this question, it is observed that although some articles (n = 6) (Bento and Garotti, 2019; Carlson, 2018; Grabowski and Roberts, 2016; Johnsen, 2012; Skjerve et al., 2012; Tveiten et al., 2012) make reference to adaptive processes, there is little in terms of articulating or investigating evolutionary processes related to resilience. The literature assumes in different forms a normative perspective towards resilience by focusing on indicators of resilience such as commitment, awareness and preparedness. The literature of the rationale of resilience engineering in the domain of safety performed by Bergström et al. (2015) presents the same finding observation. Furthermore, some articles do not conceptually differentiate system resilience from robustness. For instance, Azadeh et al. (2016) claim that resilience is related to human and equipment redundancy. However, although redundancy is often presented as a common recommendation for promoting system robustness, resilience implies in learning and adaptive changes. The implementation of integrated operations work forms in recent years have changed the structure of interactions by facilitating communication among professionals of different areas that would otherwise perform tasks spatially or sequentially separated from each other. There is a need for a better understanding of the implications of such business models to resilience not only in terms of preventing crisis situations but also providing spaces for open communication and the emergence of learning and adaptations. The lack of applications of Bayesian network models to study organizational resilience in the oil and gas industry is a gap that needs to be further explored. Further research can benefit from the analysis of probabilistic structural relation between variables. This would bring an important contribution in relation to both survey and qualitative approaches identified in the selected articles.

Finally, although there is little evidence that the concept of resilience informs practices in the oil and gas industry, it is fair to expect that different future scenarios will present challenges that will require a resilience perspective. For instance, social and economic fluctuations usually bring demographic changes in the industry bringing important implications such as the loss of experiential knowledge (Bento and Garotti, 2019). The post-covid-19 period will also demand learning and adaptations at different levels. At this point, there is the expectation that there will be less workers onboard offshore structures and this may affect the backlog level of maintenance. If this happens, it will be important to understand resilience and adaptation processes as responses to the reduction of the number of offshore personnel in the context of operations and safety. It will be important to analyze emerging practices from the perspective of resilience even if these are not originally embedded by the concept. However, the concept may also inform practices by mostly looking at the social interactional aspect of oil production. Other challenges may emerge as the industry both explores new (and inhospitable) geographical areas and expands its activities towards renewable energy sources. Organizational responses to such challenges will require adaptive capabilities in response to the new forms of internal and external complexity.

6. Conclusion

This scoping review produced an overview of organizational research on resilience in the oil and gas industry by focusing on conceptualizations, contexts and units of analysis. The analysis demonstrates that safety is a central topic in the study of resilience. However, there are other important organizational topics that can be addressed through the perspective of resilience such as learning and the emergence of new knowledge as a response to unexpected events which may not be exclusively related to safety. Furthermore, the literature highlights diverse topics to be further explored such as the relation between formal and informal interactions, and integrated operations in complex systems. The twenty selected papers shared an optimistic perspective towards resilience in the oil and gas industry. However, the scoping review of the literature reveals gaps that need to be addressed in order to improve the scientific and industrial relevance of the concept. In many ways, the concept is often presented as a normative concept and there is little development in investigating the dynamics of adaptive processes in the industry. Further organizational research in resilience in the oil and gas industry may bring an important contribution by providing a deeper understanding of: emergent patterns of interaction among agents at different levels and processes, and how these may facilitate learning and adaptation beyond system robustness. Organizational responses to the ongoing coronavirus pandemics provides an opportunity to explore such themes.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests that could have to influence the research presented in this paper.

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