Social-ecological Resilience in Extreme Natural Environments

A Multiple Case Study of Arctic Offshore Supply Ecosystems

Tsvetkova, Antonina; Gammelgaard, Britta

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Operational resilience in extreme natural environments: A multiple case study of Arctic offshore supply ecosystems

Abstract

Purpose – This study aims to explore how the operational resilience of supply chains and networks is achieved in extreme natural environments.

Design/methodology/approach – An in-depth, multiple qualitative case study of offshore supply operations involved in Arctic oil and gas field projects is conducted. Data from semistructured interviews, personal observations and archival materials are analysed through ecosystems theory supported by institutional approaches.

Findings – The findings suggest that supply chain resilience can be created through dynamic, adaptive and interconnected ecosystems where supply chain actors play an important role in responding to change. Furthermore, the study found that technologies support operational resilience by maintaining ecosystems as institutions under extreme environmental conditions.

Research limitations/implications – This study develops a comprehensive understanding of how operational resilience is built through ecosystems. The theory of business ecosystems is underpinned by institutional theory because of the special conditions in extreme natural environments. The study's empirical basis is offshore oil and gas projects in the Arctic. However, future growth of offshore projects, such as windmill farms and so-called energy islands, may also benefit from the study's results.

Originality/value – This research contributes knowledge about how operational resilience may be created through supply ecosystems and how the institutional logic and institutional work in supply ecosystems contribute to operational resilience under extreme environmental conditions, such as in the Arctic.

Keywords Offshore operations, Oil & gas industry, Arctic operations, Institutional theory, Case study

Paper type Research paper

Introduction

Some industries, such as offshore oil and gas, are particularly vulnerable to disruptions because disruptions and delays are immensely costly. In recent years, oil and gas companies have moved offshore operations further north and into remote Arctic areas. The Arctic seas bring forth numerous risks and challenges for managing oil and gas offshore operations. These include severe natural conditions (low temperatures, icing, polar lows, darkness), remoteness from ports and land infrastructure as well as the vulnerability of the Arctic natural environment itself (Milaković et al. 2015). These environments further make Arctic operations subject to national and international public interests and regulations. Under these conditions, the deployment of offshore projects entails high risk because of potential disruptions in transport and supply, as well as emergencies related to oil spills and accidents on platforms and vessels with many people on board. Therefore, these projects require constant attention to anticipate potential vulnerabilities.

Oil and gas operations are carried out by several actors in vertical supply chains and business ecosystems (Jacobides et al., 2018). The operational resilience of such chains and systems is necessary to recover operational capabilities after disruptions occur (Wieland & Durach, 2021). The systems, however, also need to be able to prevent disruptions (Petitt, 2010), as well as respond to unexpected events and disturbances (Pettit et al., 2019). Surprisingly, empirical studies on how resilience is established in supply chain operations are sparse and generally focus on fragmental aspects (Ponomarov & Holcomb, 2009). Further, very little is known about how to create operational resilience in extreme environments such as the Arctic.

Thus, the present study aims *to answer the question of how the operational resilience of supply chains and networks is obtained in extreme natural environments.* To answer this, we apply theories of business ecosystems combined with the help of institutional theory to address the operations of the systems (Sayed et al, 2017). Further, a multiple case study of offshore oil and gas operations in Arctic projects has been chosen as the empirical foundation. Arctic offshore oil and gas projects consist of complex communities of specific interactions and interdependencies among the involved actors. They represent distinct business ecosystems that have recognisable boundaries within which offshore operations take place. Resilience is a critical component of the ecosystems' nature in that it determines how actors can adapt to environmental disturbances (Pettit et al., 2019). Therefore, value is not created by individual entities, but through multiple ties of collaboration within the ecosystem (Möller & Rajala, 2007). Value-creating activities within offshore business ecosystems include cargo transportation, as well as extra support regarding safety at sea, environmental precautions, living up to security standards according to international rules and regulations, and emergency preparedness (Kristiansen, 2005).

Theory on business ecosystems (Aarikka-Stenroos & Ritala, 2017; Adler, 2017; Jacobides et al., 2018) is chosen as the overall theoretical framework to understand how operational resilience is established in supply chains and networks in extreme natural environments. However, the theoretical foundation of business ecosystems largely builds on theory from the field of corporate strategy. The corporations owning the oil and gas projects may very well act strategically and be competitors, but studying operations in extreme and remote environments makes addressing organisational actions and sense-making of actions necessary, too. In many situations, there will be no time to wait for an organisational hierarchy to make the required decisions. Therefore, theory on 'institutional work' and 'institutional logics' will underpin ecosystems theory to understand how the ecosystem seeks to obtain operational resilience. *Institutional work* is defined as 'the purposive action of individuals and organisations aimed at creating, maintaining or disrupting institutions' (Lawrence & Suddaby, 2006, p. 215) and allows for a deeper investigation of how organisations and institutions affect each other through operational practices. The concept of *institutional logics*, on the other hand, allows for focusing on values, beliefs, rules and assumptions as organising principles (Thornton & Ocasio, 1999) of ecosystems. Thus, the institutional logic approach is helpful to investigate ecosystems' rationalities towards creating resilience in offshore operations in Arctic waters. Importantly, the values of the different actors need not be the same, and the institutional logic often needs to be negotiated between the actors of the ecosystem. McPherson and Sauder (2013) suggest that actors are likely to negotiate the meaning of their behaviours through the enactment of elements of the dominant logic rather than negotiate across different logics. Therefore, in the offshore operations context, it seems fruitful to examine how actors employ available logics as tools to negotiate the meaning and practices of ecosystems in creating operational resilience. In this way, institutional logic becomes an organising principle of ecosystems (McLoughlin & Meehan, 2021).

The present article is organised as follows: The next section outlines the domain of resilience in supply chain management literature in more detail. Relevant discussions for business and supply ecosystems can be found in the literature. This is followed by a theoretical framework that combines business ecosystem theory with institutional approaches. The fourth section describes the research method. Then, four empirical cases are presented, with the findings analysed and discussed thereafter. The paper concludes with the theoretical and practical implications of the study and an outline of future research directions.

Operational Resilience in Supply Chain Management: The Literature

As a countermeasure and way to combat disruptions, organisations and supply chains must be resilient. Resilience is defined as 'the capacity for an enterprise to survive, adapt and grow in the face of turbulent change' (Fiksel, 2006, p. 16). Christopher and Peck (2004, p. 4) further define resilience as 'the ability of a system to return to its original state or to move to a new, more desirable state after being disrupted', thereby also emphasising that disruptions may lead to an improved state of a system. Also, Scholten et al. (2014) argue that being prepared for any type of disruption is what allows companies to respond quickly, thereby becoming less vulnerable to disruptions. Along these lines, Ponomarov and Holcomb define supply chain resilience as 'the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function' (2009, p. 131).

According to Pettit et al. (2013), almost all supply chains experience various types of disruptions. The reason for resilience being so important in the offshore supply chain is that supply chain resilience capacity and capability save costs, human lives and environmental disasters by foreseeing changes, planning resource allocation and producing a desired outcome during the offshore operation timeline (Hollnagel et al., 2006; Hollnagel, 2011). Furthermore, Wahl et al. (2020) see resilience as revolving around knowing what to expect, what to look for and what to do if disruptions were to occur. These capabilities make it possible to predict, plan and produce a desired outcome while simultaneously adjusting functionality before or following changes and disturbances. Wieland and Durach (2021) further point to the need for so-called transformational adaptations when political, economic or cultural crises arise outside of the supply chain but still affect its ability to function. They could have mentioned extreme natural environments as another situation in which a supply chain or ecosystem will need to adapt transformationally. Of interest to the present study, they further point to social-ecological systems where social actors influence ecological systems, such as the Arctic. They further distinguish between supply chain resilience as engineering resilience and socio-ecological resilience, where the first refers to an instrumental approach to resilience and the latter to an approach where the supply chain systems are intertwined with their contextual and natural environments.

Hollnagel et al. (2006), on the other hand, lean on more traditional systems theory in outlining resilience as the capability of an entire organisation to *monitor* and *anticipate threats* to normal operations and *respond* to them. This is further expanded by Hollnagel's (2011) study, in which a fourth capability of resilience is added: the *ability to learn*. First, monitoring operations and identifying potential threats before they occur is imperative. Second, the company must be able to anticipate developments further into the future and consider possible future events or conditions that may affect their ability to function. Anticipation is one of the most challenging tasks for the organisation because it requires an overview of all the risks to respond quickly to all kinds of possible emergencies and accidents during offshore operations. Third, a company must be able to respond to both regular and irregular variability, disturbance and opportunities. The response must be timely, effective and aware of how and when to react while having the resources to implement the response actions. Finally, the ability to learn from experience is essential. This requires an understanding of the management of operations and how to create resilience beyond quantitative data analysis (Hollnagel, 2011).

In the present paper, we first lean on Hollnagel's (2011) four basic aspects of resilience: monitoring, anticipating, responding and learning. Moreover, we add to this understanding McManus et al.'s (2008) proposal of resilience as a function of adaptive capacity in a complex, dynamic and interconnected environment. With this addition, we can understand the resilience of supply ecosystems, and through institutional work and logics, we can learn more about this adaptive capacity that results in operational resilience in extreme natural environments. Therefore, the outcome of our study is deeper insight into the actual processes of creating operational resilience in business ecosystems in extreme natural environments such as offshore operations in the Arctic. The study may be aligned with Azadegan and Dooley's (2021) meso-level type of supply network resilience. This type of supply network resilience acknowledges that many supply networks can be part of networks that create resilience against external and industry-wide disruptions. From a macro level, government agencies acknowledge that these networks can prevent disruptions and recover from them through their relationships. Meso-level networks, that is, ecosystems, can serve the purpose of preventing disasters in vulnerable, natural environments such as the Arctic.

Theoretical Framework

Business Ecosystems

Borrowed from the biological sciences, the concept of ecosystems refers to a group of interacting companies that depend on each other's activities (Jacobides et al., 2018). A key message from the literature on ecosystems is that the environment presents 'common adaptive challenges to organisms' (O'Neill et al., 1986, p. 21), where actors not only coordinate activities but also share these adaptive challenges with each other (Ketchen et al., 2014). Thus, the actors in such ecosystems have to adapt to contextual conditions that, in turn, can make them reconsider their core competencies, as well as the role of supply chain management practices (Tsvetkova & Gammelgaard, 2018).

Most studies on business and/or supply ecosystems have explained ecosystem functioning and outcomes through a corporate strategy perspective (Adner, 2017; Hannah and Eisenhardt, 2018; Jacobides et al., 2018; Mills et al. 2004; Ketchen et al., 2014), where value creation and value capture are essential concepts rather than at the operational level, where the role of these terms is less prominent. Compared with common supply chain thinking, organisations within the ecosystem are both independent and interdependent. They need to cooperate with one another to create value and compete for limited resources to capture value, thereby creating a situation of 'coopetition' (Hannah & Eisenhardt, 2018; Ketchen et al., 2014). Organisations may become 'trapped' within an ecosystem as suppliers become more dependent on their customers; if this is the case, that is, being intertwined with the ecosystem, exit is hardly possible (Ketchen et al., 2014; Krause & Ellram, 2014). At the same time, research also suggests that ecosystems—as opposed to integrated supply chains—are increasingly critical for competition (Adner, 2017).

Another feature of ecosystems is that each organisation pursues the dual goals of creating value for itself and other ecosystem members. As defined by Jacobides et al., 'ecosystems are groups of firms that must deal with either unique or super-modular complementarities that are nongeneric, requiring the creation of a specific structure of relationships and alignment to create value' (2018, p. 2263). From this perspective, ecosystems allow collaboration and coordination without requiring hierarchical governance because partners can make their own decisions while staying interdependent. Furthermore, each organisation's knowledge and skills must be leveraged across the entire ecosystem to create unique ecosystem-wide competencies that benefit all members (Ketchen et al., 2014). An essential contribution here has been made by Adner, who proposes that 'the ecosystem is defined by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize' (2017, p. 42). The alignment of partners, which can be defined as a mutual agreement among the partners regarding positions and activity flows, becomes the purpose to 'secure its role in a competitive ecosystem' environment (Adner, 2017, p. 47).

Aarikka-Stenroos and Ritala take a somewhat different perspective on business ecosystems in defining business ecosystems as 'a co-evolutionary business system of actors, technologies and institutions' (2017, p. 24). However, different actors may have different views on the value proposition because of a divergence of interests and divergence in expectations of value creation and value distribution to third parties (Adner, 2017). Furthermore, the interplay of cooperation and competition within the ecosystem may make it difficult to achieve a balance between value creation and value capture (Hannah & Eisenhardt, 2018). Important for the current study is that this definition includes shared technologies and institutions. Furthermore, Aarikka-Stenroos and Ritala (2017) mention regulators, policy makers and interest groups as potential actors of ecosystems. These actors are also included in our understanding of a business ecosystem as an institution in itself (McLoughlin & Meehan, 2021), although potentially being embedded in several (sub)institutions.

Institutional Work and Institutional Logics

The present study argues that a deeper understanding of the interactions between supply ecosystem actors is necessary as prerequisites for operational resilience in extreme natural environments, such as offshore projects with the uncertainties and complexities of Arctic ice-infested waters. Furthermore, shared technologies, such as supply vessels, play a role in maintaining the ecosystem.

Individual actors in oil and gas ecosystems belong to multiple social institutions seeking to realise the interests and values of their specific institutions (DiMaggio, 1988). They further work with shaping and executing the practices consisting of shared routines that allow them to frame essential issues leading to potential change of existing routines. This institutional work focuses on the somewhat invisible aspects of operational activities that reflect how actors affect existing, legitimate practices within a domain, such as an ecosystem. Lawrence et al. define institutional work as 'the practices of individuals and collective actors aimed at creating, maintaining and disrupting institutions' (2011, p. 52). Thus, the concept of institutional work highlights the intentional actions taken to create, maintain or disrupt institutions 'through actions, interactions and negotiations of multiple actors' (Jarzabkowski et al., 2009, p. 284). Actions can present not only visible, radical and dramatic, but also mundane, efforts, emotions and compromises that involve little more than day-to-day adjustments to the practice—and they may have unintended consequences. Actors who do the actual work of making and shaping operational practices intend to operate strategically, to cope with, create or modify the environment within which they live, work, operate and that provides them with their professional roles, relationships and resources (Lawrence et al., 2011). Interests and conflicts among actors may matter when reproducing or destroying existing institutions (DiMaggio, 1988). However, institutional work theory does not exclude the existence of institutional logics that provide templates for action and regulative mechanisms that enforce these templates. Action, in turn, affects those templates and regulative mechanisms (Phillips et al., 2004), though institutional work theory focuses on how actions and actors affect institutions at large.

The forms of institutional work aimed at maintaining institutions require cooperation; these include supporting and repairing social mechanisms, ensuring adherence and compliance to rule systems and reproducing existing norms and belief systems. This type of work focuses on the ability of actors to establish and maintain collaborative ties. It is necessary to make the rule system comprehensive by policing and enabling new norms and providing a sense common to all involved actors (Lawrence & Suddaby, 2006).

At the same time, the actors' ability to produce any type of institutional work can be restricted by institutional logics that provide guidelines for individuals' behaviour within the same organisational field, thereby creating 'the repertoire of collective actions' (Thornton et al., 2012). Thornton and Ocasio define institutional logics as 'the socially constructed, historical patterns of material practices, assumptions, values, beliefs and rules by which individuals produce and reproduce their material subsistence, organise time, and space, and provide meaning to their social reality' (1999, p. 804). Thus, institutions create expectations that define legitimate and appropriate actions for individuals and organisations, that is, what is acceptable behaviour (DiMaggio, 1991), forming the logics by which laws, rules and taken-for-granted behavioural expectations appear natural and permanent (Zucker, 1987).

Organisations must deal with different societal levels like markets, professions, corporations, communities and so on, which are associated with distinctive institutional logics (Scott, 2014); the same can be observed with ecosystems. Each logic defines a specific set of behavioural models for motivating social entities and organising institutional and business environments. The diversity of logics can be expressed in processes like lobbying business interests to legislative bodies to change legal framework; social pressures to increase normative beliefs and conscientious societal values in managerial ideologies, organisational behaviour and actions; or political pressures because of new political alignments to make companies adapt to a new environment. It can be argued that the interaction of different actors' practices and values creates the prerequisites for a new logic that can replace, compete with or complement other dominant logics.

The outcomes of an organisational activity result from the interplay between institutions' and actors' operational activities. Although actors strive for power, status and benefits, prevailing institutional logics simultaneously enable and constrain their actions, as well as 'the means and ends of their interests' (Thornton and Ocasio, 2008, p. 103). During this interplay between institutions and actions, logics at different societal levels may compete and be undermined or replaced by another dominant logic to promote conformity within the environment (Greenwood et al., 2011). This process encompasses institutional change and deinstitutionalisation when institutions weaken and disappear (Scott, 2014). Thornton and Ocasio (2008) have emphasised that it is not about whether actors' motivation and actions are rational or irrational, but instead, it is about how the relative confrontation and conformity of different institutional logics affect organisational behaviour.

Thus, the present study focuses on providing deeper insights into how operational resilience is made possible through different forms of institutional work and institutional logics in Arctic offshore business ecosystems. With reference to the discussion of operational resilience above, institutional works relate to monitoring, anticipating, responding to disruptions and learning from them. Institutional logics, on the other hand, refer to how the actors understand and implement operational resilience across their business ecosystems (McLoughlin & Meehan, 2021).

Methods

Research Design

An exploratory research design using qualitative data from four case studies was applied. The multiple case study research method was chosen as the most appropriate to elaborate on existing theory (Eisenhardt, 1989; Ketokivi & Choi, 2014; Voss et al., 2002) and 'to obtain a holistic view of a specific phenomenon' (Gummesson, 2000, p. 86) within unexplored real-life contextual settings and events (Yin, 1984). This research method was applied to capture the contextual settings and institutional aspects of different supply ecosystems in Arctic environments.

Four offshore ecosystems located in Arctic seas were selected according to the principle of maximum variation (Flyvbjerg, 2006). Two cases were Norwegian and two Russian, and each case operated under different environments and geography. The two key dimensions to be considered for case selection were experience in offshore supply operations and experience in interactions with institutional influence and contextual factors. The sample included two stages of offshore field project development—exploitation and exploration—to illustrate the challenges of providing supply chain resilience of offshore operations in different Arctic environments.

Data Collection

Qualitative data were collected from multiple sources, as recommended in the literature (Voss et al., 2002). Fourteen semistructured and in-depth face-to-face interviews and six telephone interviews were conducted with senior managers from several oil companies operating in the Arctic Seas, shipping companies, vessel designers, ice management consulting companies and international ice advisory boards (see Appendix 1). All respondents were selected for their experience and practical knowledge in operating offshore field projects, supply logistics, ice management and outsourcing decision-making processes.

The use of a semistructured interview approach enabled asking additional questions by providing clarifications of certain issues or helping keep the interview focused on the intended topics, especially when the respondents had difficulty expressing their opinions and views (see Appendix 2). All the interviews were tape-recorded with the respondents' consent and supplemented by hand-written notes, transcribed, validated with the respondents and consequently analysed. The interviews took place in Bergen, Oslo, Kristiansand, Tromsø (Norway) and Moscow (Russia) during two periods: May–October 2017 and August–September 2018. The interviews were conducted in English, Norwegian and Russian. The non-English interview responses were translated into English for a comprehensive analysis. When necessary, follow-up interviews with additional questions were conducted via email, telephone or in person. To comply with ethical issues, the respondents' and companies' names were omitted from the data analysis and reporting.

Other data were collected from secondary sources, such as companies' documentation, press releases and research reports, as well as legislative laws and regulatory policies on offshore operations in Arctic Seas. The documentary sources helped in preparation for the interviews and, later, in analysing the empirical data to complement the findings. Using several different types of data sources allowed us to increase the internal consistency of data and validity of research findings (Voss et al., 2002; Yin, 2018).

Data Analysis

The analysis included two phases. First, data were analysed *within the case* and presented as case narratives (Eisenhardt, 1989). Next, we compared the findings according to different dimensions of the ecosystems. These dimensions were as follows: key actors, operations, location, main challenges, role of the ecosystem and key technologies of the ecosystem. Next, we analysed the cases through the theoretical framework as a *cross-case* analysis. A theory-based cross-case analysis was conducted to move from the four individual cases to show and understand variability (Flyvbjerg, 2006).

Case Presentation: Four Ecosystems

Ecosystem A

Enhancing safety and resolving massive technical problems on the offshore platform were viewed as a fundamental part of ongoing oil production in the Barents Sea.

The offshore operations were served by two supply vessels—one for emergency response and the other a rescue vessel for stand-by duties—and three shuttle tankers. Supply chain operations were predictable, although a distance of 88 km from the supply base created risks. Both supply vessels were constantly on the move between the supply base and offshore platform, with a normal transit time of 4 hours, increasing under bad weather conditions.

There were several challenges to search and rescue (SAR) activities, as well as oil spill preparedness. These challenges were, among many, remoteness, limited infrastructure, long response times for resources from the Norwegian Sea and the North Sea, polar winter nights, and icing during winters. To address these challenges, the leading actor—an oil company—used facilities to detect and monitor immediate discharges from the platform like satellites, planes and helicopters equipped with synthetic aperture radars, side-looking airborne radars and infrared detectors. The platform was also equipped with infrared detectors and radars. As emphasised by a senior oil company manager, 'Our logistics department must monitor, anticipate and adequately respond to any possible emergencies and learn consequences. Anticipation is the most challenging area for logistical planning. The task is to allocate transportation resources like vessels and helicopters in an optimal way that makes it possible to foresee possible changes in case of an emergency. However, it is tough to overview all the risks and decrease the number of unplanned ad-hoc solutions. So the logistics system always must be on the alert for emergencies' (R3).

Furthermore, the supply vessels were equipped with additional systems of oil spill protection, infrared cameras and oil-detecting radars, and they had a spreading capacity. The emergency response and rescue vessel were equipped with oil spill protection. Additionally, infrared technology was developed to see the oil spill in the darkness of polar nights. Sensors in mini buoys monitored the direction of an oil slick.

However, these innovative practices in SAR and oil spill responses were not enough. Despite the remote location of offshore operations from the coast, hydrometeorological conditions like sea current and wind made the drifting time in case of any oil spill accident too short in reaching the coastline in a matter of hours. This caused a challenge for developing contingency plans and efficiently managing emergency response systems in this area. Conflicts over safety concerns were closely watched by the authorities, who made a temporary suspension of operations several times.

In doing so, the leading actor adopted a new role towards other actors in the Arctic Sea, namely fishermen, in terms of establishing a new contingency plan in which fishing vessels contributed to oil recovery operations. This experience—making these fishermen part of the ecosystem—became one of the most significant innovations in the emergency preparedness system in northern Norway. Fishermen maintained their fishing routines while creating particular value by enhancing preparedness for possible oil spills as an extra activity. This included regular courses, exercises and real action. Fishermen were obliged to maintain their vessels in prescribed conditions and to have the required equipment. The specific tasks of fishermen were to drag oil booms with their vessels to the emergency location, monitor oil slicks and block off coastal inlets. They also had to report their accessibility and location. As emphasised by a senior manager of the oil company, 'The partnership with fishermen was in our favour because fishermen possess current day-to-day knowledge about sea currents and the influence of weather, waves, wind and local geography. Another large advantage of incorporating local fishing boats is that they can be mobilised within a short time frame. Further, fishing boats can operate light and mid-weight boom systems' (R1).

Before this arrangement, there were confrontations between the petroleum industry and fisheries. The operational mechanism of oil spill response became a united front between oppositionists, oilmen and fishermen, and the conflict was less polarised. The existence of coopetition tensions was recognised and accepted by the competing actors involved. This affected the scope of knowledge sharing and interaction in ensuring the safety that took place between them. As told by a senior manager of the operator, 'The involvement of fishermen with relatively small vessels to be used in oil spill contingency operations demanded extending the existing regulatory framework. Then, we could formally contract fishermen. This form of cooperation became a new kind of value creation for fisheries and the regional economy in the north. Now, fishermen get a general financial reimbursement and specific compensation for days spent on training, courses or real action. It is worth noting that fishing vessels exercise at least twice a year. Therefore, it is promising cooperation with mutual benefits for both industries that allowed us to increase emergency response actions along the coastline. Fishermen have demonstrated their high interest in participating in preparedness systems: when we just announced this opportunity, owners of more than 140 fishing vessels registered in the coastal response' (R1).

In the first instance, 30 local fishing vessels started assisting with possible emissions reaching coastal areas. The vessels were adapted and equipped with newly developed oil collection equipment operated by a single fishing boat and at higher speeds than the traditional system of lenses drawn by two vessels. To increase value creation in interaction and coherence, the oil company conducted several SAR and oil spill response exercises near the offshore operations that verified the field contingency equipment and effectiveness and functionality of the contingency plans.

Ecosystem B

In Ecosystem B, the mechanism of enhancing safety focused on the pooling of resources between different field projects. The offshore operations contained oil exploration and were served by two supply vessels and one emergency response and rescue vessel for stand-by duties. The operational and supply processes were entirely predictable, although drilling operations had to be fulfilled for a brief time before favourable weather conditions changed. Long distances between the drilling site and supply base (570 km) and limited infrastructure were the main challenges for planning logistics operations and ensuring regular support. Because of these factors, both supply vessels were constantly moving between the drilling site and supply base. It required 24 hours of sailing in one way, and two supply vessels made two round trips per week. However, many delays were caused by inefficient base handling and reduced visibility (primarily because of frequent fog). As emphasised by a senior manager, 'It required too long preparations and many efforts to elaborate the logistics and emergency preparedness systems for such a remote location from the shore—about eight months before the drilling operations started. We conducted some research to organise an optimal utilisation of logistical resources. However, some nuances might occur only during the project implementation' (R4).

The expected potential dispersion of oil in the ocean was estimated at 120 km. Being on duty near the rig for 24 hours, the stand-by vessel was equipped with oil spill protection equipment in compliance with the standards. In case of any possible accident, the vessel would be capable of commencing damage-limiting operations immediately within 2 hours, here in the form of the deployment of marine booms and skimmer equipment. Furthermore, according to the officials' recommendations for such remote Arctic locations, the first supply vessel should be near the rig within 13 hours and second supply vessel within 30 hours.

The remoteness undermined the availability and efficiency of the emergency preparedness system in case of oil spills primarily because of the lack of resources, long time of resource reallocation and limited infrastructure. Thus, it required extra capacity. Company A elaborated on an innovative solution to hire a stand-by vessel from oil company B that served simultaneously for the offshore operations located at a distance of 293 nm within Ecosystem A. The response time for this stand-by vessel was defined as 26 hours to reach the drilling rig and commence damage-limiting operations. As emphasised by a senior logistician, 'This shared stand-by vessel took part in the organised emergency exercise, but it was assumed to support only in the case of any possible emergency' (R7).

The leading actor also had challenges with personal transportation to the rig by helicopters. The flight time was 1 hour and 42 min. The crew shift was in two weeks. As told by a senior manager, 'Due to long distances and requirements on emergency preparedness, the helicopter could take on board only seven passengers each flight because it needed capacity for extra fuel to reach the rig and then the supply base. The crew onboard the rig was about 120 persons, and we changed 60 persons per week. It was risky to use the helicopter for the crew shift for such long distances. Because of fog frequency, we had to anticipate cases in which it was impossible to use helicopters. Supply vessels became an optimal solution for transporting personnel on time and be able to reallocate maritime resources in an optimal way, not causing delays in the offshore operations' (R2). At the same time, SAR pickup capacities from the sea were limited because of high waves near the drilling site. It was an important issue for the safe rescue of lifeboats and man-overboard boats in these conditions.

Further, oil company A shared two helicopters—a SAR helicopter and transport helicopter—also involved in the other offshore field project within Ecosystem A. The shared transport helicopter could also be used as a SAR helicopter when needed. Both helicopters were equipped with the newly developed night vision technology, which significantly improved SAR capacity in the darkness. As emphasised by a senior logistician, 'Maintaining an effective emergency response capability is critical to any organisation contracting for helicopter operations in a hostile environment. The sharing utilisation of both helicopters enhanced the capacity and flexibility of SAR operations and long-term planning for the supplier. It was the first positive experience of sharing two helicopters and a stand-by vessel served for another offshore project in the case of any possible accidents and regular emergency exercises. We are going to share these helicopters again for developing the next offshore field next year' (R2).

The two oil companies collaborated on the joint goal of value creation goals to enhance safety capability. However, the resource pooling indicated that the leading actor—oil company A—cared more about economic preferences and actors involved rather than safety concerns for the environment. Meanwhile, Ecosystem B faced widespread protest from environmentalists when they entered a 500-metre safety area around the rig on kayaks and rubber boats. The rig's crew stayed on board, but the drilling operations were stopped for several days. Such a continuous opposition of views on energy resources between environmentalists and oilmen pushed the key actors to prepare a special agenda of natural resource safety. As told by a coastguard representative, 'Despite a number of drilling operations being carried out that year, this drilling site was of special interest because this Arctic area is new, more sensitive, and remote than other sites. Environmentalists' actions are very annoying for oil companies, but they attract public attention, thereby making companies strengthen emergency preparedness against oil spills' (R5).

Ecosystem C

Ecosystem C emerged when two field projects—offshore platform and onshore site—were united by a single supply and oil distribution system supported by vessels of different types. Supply operations, as well as oil export distribution from both field projects, were only possible by sea transport: the former was located on the shelf of the Pechora Sea at 980 kilometres from the supply base, and the latter, located on the Yamal Peninsula, was thousands of kilometres away from the traditional infrastructure.

Earlier, the leading actor—an oil company—hired third-party supply vessels and oil tankers. It also leased several third-party small supply bases located thousands of kilometres away from both projects. This challenged supply operations by causing numerous delays and increasing transaction costs; the dependence on third parties' actions created uncertainty and unpredictability. Meanwhile, the operational scale of both field projects grew steadily. For instance, in 2015, the total cargo volume for the offshore platform was about 100 thousand tonnes, including 30 thousand tonnes of drinking water and approximately 25 thousand tonnes of diesel fuel delivered from the supply base. About 12 thousand tonnes of cuttings were transported from the platform to the shore in 2015 because the platform operation principle envisaged zero discharges. As told by a senior manager, 'Logistics planning focuses primarily on volumes of cargo traffic to estimate the number of vessels needed. The development of one offshore well is estimated at 4.2 thousand tonnes of materials and equipment to be delivered from the supply base, meaning the equivalent of a large railway train loaded with pipes, chemicals, bulk and so on. Now, we exploit 22 wells of 32 planned by 2023' (R8). After the offshore platform experienced environmentalists' attack in September 2013, new amendments were made in the legislation to strengthen measures to prevent oil spills and protect Arctic biodiversity, thereby putting substantial pressure on the leading oil company (i.e., actor).

The challenges of supply operations and shipping oil from both fields were resolved by building their own special operational fleet and logistics infrastructure, including their own supply base. Their own supply vessels and oil tankers were multipurpose icebreaking vessels of high ice class designed to operate without icebreaker assistance in 1.8-metre thick fast and drifting ice under -35^{0}C. They were 'double-acting', meaning they could move both forwards and backwards in ice, with the result being that they had high manoeuvrability in icebound conditions. Further, supply vessels ensured technological and environmental operational safety and, where necessary, secured shuttle oil tankers during cargo handling. During an evacuation, each vessel could hold up to 150 people.

However, long distances, fast and drifting ice for more than 230 days per year and ice rubble formation at the offshore platform made it complicated to ensure regular support. It took a minimum of 4–6 days roundtrip time for supply vessels between the offshore platform and the supply base and up to 10 days between the onshore site and supply base to be constantly on the move. Although access to the onshore field completely froze for several metres and required icebreakers' duty, a wide ice-free zone for the vessels was formed behind the offshore platform along the water current. All of these factors made operational management insufficient.

Then, a digital Supply Chain Management system—code-named 'Captain'—was developed to ensure year-round uninterrupted supply and oil shipments. It analyses about 15,000 input parameters, including telemetry from support vessels and tanker fleets, cargo tanks of a floating oil storage facility and terminals, weather conditions, actual and forecast ice conditions and vessel traffic. Every 15 minutes, the system recalculates the schedule of tankers and oil shipments from the terminals, choosing the optimal solution from more than 66.5 million options. As emphasised by a senior manager, 'The core objective of the new system is to manage logistics in the Arctic safely and to ensure that growing volumes of oil produced are dispatched at the lowest possible cost. Now, our Arctic fleet logistics, including 12 oil tankers, three supply vessels, four high-tech icebreakers and two stand-by vessels, can, where necessary, be adjusted with immediate effect. As a result, it considerably improved efficiency in logistics management, reducing costs by 12%' (R8). The new approach to managing supply and oil shipment operations allowed for modernising and expanding key mainline infrastructure to increase freight traffic on the Northern Sea Route.

The maximum size of possible oil spills from the offshore platform was officially calculated to be 1,500 tonnes of oil for wells and 10,000 tonnes for oil tankers. The impacted area could reach 140,000 square kilometres and more than 3,000 kilometres of shoreline. The tanker loading line is equipped with an emergency termination and shutdown system that can, if necessary, stop shipment operations almost instantaneously. As emphasised by a senior manager, '7 seconds is the maximum time taken to stop oil loading onto tankers in any emergency. Round-the-clock monitoring of the offshore and onshore activities is facilitated through specialist sensors, instantly transmitting any changes in its operation' (R9).

Two vessels equipped with additional equipment for oil spill recovery in ice conditions constantly served stand-by and rescue duty near the field sites. They fulfilled emergency preparedness and ice management, including icebreaking, ice monitoring and providing data about ice conditions and ice floe movements. This allowed foreseeing possible changes in the utilisation of the vessels and other logistics resources that were likely to occur. Furthermore, all the offshore service vessels were interchangeable in executing supply functions and/or stand-by duties. As emphasised by a senior manager, 'Cooperation between oil operations managers and logistics managers tasks operational risk assessments and monitoring the operations to ensure real-time data and anticipate issues that can cause accidents or delays in offshore operations. It would be a big challenge to perform evacuation operations or eliminate oil spills in such harsh Arctic conditions. Knowledge of where vessels are enables us to respond quickly in any emergency and be prepared for possible changes in resource allocation, for example, the vessel schedule and route because of the weather and ice conditions or in any emergency' (R8).

Helicopters based at the nearest settlement were intended to participate in search-and-rescue operations and assist in firefighting. However, a senior manager said, 'We faced many issues with the use of helicopters, for example, because of the abundance of fogs. Sometimes, we had to use the supply vessels for personnel transportation. These issues with helicopters increased operational risks and negatively influenced the cargo capacity of our supply vessels […], and our experience of operating in Arctic waters showed that the supply vessels were the only resources that could ensure a remarkable capacity for ensuring emergency preparedness far away from the onshore facilities in Arctic waters. Furthermore, helicopters fly at an altitude of over 500 m so as not to disturb animals and birds, which means time-costing during possible emergencies' (R11).

Enhancing the consolidation of logistics infrastructure and ensuring reliability with multipurpose icebreaking supply vessels and oil tankers was considered a primary economic task for field project development. This made oil production operations meet the most stringent safety requirements, making them capable of withstanding maximum ice loads. Ecosystem C's full-service continuity and safe operation became possible by introducing innovative and green technologies to managing supply and oil shipment operations.

Ecosystem D

The uniqueness of operations within Ecosystem D was given by the involvement of numerous partners and suppliers from various areas of activity where Arctic water areas have been trapped in ice for most of the year. Overall, a senior manager of an oil company described these exploratory operations as 'the biggest campaign in the Arctic ever where the most important was the selection of competent suppliers and partners'. A project manager of a shipping partner stated, 'Despite the high competence of each contract partner, everyone understood that the level of experience was insufficient because there have never been projects in such harsh ice conditions and so long water drilling depth. So, the responsibility was enormous to find a proper way to coordinate partners' different activities. That was a big part of SCM practice'. Therefore, establishing an ice-defence system had a high priority.

One of the main challenges for offshore activities in the Kara Sea was the unpredictability of ice mass drifting and icebergs, especially in polar night conditions. As emphasised by a senior manager of the operator, ‘We prefer to work with ice, but not to fight ice!’ (R15). Therefore, ice management, including breaking ice formations and altering possible iceberg courses, was a primary function of supply chain practice. This was carried out by separate vessels so as not to distract supply vessels from their primary functions. In addition, five drones and iceberg tracking were used to eliminate any risks in the drilling area.

Lowering risk was thoroughly introduced in all planning stages and operational execution. Because the rig had no ice-strengthening capabilities, ice-free water along the towing route and around the drilling site was a priority requirement. The convoy of four service vessels and one icebreaker involved in the rig towing and ice-defence operation was not allowed to enter the inlet strait of the Kara Sea before ice-free water in a radius of 40 nm from the drilling site, and no potential hazardous ice 10 nm on each side of the planned towing route was documented by air and satellite reconnaissance. These criteria show massive effort made in terms of metocean services and ice reconnaissance. Several service providers with extra ice expertise in ice-infested waters were hired for ice consultancy, metocean data processing, and ice handling.

The fleet supporting the drilling rig consisted of 15 high ice-class vessels of different types, including anchor handling, supply vessels and two icebreakers. All vessels were equipped with spill response and ice management capabilities. Although it took almost two years to obtain mandatory government approvals and prepare for offshore activities, planning and elaborating logistics operations required the greatest effort. For instance, one of the two icebreakers involved in Ecosystem D was escorted to the drilling site by another even larger atomic icebreaker, which simultaneously led the vessel convoy along the Northern Sea Route. This transition took almost a month. In total, this icebreaker’s journey lasted 134 days, and it sailed 24,066 nm during drilling activities.

The onshore decision-making centre provided operational process management of all offshore activities to make supply chain resource allocation mostly efficient and safe. As emphasised by a senior manager of the ice management company, 'Actually, such a vast distance and enormous complexity in anticipating ice conditions were decisive factors in involving so many vessels of different types. This operation centre functioned as a brainstorming area where ice advisers, ice analysts, meteorologists and key specialists from oil and shipping companies came together and processed data about satellite imagery, aerial ice reconnaissance and weather forecasts. Through a single communication system, everyone—staff on the rig, oil companies' managers, crews on board, suppliers, vessel operators, staff from the shore and infield operation centres—had online ready access to up-to-date information about weather and ice conditions, time data, vessel positioning, cargo documentation and so forth in real time. That helped ensure risk-sharing, enhance control and competence-sharing, as well as make operations safe and effective' (R4).

Helicopters would assist in ice reconnaissance and personnel transfer, but they were excluded because of the unavailability of civil airports within range and military regulations. Lacking regional port facilities forced supply services and crew changes to operate out of a new offshore base located at ca. 850 nm or 1,600 km from the drill site, which was the closest alternative. This resulted in a minimum of eight days' roundtrip for service vessels and crew change.

The operation area had special regulatory status, including strict navigation rules within the waters of the Northern Sea Route and some restrictions because of the proximity of a military zone. As one manager noted, 'Some of our service vessels experienced a quite annoying situation when they had to change course at the request of the naval ships between the drilling site and the supply base. Even the nearby islands were banned from being used as a refuge for vessels in extreme winds, which, in our opinion, could be contrary to international maritime law. These were limiting factors for logistics preparation and emergency preparedness planning' (R12).

Another limiting factor became a political issue when the companies were forced out of the Russian Arctic after the U.S. and EU sanctions against the Russian role in the Ukraine conflict.

The environmental NGO intended to protest offshore activities. Thus, special forces and negotiators were hired to avoid dangerous actions. Different coastguard vessels from Norway and Russia followed the rig towing along the entire route to Kara Gate. The NGO's boat stayed for about three days trying to enter the Kara Sea and then left after the Russian coastguard boarded and threatened to use force. Except for a minor incident, while the rig was located in the yard, no confrontation was experienced.

Besides discovering substantial oil reserves, ensuring safety and emergency preparedness was supported by intensive scientific studies and expeditions. This created a positive public image for the technological initiative around the activities and resources involved.

Summary of the Case Narratives

Table 1 summarises the features of the four ecosystems. It also highlights how supply vessels participate in maintaining four offshore ecosystems, thereby contributing to the operational resilience of the supply ecosystems.

Table 1. *Summary of the Four Cases*

About here###

Analysis and Discussion

The four ecosystems illustrate four different solutions for creating resilience of their oil and gas operations in the extreme natural environments of the Arctic (Table 2, column 5). In all cases, the lead organisations—the oil companies—used the ecosystem to create operational resilience. Ecosystem A worked deliberately to include the formerly hostile fishermen in the ecosystem to help monitor potential oil spills and further train SAR activities in response to potential disruptions. Government agencies supported this development, meaning that the institutional work in this system created an ecosystem. Ecosystem B demonstrates maintaining institutional work by sharing assets that leave resources for enhancing safety capabilities. Ecosystem C went in the opposite direction as Ecosystem A and disrupted their ecosystem by eliminating some third-party suppliers to integrate Arctic transport with increased safety as a result. They substituted for fewer suppliers with investments in new technologies, primarily their own fleet. Investments in advanced information and communication systems further increased the safety of transport close to its fields in general. Finally, Ecosystem D's institutional work focused on knowledge development, sharing and consolidation between the many ecosystem actors. The four different types of institutional work have been labelled 'united front', 'sharing assets', 'transport independence' and 'knowledge consolidation' (see Table 2, column 3).

Even though not all the cases demonstrated safety as the overall institutional logic as the organising principle, all ecosystems had both safety and protection of nature as part of their logic. In all four cases, the findings point to *institutional work* as an essential driver for change towards new institutional logics. The four different *institutional logics* constitute the prevailing patterns of behaviour and templates of actions by different actors within the ecosystems (see Table 2, column 4). Although actors strive for power, status and benefits, institutional logics simultaneously enable and constrain their actions, as well as 'the means and ends of their interests' (Thornton and Ocasio, 2008, p. 103). These logics were labelled 'safety', 'cost efficiency', 'consolidation of resources', and 'integration of interdependence'. Importantly, shared technology in the form of supply vessels contributed to primarily maintaining the ecosystems by physically connecting the ecosystem actors onshore and offshore. They further assist in monitoring offshore operations and weather conditions, enabling flexibility of the transport processes, monitoring the current situation and responding to possible emergencies, providing real-time data and anticipating challenges that may cause accidents and disruptions in offshore operations, ensuring **response** operations to any emergencies and supporting training exercises to improve preparation for different scenarios and some others. All these activities make an essential foundation for the **anticipation** of disruptions that might occur, however challenging they may be. These activities further enable building resilience in the development of offshore field projects in the Arctic seas, primarily through ensuring emergency preparedness and emergency handling (Hollnagel et al., 2006; Hollnagel, 2011).

The findings show that the four ecosystems seek operational resilience through four different pathways of institutional work and institutional logic. The cases show 'ecosystem extensions', 'pooling of resources', 'multipurpose technology' and 'context management' as resilience solutions (Table 2, column 5). In all four cases, the ecosystems had played a vital role and change had been set in motion through nonbusiness actors. The cases further show that ecosystems in extreme, natural environments are intertwined with their contextual environments (Wieland & Durach, 2021). This is also consistent with the findings of Borch and Kjerstad (2018) and Milaković et al. (2015).

Table 2 summarises the case analysis of the four ecosystems. Column 1 lists the ecosystems informing them about their primary value proposition. Column 2 lists key actors in ecosystems and their different goals, creating tensions in the ecosystem and, thereafter, changes in institutional work and logics. The purpose of these ecosystems was, in all cases, resilience, whether economic and/or environmental.

Table 2. *Resilience Solutions as a Result of Interactions between Institutional Logics and Institutional Works within Ecosystems*

###About here###

Conclusions and Implications for Theory and Practice

The present study has provided insights into how resilience was created in four oil and gas supply networks in four different environmental settings in the Arctic seas. The four cases showed different ways of creating resilience in their operations, but all of them used their supply ecosystems where different institutional logics and work emerged and created the basis for four different resilience solutions. Based on the present study, we propose that resilience solutions—*extending the ecosystem*, *pooling of resources*, *multipurpose technology* and *context management*—are viable strategies for establishing operational resilience of supply networks and that an ecosystems approach is useful and maybe even necessary when operating in extreme natural environments. It is important to note that not only private enterprise actors created the resilience solutions, but also pressures from governments and environmentalists played a role along with nature itself through extreme sea and weather conditions, as well as long distances between on- and offshore installations and that choosing any of the resilience solutions may depend on the characteristics of the ecosystem. Finally, shared technologies are important in maintaining ecosystems.

By underpinning the theory of business ecosystems with institutional work and logics, the current study contributes to ecosystems theory by including operational aspects, particularly through the theory of institutional work. In extreme natural environments, institutional factors are more important than competition in creating, maintaining and potentially disrupting ecosystems. Collaboration between the actors, as well as sharing institutional logics in supply ecosystems, is crucial for developing a common understanding of current risk and, subsequently, for creating resilience. However, these norms may be challenged by actors and change over time to adapt to disturbances and continue operations at the desired level of connectedness and control over structure and function (Ponomarov & Holcomb, 2009).

The present study contributes further to supply chain resilience theory that resilience within supply ecosystems is not static but rather is adaptive and transformative through the different goals and conflicts by actors whereby new institutional work practices develop. These may lead to change in the institutional logics—and, hence, new resilience solutions—of the ecosystem but also in macro institutions such as governments. Furthermore, our findings indicate that ecosystems themselves can act as mechanisms for building resilience within them and for adaptation and restoration of the environment (e.g., in the case of oil spills) through risk-sharing, cost-sharing and competence-sharing among the involved actors (Azadegan & Dooley, 2021).

Implications for practice are that there are more ways to create resilience in supply chains and networks in extreme natural environments and that the business ecosystem is an important resource for operational resilience, including safety for humans, equipment and nature.

Finally, future research should expand the geographical scope of the Arctic seas as extreme natural environments and include studies of other types of economic activities in extreme environments, showing the role of ecosystems in creating resilience. In particular, more empirical studies on how supply chain operations interact with contextual and institutional factors are suggested.

References

Adner, R. (2017). Ecosystem as structure: An actionable construct for strategy. *Journal of Management, 43*(1), 39–58.

Azadegan, A. & Dooley, K. (2021). A typology of supply network resilience strategies: Complex collaborations in a complex world, *Journal of Supply Chain Management*, *57*(1), 17–26.

Borch, O. J., & Kjerstad, N. (2018). The offshore oil and gas operations in ice infested water: resource configuration and operational process management. In L. P. Hildebrand & L. W. Brigham (Eds.), *Sustainable shipping in a changing Arctic* (pp. 401–425). Springer.

Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management, 1*(5), 1–13.

DiMaggio, P. J. (1988). Interest and agency in institutional theory. In L. Zucker (Ed.), *Institutional patterns and organizations: Culture and environment* (pp. 3–22). Bellinger Publishing Co.

DiMaggio, P. J. (1991). Constructing an organizational field as a professional project: U.S. art museums, 1920–1940. In W. W. Powell & P. J. DiMaggio (Eds.), *The new institutionalism in organizational analysis* (pp. 267–292). University of Chicago Press.

Eisenhardt, K. M. (1989). Building theory from case study research. *Academy of Management Review, 14*(4), 532–550.

Fiksel, J. (2006). Sustainability and resilience: Towards a systems approach. *Sustainability: Science, Practice and Policy, 2*, 14–21.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry, 1*(2), 219–245.

Greenwood, R., Raynard, M., Kodeih, F., Micelotta, E. R., & Lounsbury, M. (2011). Institutional complexity and organizational responses. *The Academy of Management Annals, 5*(1), 317–371.

Gummesson, E. (2000). *Qualitative methods in management research* (2nd ed.). Sage Publications.

Hannah, D. P., & Eisenhardt, K. M. (2018). How firms navigate cooperation and competition in nascent ecosystems. *Strategic Management Journal, 39*(3), 3163–3192.

Hollnagel, E. (2011). Epilogue: RAG – The resilience analysis grid. In E. Hollnagel, J. Pariès, D. Woods, & J. Wreathall (Eds.), *Resilience engineering in practice – A guidebook* (pp. 275-296). Ashgate Publishing Limited.

Hollnagel, E., Woods, D., & Leveson, N. (2006). *Resilience engineering. Concepts and precepts.* Ashgate Publishing Limited.

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal, 39*(8), 2255–2276.

Jarzabkowski, P., Matthiesen, J., & Van de Ven, A. H. (2009). Doing which work? A practice approach to institutional pluralism. In T. B. Lawrence, R. Suddaby, & B. Bernard Leca (Eds.), *Institutional work actors and agency in institutional studies of organizations* (pp. 284–316). Cambridge University Press. https://doi.org/10.1017/CBO9780511596605.011

Ketchen, D. J., Crook, T. R., & Craighead, C. W. (2014). From supply chains to supply ecosystems: Implications for strategic sourcing research and practice. *Journal of Business Logistics, 25*(3), 165–171.

Ketokivi, M., & Choi, Th. (2014). Renaissance of case research as a scientific method. *Journal of Operations Management, 32*(5), 232–240.

Krause, D., & Ellram, L. M. (2014). The effects of the economic downturn on interdependent buyer–supplier relationships. *Journal of Business Logistics, 35*(3), 191–212.

Lawrence, T. B., & Suddaby, R. (2006). Institutions and institutional work. In S. R. Clegg, C. Hardy, T. B. Lawrence, & W. R. Nord (Eds.), *Handbook of organization studies* (2nd ed., 215–254). Sage.

Lawrence, T. B., Suddaby, R., & Leca, B. (2011). Institutional work: Refocusing institutional studies of organization. *Journal of Management Inquiry*, *20*(1), 52–58.

McLoughlin, K., & Meehan, J. (2021). The institutional logic of the sustainable organization: the case of a chocolate company. *International Journal of Operations & Production Management*, *41*(3). 251–274.

McManus, S., Seville, E., Vargo, J., & Brunsdon, D. (2008). Facilitated process for improving organizational resilience. *Natural Hazards Review, 9*(2), 81–90.

McPherson, C. M., & Sauder, M. (2013). Logics in action: Managing institutional complexity in a drug court. *Administrative Science Quarterly, 58*(2), 165–196.

Milaković, A.-S., Ehlers, S., Westvik, M. H., & Schütz, P. (2014). Offshore upstream logistics for operations in Arctic environment. In S. Ehlers, B. E. Asbjornslett, O. J. Rodseth, & T. E. Berg (Eds.), *Maritime-port technology and development* (pp. 163–170). CRC Press.

Mills, J., Schmitz, J., & Frizelle, G. (2004). A strategic review of supply networks. *International Journal of Operations & Production Management, 24*(10), 1012–1036.

Möller, K., & Rajala, R. (2007). Rise of strategic nets – New modes of value creation. *Industrial Marketing Management, 36*(7), 895–908.

O'Neill, R. V., DeAngelis, D. L., Waide, J. B., & Allen, T. F. H. (1986). *A hierarchical concept of ecosystems*. Princeton University Press.

Pettit, T., Croxton, K., & Fiksel, J. (2013). Ensuring supply chain resilience: development and implementation of an assessment tool. *Journal of Business Logistics, 34*(1), 46–76.

Pettit, T., Croxton, K., & Fiksel, J. (2019). The evolution of resilience in supply chain management: a retrospective on ensuring supply chain resilience, *Journal of Business Logistics, 40*(1), 56–65.

Phillips, N., Lawrence, T. B., & Hardy, C. (2004). Discourse and institutions. *Academy of Management Review, 29*(4), 635–652.

Ponomarov, S., & Holcomb, M. (2009). Understanding the concept of supply chain resilience. *The International Journal of Logistics Management, 2*(0), 124–143.

Sayed, M., Hendry, L. C., & Bell, M. Z. (2017). Institutional complexity and sustainable supply chain management practices. *Supply Chain Management: International Journal, 22*(6) 542–563.

Scholten, K., Scott, P. S., & Fynes, B. (2014). Mitigation processes – Antecedents for building supply chain resilience. *Supply Chain Management: An International Journal, 1*(9), 211–228.

Scott, W. R. (2014). *Institutions and organizations: Ideas, interests and identities* (4th ed.). Stanford University.

Thornton, P., & Ocasio, W. (1999). Institutional logics and the historical contingency of power in organizations: executive succession in the higher education publishing industry, 1958–1990. *American Journal of Sociology, 105*(3), 801–843.

Thornton, P., & Ocasio, W. (2008). Institutional logics. In R. Greenwood, C. Oliver, K. Sahlin, & R. Suddaby (Eds.), *The Sage handbook of organizational institutionalism* (pp. 99–129). Sage.

Thornton, P., Ocasio, W., & Lounsbury, M. (2012). *The institutional logics perspective: A new approach to culture, structure, and process.* Oxford University Press.

Tsvetkova, A., & Gammelgaard, B. (2018). The idea of transport independence in the Russian Arctic: A Scandinavian institutional approach towards supply chain strategy. *International Journal of Physical Distribution & Logistics Management, 48*(9), 913–930.

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management, 22*(2), 195–219.

Wahl, A., Sleire, H., Brurok, T., & Asbjørnslett, B. (2020). Agility and resilience in offshore operations. In *Proceedings of the Third Resilience Engineering Symposium* (pp. 283–290).

Wieland, A., & Durach, C. F. (2021). Two perspectives on supply chain resilience. *Journal of Business Logistics, 42*(3), 315–322.

Yin, R. K. (2018). *Case study research. Design and methods*. Sage.

Zucker, L. (1987). Institutional theories of organizations. *Annual Review of Sociology, 1*(3), 443–464.

Table 1. *Summary of the Four Cases*

	Ecosystem A	Ecosystem B	Ecosystem C	Ecosystem D
Leader	Oil company	Oil company A	Oil company	Oil company A (Russia)
Other key actors	Fishermen, authorities	Oil company B, authorities, environmentalists	Third-party suppliers, authorities, environmentalists; nature reserve areas	Oil company B (USA), third-party suppliers, policies, militaries, scientists, environmentalists
Operations	Offshore oil production	Offshore exploration	Offshore and onshore oil production projects	Offshore exploration
Location	Barents Sea – Southwest (Norway)	Barents Sea – Northwest (Norway)	Pechora Sea (Russia)	Kara Sea (Russia)
Main challenges	Remoteness; polar nights; Short drifting time to the coast; Long response time	Remoteness, polar nights; high waves; Lack of infrastructure; Limited use of helicopters	Remoteness, polar nights, ice rubble formation; high ice drifting, high waves; Close to national flora and fauna reserves	Remoteness; polar nights; ice and icebergs; close to military bases; Prohibition on use of helicopters
Role of the ecosystem	Enhancing safety capabilities through collaboration Monitoring the natural environment Training of contingencies	Saving resources and money	Adopting green technologies provided by lead actor to the benefit of actors and the environment of the Pechora Sea close to the fields	Risk-sharing and competence-sharing
Main technologies of ecosystems: Supply vessels and information systems	Low ice class; Narrow specificity with a focus on concrete functions: towing, anchor handling	Low ice class; Narrow specificity with a focus on concrete functions: towing, anchor handling	High ice class; Multifunctional and interchangeable; Explicitly designed to operate in extremely harsh ice conditions; High maneuverability; Increased capacity Existing ecosystem actors were replaced by a digital system to manage own logistics infrastructure	Low and high ice class; Narrow specificity with a focus on concrete functions: towing, anchor handling, personnel transport, ice monitoring, oil spill recovery, icebreakers
Shared technology: Supply vessels	Cargo delivery; Facilitation in coordinating the transport process; Providing real-time data and being on the alert for emergencies; Flexibility in reallocating transport facilities optimally if accidents occur			

Table 2. *Resilience Solutions as a Result of Interactions between Institutional Logics and Institutional Works within Ecosystems*

Ecosystems; main value proposition	Key actors and primary aims	Institutional Work: Creating, maintaining, or disruption of ecosystem	Institutional Logic: Organising principle	Resilience solutions
Ecosystem A–oil exploitation	**Oil company:** • Oil production; • Profits **Fishermen:** • Fishing; • Protecting fish stocks **Governmental restriction:** • Regulation of offshore operations (numerous suspensions)	**'United front':** • Extending the ecosystem with fishermen; • Operating fishing vessels; • Creating the united front of oppositionists – oilmen and fishermen – against oil spills • Data sharing between oilmen and fishermen	**Safety:** Creating a unified logic of safety – 'if necessary, we will certainly help'; • Constant monitoring and anticipation of oil spills; • Amending the regulatory framework to contract fishermen	***Extending the ecosystem***
Ecosystem B–oil exploration	**Oil company A:** • Oil production; • No disruptions; • Profits **Oil company B:** • Oil production; • Profits **Environmentalists:** • Arctic protection • Protesting: 'This is people vs. Arctic oil'	**Sharing assets:** • Sharing the same stand-by vessel and SAR helicopter for two offshore field projects; • Consolidating transport resources and costs; • Pushing the agenda of natural resources safety	**Cost efficiency:** • Enhancing safety capability through resource pooling; • Receiving facilities; • Achieving economy of integration by exploiting interdependencies between the activities	***Pooling of resources***
Ecosystem C–oil exploitation	**Oil company:** • Oil production; • Profits; • High reputation **Third-party suppliers:** • Staying a part of the offshore system; • Looking for interdependence **Environmentalists:** • Protecting Arctic • Protesting offshore oil activities; **Government:** • Protecting nature reserve areas	**'Transport independence':** • Building own fleet of offshore vessels and oil tankers able to operate without icebreakers in 1.8-metre thick drifting ice; • Building a supply chain system on completely digital technologies; • Ice management; • New logistics solutions to prevent oil spills and protect Arctic biodiversity	**Consolidation of resources:** • Better control on the operational activity; • Single real-time system for monitoring and anticipating emergencies; • Flexibility in sourcing and operation fulfilment; • Increasing safety; • Less complexity and interdependence; • Amending the Russian legislation	***Multipurpose technology***
Ecosystem D–oil exploration	**Oil company A (Russia):** • Oil production; High profits; High reputation **Oil company B (USA):** • Oil production; High profits; High reputation **Third-party suppliers:** • Staying a part of the offshore system; • Providing 'tangible' assets like supply vessels **Governmental restriction:**	**Knowledge consolidation:** • Logistics solutions based on intensive scientific support; • Using multipurpose vessels; • Managing icebergs; • Applying drones • Minimising medical risks – health certificates and dedicated hospital function by stand-by vessels	**Integration of interdependencies:** • Consolidating competencies and transport resources; • Increasing flexibility of the system; • Integrated system of capabilities for monitoring and anticipating emergencies and weather conditions	***Context management***

	• Helicopters prohibited • Militaries • International sanctions **Scientists:** • Ice management **Environmentalists:** • Nature protection			
Ecosystems: main value proposition	**Key actors and primary aims**	**Institutional Work: Creating, maintaining, or disruption of ecosystem**	**Institutional Logic: Organising principle**	**Resilience solutions**
Eco system A–oil exploitation	**Oil company:** • Oil production; • Profits **Fishermen:** • Fishing; • Protecting fish stocks **Governmental restriction:** • Regulation of offshore operations (numerous suspensions)	**'United front':** • Extending the ecosystem with fishermen; • Operating fishing vessels; • Creating the united front of oppositionists – oilmen and fishermen – against oil spills • Data sharing between oilmen and fishermen	**Safety:** Creating a unified logic of safety – 'if necessary, we will certainly help'; • Constant monitoring and anticipation of oil spills; • Amending the regulatory framework to contract fishermen	***Extending the ecosystem***
Ecosystem B–oil exploration	**Oil company A:** • Oil production; • No disruptions; • Profits **Oil company B:** • Oil production; • Profits **Environmentalists:** • Arctic protection • Protesting: 'This is people vs. Arctic oil'	**Sharing assets:** • Sharing the same stand-by vessel and SAR helicopter for two offshore field projects; • Consolidating transport resources and costs; • Pushing the agenda of natural resources safety	**Cost efficiency:** • Enhancing safety capability through resource pooling; • Receiving facilities; • Achieving economy of integration by exploiting interdependencies between the activities	***Pooling of resources***
Ecosystem C–oil exploitation	**Oil company:** • Oil production; • Profits; • High reputation **Third-party suppliers:** • Staying a part of the offshore system; • Looking for interdependence **Environmentalists:** • Protecting Arctic • Protesting offshore oil activities; **Government:** • Protecting nature reserve areas	**'Transport independence':** • Building own fleet of offshore vessels and oil tankers able to operate without icebreakers in 1.8-metre thick drifting ice; • Building a supply chain system on completely digital technologies; • Ice management; • New logistics solutions to prevent oil spills and protect Arctic biodiversity	**Consolidation of resources:** • Better control on the operational activity; • Single real-time system for monitoring and anticipating emergencies; • Flexibility in sourcing and operation fulfilment; • Increasing safety; • Less complexity and interdependence; • Amending the Russian legislation	***Multipurpose technology***
Ecosystem D–oil exploration	**Oil company A (Russia):** • Oil production; High profits; High reputation **Oil company B (USA):** • Oil production; High profits; High reputation **Third-party suppliers:** • Staying a part of the offshore system; • Providing 'tangible' assets like supply vessels	**Knowledge consolidation:** • Logistics solutions based on intensive scientific support; • Using multipurpose vessels; • Managing icebergs; • Applying drones • Minimising medical risks – health certificates and dedicated hospital function by stand-by vessels	**Integration of interdependencies:** • Consolidating competencies and transport resources; • Increasing flexibility of the system; • Integrated system of capabilities for monitoring and anticipating emergencies and weather conditions	***Context management***

	Governmental restriction: • Helicopters prohibited • Militaries • International sanctions			
	Scientists: • Ice management			
	Environmentalists: • Nature protection			

Appendix 1. List of respondents participating in interviews

Respondent number	Position	Company	Case	Date	Duration	Type
R 1	Senior Adviser in Logistics and Emergency Preparedness	Norwegian oil company #1	Ecosystem A	29.09.2017 12.09.2018	3 h 1 h 30 min	Face to face
R 2	Managing Director (CEO)	Norwegian oil company #2	Ecosystems B & C	16.08.2017 04.10.2017	3 h 3 h	Face to face
R 3	Charterer	Norwegian shipping company	Ecosystem A	14.09.2017	1 h 10 min	Telephone interview
R 4	Managing Director	Ice management consulting	Ecosystems B & D	27.09.2017 06.09.2018	2 h 45 min 2 h	Face to face
R 5	Coastguard Representative	Supply base	Ecosystem B	07.06.2017	1 h	Face to face
R 6	Master	Supply vessel	Ecosystems A & B	29.05.2017	2 h	Face to face
R 7	Design Manager and his colleagues	Norwegian vessel design	Ecosystems A & B	17.08.2017	1 h 25 min	Telephone group interview
R 8	Import Substitution Director	Russian oil company #1	Ecosystem C	17.08.2017 18.09.2018	1 h 1 h 30 min	Telephone interview; Face to face
R 9	Senior Manager	Russian oil company #1	Ecosystem C	10.10.2017	2 h	Face to face
R 10	Bulk Operator	Supply base	Ecosystem C	23.08.2018	1 h 15 min	Telephone interview
R 11	Senior Manager	Operator	Ecosystem C	04.09.2018	40 min	Telephone interview
R 12	Senior Manager	Russian oil company #2	Ecosystem D	30.08.2018	1 h	Telephone interview
R 13	Chief Officer	Supply vessel	Ecosystem C	27.09.2018	1 h	Face to face
R 14	Drilling Supply Responsible	Operator	Ecosystem D	05.10.2017	42 min	Face to face
R 15	Operator Logistics Operations	Operator	Ecosystem D	19.09.2018	1 h 45 min	Face to face
R 16	Senior Manager	International ice advisory board	Ecosystems A, C & D	20.09.2017	1 h 20 min	Zoom

Appendix 2. Interview guide

1. How long have you been working within the offshore oil and gas industry?
2. What is the position in the department where you work, and how is it linked to other parts of the company?
3. Could you elaborate on your job tasks and the challenges you face in the company?
4. Please provide details about the most important current projects being implemented by your company.

Management of supply logistics and emergency preparedness at the N oil field:

Please provide information about the supply logistics management of the project:

1. How is the management of supply field logistics operations organised?
2. What are the relationships between the oil company, its suppliers, and vessel providers? How many contractors were engaged?
3. What are the natural conditions near the offshore operations that may challenge the implementation of the project?
4. Based on the offshore operations' remoteness from the shore, what experience has your company gained? How will this experience be utilised in other offshore Arctic projects?
5. How many offshore supply vessels are involved in the project?
6. What is the schedule for the offshore supply vessels?
7. How much time does it take for a vessel to reach the supply base?
8. Do offshore supply vessels contribute to the resilience of the supply chain and oil drilling and production operations? If so, in what ways?
9. Regarding personnel transportation, what were the main challenges? How many people worked on the platform?
10. Does your company engage additional supply vessels for the projects? If so, what are the reasons for doing so?

Transport infrastructure and onshore supply base facilities:

11. Does your company utilise its own supply base, and is this base also utilised for other offshore projects?
12. Has your company operated its own helicopter base, and how many helicopters are employed for personnel transportation in the project?
13. What challenges has the company encountered in transporting personnel?
14. Are there any area restrictions concerning the use of helicopters and UAVs in some of the licenses?
15. How many personnel are involved in the drilling (or oil production) operations on the platform?
16. What challenges did the operator face in ensuring regular support for the offshore operations?
17. Has your company experienced any delays in supplying certain materials/essential goods for staff because of the long distance between the drilling platform and supply base during the drilling operations?

Ice management practices:

18. What methods or technologies does your company utilise to monitor and detect the presence of icebergs and ice formations in the vicinity of the drilling (oil production) platform?

19. How are decisions made regarding ice management strategies, such as ice tracking, ice avoidance, or ice-breaking operations?
20. What is the frequency of ice management activities during different seasons in the Arctic?
21. How do ice management practices vary depending on the severity of ice conditions, such as ice concentration and ice thickness?
22. Are there any specific protocols or guidelines in place for communication and coordination between the offshore platform and ice management vessels?
23. How does the presence of ice affect supply chain logistics and transportation of essential goods and personnel to and from the offshore platform?
24. What contingency plans are in place to address unexpected challenges or emergencies related to ice management during offshore operations?

Emergency preparedness and response:

25. How do you handle emergency situations and ensure safety during offshore operations?
26. What specific roles and functions do offshore vessels play in emergency preparedness and oil spill prevention during drilling operations?
27. How does your company monitor and execute oil spill protection measures in the darkness surrounding the platform? What equipment is utilised for this purpose?
28. How frequently is monitoring conducted for potential oil spills?
29. What is the estimated migration time in the event of an oil spill, and how is this time frame determined?
30. What challenges are encountered in the evacuation and transportation of staff during foggy conditions when helicopters cannot be utilised? Additionally, what measures are in place for antiterrorist and other potential emergencies?
31. Can you share your experience with drone support testing in emergency situations? How helpful was it, and how was it organised?
32. What measures are in place to address environmental concerns and protect the Arctic ecosystem during drilling and production activities?
33. How does your company manage waste disposal and the environmental impact on the drilling platform?
34. What technologies or innovative solutions does your company employ to enhance operational efficiency and reduce your environmental footprint in the Arctic region?

Regulation:

35. What are the specific rules, regulations and industry standards that your company must comply with when managing offshore operations in the Arctic waters? How does your company ensure adherence to these requirements?
36. In your opinion, what aspects of the regulations by the Russian and Norwegian authorities can be enhanced to foster cross-border cooperation in technology development and promote bilateral supply operations?
37. How does your company manage compliance with environmental regulations and best practices to minimise its ecological impact on the Arctic region?
38. Can you elaborate on the coordination and collaboration with other companies operating in the Arctic to ensure a comprehensive approach to safety and emergency response planning?
39. Are there any plans for future expansion or new projects in the Arctic region, and how will they be managed in terms of logistics and supply chain?