

Lean Production: One path to Organizational Resilience?

Maria Sydnes, Anne Haugen Gausdal & Ingrid Dahl Åssveen

Abstract

In this in-depth single-case study from a large international aerospace and defense company, we ask the following research question: In what ways do lean production influence organizational resilience? Our findings suggest that various lean practices, such as lean meetings, using lean tools and a Lean Production inspired organizational culture promote the development of organizational capabilities that foster anticipation, coping, and adaptation - the three stages of Organizational Resilience. We find that lean practices enhance agility, promote more flexible procedures, increased strategic decentralization and greater 'sharp end' involvement – all of which are conducive to resilience. Further, our data suggest that organizational learning and a lean-inspired culture reinforce the synergy between lean practices and Organizational Resilience. Interestingly, if there is too much standardization, lean practices may potentially also undermine organizational resilience.

Keywords: lean production; lean meetings; lean tools; organizational resilience; organizational knowledge base; organizational capabilities

1. Introduction

Resilience has become imperative for modern organizations, not only to survive in the short term but also to be able to adapt to change and prosper in the longer term (Suryaningtyas et al. 2019). We understand organizational resilience (OR) as the 'ability to anticipate potential threats, to cope effectively with adverse events, and to adapt to changing conditions' (Duchek 2020, 220). Lean Production (LP) may promote resilient organizational performance (Birkie 2016; Lotfi and Saghiri 2018; Saurin et al. 2017; Soliman et al. 2018, Habibi Rad et al. 2022), and most 'lean' practices can be utilized by organizations to leverage their capacity to mitigate disruptions (Ahmed and Huma 2021; Soliman et al. 2018). According to our definition of OR, disruptions mean potential threats, adverse events, and changing conditions.

However, the question of *how* to achieve OR remains unanswered (Chen et al. 2021). Despite the evident connection between LP and OR, their relationship has remained largely unexplored (Birkie 2016; Rosso and Saurin 2018). Habibi Rad et al. (2021, 16) call for research that examine ‘various features such as applicability, effectiveness, challenges and practical implications of these paradigms’. Antony et al. (2021) call for more research on LP in general, and Bhamu and Sangwan (2014) and Jasti and Kodali (2015) call for empirical studies. More specifically research calls focus on the relation between organizational characteristics, processes and outcomes related to OR (King et al. 2015; Ma et al. 2018; Ruiz-Martin et al. 2018), the trade-offs between lean and resilience practices (Touriki et al. 2021) and the effects of lean application (Antony et al. 2021). This paper addresses these gaps in the literature by exploring the connection between LP and OR, by empirically investigating how OR can be achieved, by investigating the potential for LP to improve OR, and by studying LP in the Nordic aerospace and defence industry context. We aim to address the controversy around the lean concept (Samuel et al. 2015) by demonstrating how lean can be used in practice to enhance OR. We ask: *In what ways do lean production influence organizational resilience?*

We conducted an exploratory in-depth single-case study of a production department in a large international company by triangulating data collection methods such as participant observations, in-depth interviews, content analysis of company archives, and survey data.

2. Literature

2.1 Organizational Resilience

OR research is growing fast and has evolved in a variety of fields including risk management, high reliability organizing, business strategy and continuity, disaster and

crisis management, operations management, engineering and safety, leadership, organizational and management studies. These provide differing views on what constitutes OR and how it can be conceptualized (Williams et al. 2017; Duchek 2020). Research has often treated OR as referring to the ability of an organization to respond productively to disruptions (see Lengnick-Hall and Beck 2005) – but resilience is more than mere survival. It has also been associated with the organizational capacity to cope with and adapt to unforeseen developments (Wildavsky 1988; Gittell et al. 2006). Viewed from this perspective, resilient organizations not only manage to adjust to challenging conditions, but also identify potential risks and take proactive steps, ultimately capitalizing on disruptive surprises that might otherwise have threatened their survival (Lengnick-Hall et al. 2011, 244). Finally, it has been argued that resilience refers to the incremental capacity of an organization to anticipate potentially disruptive events (Williams et al. 2017). While most studies concentrate on only one of the above-mentioned perspectives, others use two different perspectives arguing that there are different types of organisational resilience (Duchek 2020, 6). OR may refer to a dialectical interaction, a dynamic interplay and productive outcome of a tension between adaptive and proactive forces – the two basic forms of resilience described in the literature (Giustiniano et al. 2018, 116–117). Although our understanding of OR has become further refined over the years, a generally accepted definition or a shared analytical framework is still lacking (Ma et al. 2018). Our understanding of the specific capabilities that underlie OR remains limited (Duchek 2020); moreover, the concept of resilience is underdeveloped in the organization-focused literature (Rodríguez-Sánchez et al. 2021).

Building OR is not easy (de Bruijne et al. 2010): it is complex, requiring organizations to develop a unique blend of cognitive, behavioural, emotional, and relational capabilities into routines (Williams et al. 2017). Resilience is a fundamental

dimension of organizational culture (Powley and Cameron 2020) that refers to the implicit assumptions that govern beliefs, values, and purposes, and is manifested in norms and expectations as well as in artifacts and behaviour. It must be approached as a multi-level and multi-stage phenomenon that relies on continuity of the processes between the various stages (Giustiniano et al. 2018). Further, resilience is relative, emerging and changing in line with specific circumstances and challenges: it is a path-dependent organizational feature (Ortiz-de-Mandojana and Bansal 2016) ingrained in the organization that grows and develops over time (Boin, Comfort and Demchak 2010; Gittel et al. 2006; Giustiniano et al. 2018, 130; Lengnick-Hall et al. 2011). Resilience is not a ‘short-term fix’: it involves incremental growth and iterative learning from challenging events (Powley and Cameron 2020, 264). It is concerned with the continuity of organizational performance and is focused on risk management, mitigation, and attending to vulnerabilities (ibid). Studies have also conceptualized resilience as dynamic process, highlighting its active nature (Lengnick-Hall and Beck 2005). Thus, OR is not something that organizations *have*: it is something that they express or fail to express over time. Often, resilience is a capacity latent in organizations before the actual need for it arises (Somers 2009; Sutcliffe and Christianson 2012; Powley 2009). It is a ‘sustained target movement’ (Suryaningtyas et al. 2019) that cannot always be measured directly (Boin and van Eeten 2013), as its benefits may take a long time to become evident (Ortiz-de-Mandojana and Bansal 2016). Britt and Sawhney (2020) use the concepts ‘capacity for resilience’ (factors that increase the probability for resilience to be demonstrated) and ‘demonstration of resilience’ (the actual demonstration of positive adaptation) in describing the same phenomenon. OR arises from tension between proactive preparation and adaptive response, which in turn reflects on organizational processes as such. This tension becomes the very source of resilience, where the latter is a dialectical synthesis

of adaptive and reactive resilience (Giustiniano et al. 2018). OR emerges from the interaction evolving between an organization, its stakeholders, and the environment when confronted with adversity (actual or potential) (Williams et al. 2017). Therefore, analysis of OR necessitates a multilevel, dynamic perspective (van der Vegt et al. 2015, 977; Williams et al. 2017). Some studies refer to achieving ‘degrees of resilience’ (Bhamra et al. 2011), where the level of OR depends on organizational capabilities and resource availability (Duchek 2020). Recognizing that OR entails processes – a set of successive stages to be accomplished – we must bear in mind that, during these various stages, different capabilities may be important (ibid). Understanding organizational processes and capabilities may provide a clue to developing resilience.

This study is an attempt to understand OR through LP as a process that may lead to the development of organizational capabilities that enhance OR. The conceptual framework for this study is Duchek’s (2020) model, presented in Figure 1, which illustrates the three main stages of the resilience process and the underlying capabilities that together constitute the meta-capability of OR. The anticipation stage entails three specific capabilities: the ability to observe internal and external developments, to identify critical developments and potential threats, and to prepare for unforeseen events. The coping stage is associated with ‘effective handling of unexpected events so as to resist destruction’, which entails two capabilities: the organizational ability to accept a problem, and to develop and implement solutions (Duchek 2020). Third, the adaptation stage consists of reflection/ learning, and organizational change capabilities (ibid).

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Organisational capabilities that underlie the three resilience stages are extremely complex and deeply embedded in contextual factors that create conditions for their accomplishment and development. Of particular importance, there are some main antecedents (knowledge base) and drivers (resource availability, social resources, and power/responsibility).

The prior knowledge base is regarded the main antecedent of OR, as it facilitates all its dimensions, and the organizational ability to anticipate is a function of this base (Cohen and Levinthal 1990). ‘To be resilient, organizations should develop a broad and diverse knowledge base to anticipate both internal and external change, even if this knowledge is far away from the organization’s core business’ (Duchek 2020, 234). Knowledge also plays a key role in preparing organizations for crisis response and recovery (Sutcliffe and Vogus 2003). Specialized knowledge at the individual and the organizational levels on how to respond effectively to unanticipated disruptive events will enhance OR (Pal et al. 2014). Finally, a comprehensive and diverse knowledge base will facilitate organizational learning from experience, helping organizations to respond to new crises, as well as to adapt to and anticipate future disruptions (Duchek 2020).

Resource availability, social resources and power and responsibility are seen as the drivers of OR. Resource availability is important for all stages, but especially the anticipation stage. Social resources are most important for the coping stage, as are power and responsibility for the adaptation stage. In addition, successful implementation of the three stages of resilience relies on the interplay between cognitive and behavioural capabilities and actions. The three resilience stages overlap and are heavily interdependent, with a feedback loop between OR and organizational learning: an organization’s knowledge base may be enhanced through accomplishing the three resilience stages.

2.2 Lean Production

‘Lean’ is both a manufacturing philosophy (Bhasin and Burcher 2006) and a managerial practice widely adopted by organizations around the world to optimize organizational effectiveness and business performance (Ghobadian et al. 2020) and enhance competitiveness (Galeazzo and Furlan 2018). It emerged from the automotive industry in the mid-19th century (Samuel, Found and Williams 2015;). Since then, ‘lean’ has been adapted for use in almost all manufacturing and service industries (Hopp 2018), private and public (Samuel et al.2015), regardless of size (Hu et al. 2015), as well as in a wide range of organizational operations (Zhu, Yuan and Zhang 2018).

LP is a complex, multifaceted concept and there is no broad consensus on what lean implementation entails (Ghobadian et al. 2020; Saurin et al. 2021). Our study approaches LP as ‘an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability’ (Shah and Ward 2007, 791). LP permeates all elements of a socio-technical system aimed at ‘using less of everything’ – including human effort, manufacturing space, investment in tools and engineering working hours – to develop a new product (Jasti and Kodali 2015, 867). Even if competitive advantage is the goal, LP maintains a holistic focus on suppliers and customers, and internally, on the technical systems and involvement of the individual employee, through good management. ‘Dynamic learning capability’ is central here (Holweg 2007, 422). In LP, continuous improvement is the key to creating a flexible organization; and, to achieve this, learning capability remains a key element. Inputs for this learning come from feedback from suppliers, maintenance and statistical process control systems, and customer and employee involvement.

'Lean' offers several management tools for operations and processes that form an important part of the communication processes (Parry and Turner 2006). One such tool is the visual board displaying statistical process and safety information, often with simple graphical representations, also called the lean board. To avoid information overload and ensure that all team members have full input and control here, physical boards are deemed preferable to digital ones (Parry and Turner 2006). Meetings around these boards, lean board meetings, ensure they evolve as useful tools and that their content is updated and maintained. These meetings also facilitate communication among the participants (Parry and Turner 2006). Another tool is one-point lessons: educational training tools aimed at improving quality through systematizing and sharing of information about quality problems (Matt and Rauch 2014). These lessons are written down and shared on the lean board. The 5-whys tool asks 'why' questions five times to identify the root cause of a problem: it 'usually has a lot of depth and breadth' and is a 'corrective as well as preventive action' (Murugaiah et al. 2010, 529). The final lean tool discussed here is 5S on the design of efficient facilities; it consists of the five S-words: Sort, Set, Shine, Standardize and Sustain (Omogbaia and Salontisa 2017). Sort: organize and store things in order; Set: label where to store things, always storing things where they belong; Shine: keep the workplace clean and neat; Standardize: document the work methods and use them; and finally, Sustain: make a habit of continuous improvement procedures (Longstaff 2005; Omogbaia and Salontisa 2017).

The widespread application of lean manufacturing practices has been followed by tremendous increases in related research (Jasti and Kodali 2015; Pinho and Mendes 2017; Erthal and Marques 2018; Onofrei et al. 2019; Antony et al. 2021) particularly during the two most recent decades (Bhamu and Sangwan 2014; Samuel et. al 2015). However, knowledge of lean remains scattered and diverse (Yadav et al. 2017) and our conceptual

and technical understanding is still limited across industries (see Abolhassani, Layfield, and Gopalakrishnan 2016; Jasti and Kodali 2016; Filho, Ganga, and Gunasekaran 2016). Although lean has been important for both academic studies and practice (Jasti and Kodali 2015), it remains a controversial concept (Samuel et al. 2015). Therefore, the literature on lean requires further examination (Pearce and Pons 2019; Ciano et al. 2019; Uriarte, Ng, and Moris, 2020) – specifically on the effects (Antony et al. 2021) like the effect on OR explored in this study.

2.3 Lean Production and Organization Resilience

Research on lean–resilience interaction focuses mainly on the impact and application of lean and resilience paradigms (Habibi Rad et al. 2021). The chief empirical contexts have been manufacturing, automotive and public health but also construction, aerospace, transportation, cyber security, software, and food industry (ibid.). Several researchers have gone beyond the simple lean –resilience relationship and examined the integration of lean and resilience with other related paradigms associated with improving the sustainability and agility of organizational performance (see, e.g., Carvalho et al. 2011; Govindan et al. 2015; Bhattacharya et al. 2016; Lofti 2019; Ramirez-Peña et al. 2020; Purvis et al. 2016; Touriki et al. 2021).

Some studies conclude that improvement of operational performance in organizations requires dual needs to be lean, aiming to minimize all potential waste in the process, and resilient, seeking to minimize the impact of any unexpected event on the organization and process (Azadeh et al. 2017; Lofti 2019). As both aim at improving system responsiveness, and may complement each other (Shafiee et al. 2021), they should go hand-in-hand (Uhrin et al. 2020). Lean practices drive OR, and lean implementation leads to enhanced OR (Govindan et al. 2015; Ruiz-Benítez et al. 2018, 2019; Habibi Rad

et al. 2022). Resilience is a function of (among other things) leanness (Purvis et al. 2016). Lean and resilience practices may also be concurrent: indeed their simultaneous application can improve system performance (Birkie 2016; Lofti and Saghiri 201; Purvis et al. 2016). Resilience has also been assessed alongside with leanness and agility, where studies provide evidence of the positive impact of resilience on certain LP practices and operational performance outcomes (Azadeh et al. 2017; Zarrin and Azadeh 2017; Lotfi and Saghiri 2018). However, leanness may differ from resilience (Carvalho et al. 2011; Uhrin et al. 2020; Lofti 2019) and there are divergences between them (see, e.g., Habibi Rad et al., 2021, 16, for an overview). Both lean and resilience pursue objectives that, at times, may require opposite actions, leading to a conflict between the two paradigms (Ruiz-Benítez et al. 2018).

Despite the substantial increase in academic knowledge on the lean/resilience relationship, this field is still in the early stages, plagued by multiple knowledge gaps (Ruiz-Benítez 2018; Habibi Rad et al. 2021). Compatibility and the trade-offs between lean and resilience and their integration require further investigation: in particular, it is important to study the synergies and divergencies of resilience and lean paradigms, and the impacts of synergies and divergences on their effectiveness (Habibi Rad et al. 2021).

3. Methods

For an exploratory in-depth case study, we selected the department of a large international aerospace and defence company because of its high level of LP maturity and the strong relevance of OR as it deals with dangerous substances like ammunitions, chemicals and explosives. The company, headquartered in Scandinavia, is currently (spring 2022) owned partly by a government and partly by a group of private interests in two Nordic countries; it has offices in many countries and nearly 3000 employees. Further, the

company has had long experience with improvement work, e.g., implementing Agile and Six Sigma, also before it began implementation of LP. The department has around 100 employees and works with mechanical production. Its status as a pilot when the company started with LP in 2015, winning the company's Health, Safety and Environment (HSE) Prize two years later, made it a key case (Thomas 2011).

We started with observations, followed by semi-structured interviews, collecting archive data and supplementary data from a simple survey with all operators. Our observations started with a meeting with the company, followed by a guided tour around the premises and several meetings around the lean board. Altogether four team meetings – in different teams – and one department meeting were openly observed. Observation was performed by participation in the meetings with an observation guide and by taking notes, which were later fully transcribed. Two of the researchers developed the interview guides and questionnaires. The foundation for this was the research questions, the literature review and information from our observations. The guides and questionnaires included the topics of communication, involvement and the efficiency/safety dilemma. To illustrate, some of the questions in the guide were: 'In what way does Lean affect the ability to respond to unexpected things that may occur, such as emerging obstacles, disruptions and / or adverse events?; Do security shortcuts or deviations occur in the department? If so, what do you think the reason may be?'. One question in the questionnaire was: 'To what extent do you find that Lean helps to monitor processes and keep track, so that it is easier to predict signs and signals of future events?' Two samples were interviewed: 1) two key informant strategic managers; 2) seven randomly selected operators. All interviews were lasting from half an hour to one hour; they were conducted face-to-face on the company premises, recorded and fully transcribed. The questionnaire was first tested on one operator and one strategic manager, and then modified and

distributed (hardcopy) to all 77 operators who had not been interviewed. Three weeks later, we had received 67 answers, yielding a response rate of 87%. The primary data were collected by informed consent, during the spring of 2019. The archive data consist of statistics on reported incidents, injuries and hazardous conditions within the company, 2010–2018.

We analysed the transcribed interviews and observation notes using the NVivo programme employing directed qualitative content analysis. Two researchers conducted the coding: first individually, then comparing and discussing the codes before the final codes were decided. The supplementary survey data were analysed in Excel by use of simple statistics. All data were collected in a Scandinavian language; the results have been translated into English language by the authors.

4. Findings

Our findings cover meetings, lean tools, and LP-inspired organizational culture.

4.1 Meetings

Implementation of LP has led to the introduction of regular practices in the company. Team and departmental meetings are held every morning as short stand-up meetings around the lean board, and last approximately 10 minutes. Participants stand in a semi-circle around the board, which is used in all meetings, most actively in departmental meetings.

All team operators (6–10) participate in the team meetings, chaired by the supervisor. Occasionally, the quality engineer and/or the operations manager also attend. Team meetings have multiple purposes. One is reporting: all operators are invited, in turn, to report on their tasks and workstations, inform and share experiences on incidents that

have occurred or other matters they wish to take up. Another purpose is information sharing. The supervisor informs the participants of such matters as the status on cases developed following earlier proposals for measures and improvements, emphasizing 5S as regards neatness and structure; quality measures; possible upcoming revisions; and sometimes also information from the quality engineer. At one meeting, participants were updated on one specific improvement case that had reduced operation time by 40%. This good news was given by the operation manager, who spoke in the 'we' form to emphasize the collective spirit and equality. At another meeting, a serious incident at another industrial company, where one person had died after contact with dangerous chemicals, was reported. At yet another meeting, it was reported that the recent inclusion of maintenance information and ticking on the digital monitors seemed to have a preventive effect, because maintenance had been improved. At this team meeting, participants expressed the desire to get the paper-based action lists digitalized. This, they felt, would provide better overview for the supervisor, who would then be able to monitor and administer the situation without having to leave his office. Here it should be noted that safety is extremely important in this department, and a full 94% the operators see safety as being of the utmost importance at their workplace. Similarly, Health, Safety and Environment (HSE) was a key agenda item in all meetings. Indeed, the supervisor always opened the meetings by asking 'does anybody have anything concerning HSE?'. Many cases of improvement also concerned HSE, in addition to quality and other issues.

One key outcome of team meetings is shared situational understanding among the participants. The low threshold for raising issues facilitates information sharing, further encouraged by the informal and relaxed atmosphere, often accompanied by joking and small side-comments. This does not, however, affect the efficiency of the meetings. Several operators opined that the team meetings contributed to efficient handling of

problems on site. As one noted, 'if there is something, it gets recorded then and there, and something is done about it'. Another explained:

At my workstation there are two rotating machines, and a robot feeding these two. And if you should notice a potential for danger or harm, and you take it up through these lean tools, then it becomes a case. Then there is a person who is given responsibility, and a deadline, and things like that are taken care of. Not just 'yes, we'll look into it'.

Both groups of informants agreed that the team meetings contribute to much of the improvement work, including HSE. As one strategic manager put it: 'It's not up to a departmental committee until there is a change – now we just do it'.

All supervisors and the quality and maintenance engineers participate in departmental meetings, chaired by the operations manager. The focus of these meetings is on updating everyone on the status within the teams, exchange of knowledge and information and briefing on upcoming events. The aim is to share knowledge and to contribute to organizational learning. The operations manager mentioned numerous instances of teams learning from each other, as with shared risk assessments. As with the team meetings, HSE is always the first issue on the agenda at departmental meetings. Quality discussions are a regular element; participants use the lean board actively by reloading a colour marker and placing a yellow marker on any operation that might be improved. During these discussions, improvements and measures required are addressed. In addition, issues related to staffing and absence are raised. The lean board is used actively throughout the meetings. Like the team meetings, departmental meetings provide a good arena for achieving shared situational understanding. The atmosphere is informal and relaxed, with some joking and side-comments along the way; and the threshold for

raising an issue is low. As with the team meetings, this informality does not appear to have negative implications for the effectiveness of the departmental meetings.

Lean meetings seem to impact positively on the organizational ability to respond to disruptions. Commenting on LP's ability to respond to unforeseen events one strategic manager said: 'We get a quick response to it then, when we meet every day and talk about things. Then it can quickly become evident if we have something that doesn't work, if there is a deviation.' He went on to explain: 'emerging obstacles are dealt with in team meetings or in subsequent departmental meetings if there are major challenges.' Further, these meetings facilitate faster decision-making and handling of problems and challenges – before they develop into serious incidents. Here the importance of maintenance personnel and process engineers always being present at the daily department meetings, ready to offer relevant solutions, was highlighted. One strategic manager said that this helps them to get involved early, and that 'things go much faster [after implementing LP], because now we get it daily, almost hourly'. Another strategic manager noted that the team meetings contribute to good communication flow, enabling problems to be solved on the spot. He added that the department employs a preventive maintenance strategy as part of the LP structure. This approach involves maintaining continuous overview and plans for proper machine maintenance, which further contributes to reducing HSE risks.

4.2 Lean tools

One practice that is a result of LP implementation is the introduction of the lean board where all events are recorded and displayed. LP is useful tool for its ability to provide an overview and monitor production processes. Our survey showed that 78% of all operators agreed that LP had made it easier to read the signs and signals of future events. Three operators highlighted that the lean board enables continuous overview of what is

happening in the department. This facilitates control and further contributes to registering signs and signals, in turn making it possible to predict potential disruptions. The lean board brings HSE into focus. One strategic manager explained that each team has a year-wheel for HSE on this board, where injury-free days are marked in green and injury days in red. The goal is to avoid undesirable incidents, injuries, and accidents; one strategic manager noted that this lean tool contributes to daily visibility, raising awareness and monitoring of the safety status of each team. Two operators also noted that the year-wheel contributes to monitoring HSE work and safety levels. One operator mentioned the digital screens as useful because they present information on the status of machines and any maintenance needs, which is important for foreseeing and avoiding undesirable events. However, it was also emphasized that undesirable events like injuries very rarely happened.

Reporting is an inseparable part of LP. Our survey shows that 82% of the operators use the LP tool proposals for measures and improvements. All HSE reports are entered into a digital system, and managers receive electronic messages if a report has been 'open' too long without the necessary action being taken. Managers also use this reporting system to look for recurring events and signals that indicate a need for action; they consider it well-suited for monitoring security status and preventing future adverse events. Operators and the strategic managers emphasized the significant increases in HSE reporting practice after the introduction of LP. As one manager explained:

The number of HSE reports has increased significantly in this department after we started with lean. Our aim is to increase the department's reporting practice, and it is part of the reward that we get green markers on our boards and that no one gets injured.

In addition to this reward policy, our survey shows that 94% of the operators find that reported deviations and security breaches are taken seriously and followed up by the leadership. The effect of this policy in the form of increased reporting practice was supported by company statistics, as the number of reports increased by 125% (from 242 to 545) from 2014 to 2018. During the same period, the number of real injuries also increased, but this increase was much lower (44%: from 16 to 23). One manager explained the injuries were less serious: ‘we’ve gone from a few HSE deviations reported annually, to close to 100 last year, without involving any medical visits’.

LP relies heavily on standardization. The operators give very positive feedback regarding the standard operating procedure framework and one-point lessons. One operator described the latter as an ingenious tool, as they allow everyone to handle the machine in question. He believes this is a good idea, as the company has started rolling out operators on several machines; here he also emphasized the importance of the procedure being set up correctly and explained clearly, preferably with pictures, as has been done. Another operator said, ‘a good one-point lesson may show things that not everyone sees’ and that this may reduce dangerous ‘safety shortcuts’. Yet another operator noted how safety was integrated into the design of the procedure; he held that one-point lessons contribute to efficiency and fewer errors. A fourth operator said that these procedures make it easier for new employees; they reduce stress and thus the likelihood of making mistakes. One strategic manager wanted greater standardization, which, he held, could further strengthen safety. When asked about any possible disadvantages of such procedures, one operator stressed the importance of keeping procedures simple and clear. Also highlighted was the danger of being too highly steered at work. That operator felt that, in some cases, having established procedures may obstruct creativity and reduce the ability to come up with alternative solutions when

unforeseen obstacles arose. Nevertheless, he added, it was ultimately the individual's own experience that would be decisive. Our interview data were corroborated by the survey results, showing that a full 88% of the operators believe that one-point lessons and other procedures contribute to increased safety.

Our findings also show that practising 5S contributes to control and overview of equipment; according to one operator, this reduces stress and makes it easier to respond to unforeseen events and situations. One strategic manager agreed: 'we've become better at solving problems by using tools we have learned in lean, like the 5-whys.' He went on to explain that it helps to identify the root cause of problems by repeatedly asking *why* they occur. For example, it might emerge that an undesirable incident occurred because there was no safety cover inside the machine, or that the operator had not received adequate training. This manager considers the 5-whys to be a good tool, one that he applies to quality and HSE deviations.

4.3 LP-inspired organizational culture

Successful implementation of LP has led to the development of organizational cultures that enable further implementation of lean practices. One strategic manager explained that:

... a lot of improvements and investments have been made that directly affect productivity, but there have been many HSE improvements as well, as with automating processes that are heavy to work with and involve a lot of static work. We focus on operators not having to work themselves to death – and then you have to consider work forms, flow, tidiness, and having equipment that is functional and safe.

Another strategic manager felt the company was good at setting goals, but that it could be even better, including daring to be more open about what it is not so good at. In his view, that was the key to improvements in the long run. Concerning improvement of the learning culture, strategic managers also highlighted the importance of focusing on positive feedback when things were done in the 'right' way. One explained how, on his rounds in the department, he would often give positive feedback to the operators, as well as praising good suggestions for improvement and commending the proper use of protective equipment.

LP seems to have influenced ways of thinking. One strategic manager considered it positive if critical issues arise, as that could contribute to new and different ways of thinking about the matter in question. Another operator followed up by noting how people often respond, 'yes ... but we've always done things that way', and that many in the department used to think like that. Now, added, 'the introduction of LP has helped to reduce some of this thinking'.

The operators have always been involved in risk analysis to some extent; however, the strategic managers and most operators agreed that operators have become more involved in such analysis and in general safety work after the implementation of LP. The strategic managers emphasized the importance of listening to experienced operators who are familiar with the machines and know their risk potential, and of using their experience and expertise to make good assessments.

LP implementation has affected organizational learning practices. The strategic managers underline that they have a considerable focus on learning. We were also told that they conduct online learning projects for employees where they repeat important information related to HSE. Another pointed out that the reporting system and team meetings contribute to learning, as information on undesirable events and other important

matters is shared and disseminated upwards in the organization; and added that many improvements have been achieved in this way. The organization also seems to have learned from experiences with Agile, the previous improvement programme. When Agile was introduced, responsibility was placed largely with the operations department alone – which did not work out well. That convinced the strategic managers that someone at the strategic level must take overall responsibility for LP and make sure it is maintained throughout the organization. The strategic managers are now involved much more closely in LP implementation than they were with Agile.

5. Analysis of findings

It is now time to return to our conceptual framework model (Figure 1) to examine how lean practice stand in relation to the key resilient stages and their underlying capabilities. Team and departmental meetings, LP tools such as lean board, one-point lessons, the 5-whys, digital screens, and the LP culture all help to make it possible to observe internal and external developments – a core capability of the anticipation stage of OR. The team meetings involve status reports, information, and discussion of improvement work. The lean board increases visibility, awareness and monitoring of HSE work and safety status. One-point lessons are also relevant, showing ‘things that not everyone sees’ and reducing safety shortcuts. The 5-whys have led to the discovery of an undesirable incident that occurred due to lack of a safety cover inside a machine. Under the LP-inspired culture, managers acknowledge the importance of the improved learning culture, different ways of thinking, and achieving many improvements – and that the implementation of LP is now followed up more closely. However, our data clearly show that the emphasis in meetings, tools and culture is on the internal side of this capability, whereas the ability to observe external developments is rarely mentioned.

The substantial increase in HSE reporting shows that LP has contributed to the ability to identify critical developments and potential threats. The team and departmental meetings contribute to this capability because the status and experiences of incidents and problems are shared, and the preventive effect of improved maintenance information is recognized. Moreover, HSE is always at the top of the agenda; and there is keen awareness of emerging obstacles. The digital screens contribute by informing about the status of the machines and maintenance needs, and the HSE reports are recognized as an appropriate tool for monitoring status and preventing future events. Further, the screens are seen as indicating signs and signals of future events; the preventive maintenance strategy may also contribute by helping to prevent machine failures or incidents such as fires. The lean boards also contribute to this capability at a more general level. They provide information on the status of various work process, which facilitates production control. The 5-whys tool is useful for identifying the root causes of problems, thus helping critical developments and potential threats to be identified. The lean culture contributes by involving operators more in risk analysis and decision-making processes. As noted, strategic managers highlight the importance of using the expertise of experienced operators to make good assessments, and of listening to those familiar with the machines. Additionally, 78% of the operators answered that LP contributes to monitoring overview and the monitoring of status, so as to prevent future adverse events. Thus, the data suggests that the team and departmental meetings, LP tools like the lean boards, HSE reports, the 5-whys and the LP culture, all promote the ability to identify critical developments and potential threats. Daily meetings also seem to increase the speed of this capability.

LP can contribute to the ability to prepare for unexpected events in various ways. For instance, team meetings have enhanced organizational ability to identify potential

threats and take corrective actions. The 5-whys tool has been found to contribute positively, directly and indirectly – by improved ability to solve problems, identifying their root cause, and by reducing stress, thereby making it easier to respond to unexpected events and situations. The 5S approach can also help by ensuring structure and order as regards tools; likewise, the LP-inspired collaborative culture between managers and operators. However, the one-point lesson tool may also have drawbacks: if procedures are overly steered, that might impede creativity in dealing with unforeseen obstacles. On the whole, then, team meetings, the 5-whys and 5S tools and the LP culture seem to contribute positively, and the one-point lesson somewhat negatively, to the capability to prepare for unexpected events.

LP meetings, tools and organizational culture can all contribute to capabilities connected to the coping stage. This stage relies on the ability to accept a problem and develop and implement solutions. The meetings have contributed by disseminating important information upwards in the organization, resulting in many improvements. The meetings also constitute a low-threshold arena for problems that may arise. The 5S approach facilitates efficient response to unforeseen events. Finally, remarks like ‘now we just do it’ and ‘things are going much faster’ indicate that LP has reduced the time needed to implement solutions. Thus, lean meetings, the LP culture and 5S have all contributed positively to the organizational ability to accept a problem and develop and implement solutions.

Finally, for the adaptation stage, where the ability to reflect, learn and change is central, the meetings in general, and the departmental meetings in particular, contribute to reflection and learning capabilities. Both types of meetings involve reflection on how production and maintenance is progressing and how HSE is dealt with. By contributing to achieve a shared understanding they also contribute to learning at the group level.

Further, the departmental meetings give the various supervisors the opportunity to share experiences from their teams, resulting in numerous instances of teams learning from each other. The aim of these meetings is also to contribute to learning at the organizational level. One-point lessons contribute to ‘efficiency and fewer errors’ – which is a sign of learning. The 5-whys help in identifying the ultimate root cause of problems; we hold that this is because this method triggers reflection on why things happen, thereby facilitating both individual and organizational learning. Moreover, one strategic manager noted the improvement in solving problems – another sign of learning. The LP culture seems to have contributed to the recognition that listening to and drawing on the competence of experienced operators improves assessments – as a sign of reflection. The positive feedback that ensues when things are done in the ‘right’ way also improves learning. Thus, team and departmental meetings, the LP tools, one-point lessons and the 5-whys and the LP culture contribute positively to reflection and learning capability.

Organizational change, the second capability for the adaptation stage, may include structural and cultural change, as with the implementation of LP meetings and tools. Further result-oriented structural changes include new routines, like the recent inclusion of maintenance information and ticking on the digital screens. Cultural changes involve faster decision-making, new ways of thinking, appreciating and using operators’ competence more, and an improved learning culture. Thus, the team and departmental meetings, the LP tool lean boards and the LP culture all contribute positively to organizational change capability.

Culture is an essential organizational resource. It underpins and facilitates all other procedures and processes related to LP functioning, fostering the capabilities necessary for all three resilience drivers and the drivers of OR as well. LP-inspired organizational culture is also an important social resource. It provides employees with a common frame

of reference, for example by setting safety as the cornerstone of the organizational agenda. Such organizational culture builds on inclusion, trust and encouragement, which contributes to positive relationships among employees and improves organizational ability to cope with disruptions. Social resources result from respectful interactions (Lengnick-Hall et al. 2011), and regular meetings enhance face-to-face communication, in turn promoting organizational dynamics and problem-solving capacity. The social atmosphere of these meetings, rooted in trust and mutual respect, provides positive input. Thus, we find that LP-inspired organizational culture has had a clear impact on the organization's power structure, promoting power based on expertise, shared responsibilities, and organizational learning.

Collective sense-making relies on the organization's language. Here we note the special atmosphere of lean meetings and organizational culture, emphasizing the collective spirit and equality. Always having HSE at the top of the agenda creates a strong sense of purpose and joint vision, as well as fostering deep core values and a sense of identity among employees. Implementation of LP has promoted transparency and openness towards criticisms, also reducing the 'yes, but we have always done things that way' way of thinking. The 'relentless desire to question fundamental assumptions' (Lengnick-Hall et al. 2011, 246) facilitates organizational learning. Importantly, organizational core values become a basis for developing day-to-day behaviours when the firm is more likely to act upon them, rapidly and intuitively. LP implementation has led to 'things going much faster'. Likewise, team meetings facilitate prompt decision-making by improvement work and efficient handling of problems, often solved on the spot. 5-S principles stand out for their capacity to strengthen organizational ability to deal effectively with unforeseen events. One-point lessons may be extremely efficient in facilitating routines.

How the different lean practices and the lean inspired culture contribute to the stages of OR and their capabilities, as outlined in our conceptual framework (see Fig. 1), is summarized in Table 1. The overview in the table highlights that not all lean practices equally contribute to OR. Some practices (e.g. meetings and lean inspired culture) consistently enhance OR while others have rather limited effect or may even inhibit it. Another important conclusion is that the same lean practices have varying impact on organizational capabilities that build OR.

----- Please insert Table 1 about here -----

5. Discussion and concluding remarks

As noted above, a major challenge that confronts organizations is how to achieve resilience in practice (Boin and Lodge 2016; Duchek 2020; Chen et al. 2021). This study shows that Lean has a potential for achieving such resilience through well-guided operational policies and procedures, organizational learning, and lean-inspired organizational culture, and our in-depth case study offers detailed descriptions of such practices. Our findings suggest that LP has potentials far beyond mere waste reduction (Shah and Ward 2007), and that implementation of lean practices improves organizational capabilities to adapt, cope and anticipate. This is in line with earlier research that has argued that lean implementation leads to enhanced OR (Ruiz-Benítez et al. 2018, Habibi Rad et al. 2022).

In particular, our data show that lean practices contribute to multiple resilience stages. This varies among specific practices, making it difficult to separate the stages clearly. Our study provides empirical support that the stages of OR are interdependent, in line with Duchek (2020). We find that OR is complex, requiring organizations to develop

a unique blend of cognitive, behavioural, emotional, and relational capabilities into routines – as noted by Williams et al. (2017). Further, we hold that resilience is often latent in organizations (see Somers, 2009): it implies ‘resources developed and fostered internally through positive relationships and well-guided operational policies and procedures’ (Gittel 2006, cited by Powley and Cameron 2020, 264). Our data show that implementing lean leads to the development of such practices. Altogether, our study supports that lean practices enhance organizational capacity for resilience, in line with Britt and Sawhney (2020).

Previous research has highlighted the need to examine compatibility between lean and resilience and impacts of the resilience and lean synergies and divergences on their effectiveness (Habibi Rad et al. 2021). Resilience is not a ‘short-term fix’: therefore, incremental growth and iterative learning from challenging events are highlighted (Powley and Cameron 2020, 264). Reflecting on the path-dependent nature of OR (Ortiz-de-Mandojana and Bansal 2016), our data reveal a strong focus on learning as a natural outcome of lean practices and as an inherent and essential element of OR (see also Lengnick-Hall et al. 2011; Rodríguez-Sánchez and Vera Perea 2015; Khan et al. 2019; Evenseth et al. 2022). Thus, OR may enhance organizational learning capability (Rodríguez-Sánchez et al., 2021) and foster organizational self-development (Lombardi et al. 2021). Collecting information and facts, discussing these together, applying and further reflecting to ensure organizational learning may create a feedback loop between OR and organizational learning, where learning serves as both an input and an outcome of OR (Vogus and Sutcliffe 2007) – a continuously learning organization. This also indicates that there is a feedback loop and synergy between lean and OR, where they reinforce each other through organizational learning.

LP systems are socio-technical: they involve a human side in addition to the focus on materials and methods. Our data show that successful implementation of LP has led to the development of a strong organizational culture which is crucial to all the resilience stages. This is hardly surprising, given the role of organizational culture in general (Schein 1990) and in building OR in particular (Powley and Cameron 2020). Importantly, our findings highlight the importance of LP-inspired organizational culture for successful functioning of lean practices and resultant resilient organizational performance (Pal et al. 2014; Teixeira and Werther 2013). This points to another feedback loop between lean and OR, built through lean-inspired culture. Although our data allow only limited conclusions here, they do indicate the relationship between these two elements.

We find that LP relies heavily on standardization. Although essential for Lean, standardization also entails a certain rigidity which may, when improvisation is called for, impede behavioural capabilities that require organizational ability to shift to a course of action different from the norm. Our respondents made it clear that pre-established procedures may obstruct creativity and hamper the capacity to come up with alternative solutions when dealing with unforeseen obstacles. Lean therefore entails a certain rigidity which may hinder improvisation. This finding is particularly important, as improvisation is recognized as an important source of OR (Rerup 2001). Although we lack specific data on whether or how heavily the firm in our study relies on improvisation, it is important to recognize that too much standardization might undermine OR: Lean may potentially inhibit OR. This is in line with the findings of studies of the conflict between lean and resilience (Ruíz-Benitez et al. 2018).

Leanness is a prerequisite for agility (Narasimhan, Swink and Kim 2006, referred to in Purvis et al. 2016, 518) and provides a platform for developing efficient processes. We find that one outcome of lean implementation is agility and more flexible procedures,

in turn positively associated with resilience (Gligor et al. 2019). In addition, LP implementation has resulted in increased strategic decentralization, with greater involvement of the ‘sharp end’. On the other hand, greater commitment of strategic management fosters LP implementation and thereby OR. This is in line with studies showing that resilience in organizations does not come from hierarchy (Lengnick-Hall et al. 2011) but relies on striking a balance between control and innovation (Giustiniano et al. 2008), decentralization and shared decision-making (Lengnick-Hall et al. 2011; Mallak 1998).

In the literature review, we noted that OR builds on a dynamic interplay and productive outcome of a tension between adaptive and proactive forces (Giustiniano et al. 2018). Although our study does not provide any evidence of tension, we find elements of proactivity and adaptation among lean-induced practices. The overview of lean practices that influence OR stages and capabilities (Table 1) offers a strong basis for concluding that, despite certain gaps, lean practices enhance organizational capabilities to anticipate and adapt to disruptions.

In answer to the research question, in what ways do lean production influence organizational resilience? - we find that various lean practices have the potential to lead to the development of organizational capabilities that foster the three stages of OR: anticipation, coping and adaptation. The key contribution of our study to the research conversation on lean effects (Antony et al. 2021) and dynamics between the two paradigms (Habibi Rad et al. 2021) is in that it offers a more nuanced picture of how lean affects OR. While lean contributes to all resilience stages, our data clearly demonstrates that it also has its limitations (for further detail see gaps in table 1) and not all lean practices will equally enhance OR. Our exploratory study has both theoretical and practical implications. As regards theory, the relationship we have identified between LP

and OR is in agreement with previous research. However, our study adds further nuances by exploring the unexplored connection between LP and OR. This study has addressed the need for more empirical research. By empirically investigating how an organization can achieve resilience, it also fills a gap in the OR literature. By investigating some aspects of the potential for LP to improve OR, in contrast to more usual investigations of how LP may influence performance, this study also contributes to the LP literature. Further, as there have been very few empirical LP studies from the Nordic context, very few from aerospace, and no reported studies from the defence industry, our study contributes to the LP literature by providing empirical data from a Nordic aerospace and defence industry context. Our findings may prove useful for companies by offering insights for decision-makers regarding the LP–OR relationship, as well as helping companies already practising LP to enhance their resilient performance. A main strength is that our in-depth case study is partly ethnographical rather than retrospective in design, and rich in data.

Some limitations of this study should also be noted. We lack data on how real-life, critical incidents are handled, which could help us to draw clear conclusions on the coping stage. Further, a single case like that presented here offers possibilities for analytical generalizations, but limited opportunities for more generalized conclusions, which reduces the external validity of the study. Moreover, the contextual dimensions of OR have not been investigated fully. In addition, our selected case might not be representative of all industries, and the Nordic high-trust culture might not be typical of all regions. Contextual dimensions that support resilience also rely on relationships outside the organization, to facilitate effective responses to environmental complexities. Finally, all the data collected for this study have a ‘within’ focus.

This case would benefit from further investigation of the contextual elements of resilience processes external to the given organizational environment. The LP–OR relationship should be studied also in other types of industries, and in companies of various sizes and locations. Further study is also needed of the knowledge base as the antecedent to OR, what triggers OR, as well as the corresponding processes of how different experiences contribute to learning. Finally, the link between OR and organizational culture has not been yet sufficiently examined (Powley and Cameron 2020): this matter requires further investigation, as organizational culture can be used to identify the most effective ways to enhance OR.

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The authors report no conflict of interest.

Data availability

Due to the nature of this research, study participants did not wish their data to be shared publicly, so supporting data are not available.

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Tables

Table 1: Lean practices' contributions to the stages of organizational resilience and their underlying capabilities (authors' compilation)

OR stages and underlying capabilities		Anticipation			Coping	Adaptation	
		To observe internal and external developments	To identify critical developments and potential threats	To prepare for unexpected events	To accept a problem and develop and implement solutions	Reflection and learning	To change organization(s)
Lean meetings	Team	X	X	X	X	X	X
	Department	X	X		X	X	X
	Lean board	X	X				X
Lean tools	HSE reports		X				
	One-point lessons	X		(-X)		X	
	5S			X	X		
Lean culture	The 5-whys	X	X	X		X	
		X	X	X	X	X	X

Lean Production: One path to Organizational Resilience?

Figure

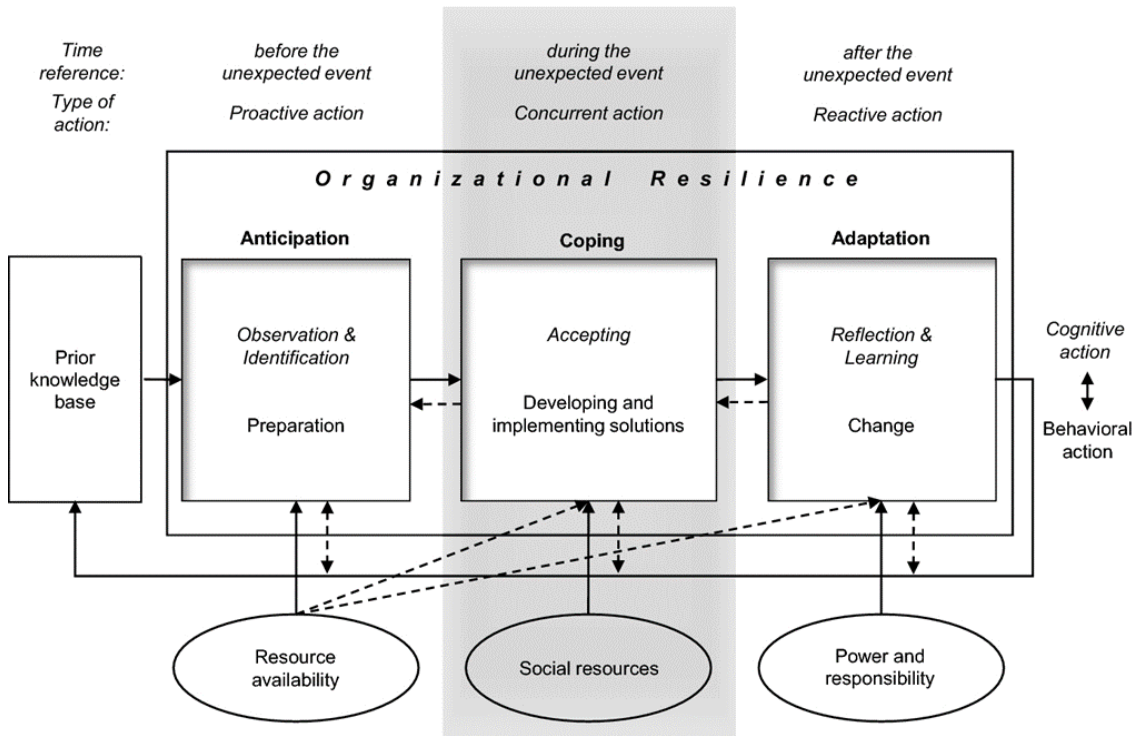


Figure 1. The conceptual framework for the study with the stages of organizational resilience and underlying capabilities (Source: Duchek 2020, 224) (Duchek’s article is distributed under the terms of the Creative Commons Attribution 4.0 International License <http://creativecommons.org/licenses/by/4.0/>, which permits unrestricted use, distribution, and reproduction in any medium, provided giving appropriate credit to the original author(s) and the source and provide a link to the Creative Commons license. No changes have been made.)