SPS2022 A.H.C. Ng et al. (Eds.) © 2022 The authors and IOS Press. This article is published online with Open Access by IOS Press and distributed under the terms of the Creative Commons Attribution Non-Commercial License 4.0 (CC BY-NC 4.0). doi:10.3233/ATDE220132

# Factory 4 Tomorrow Organization -Challenges and Enablers to Encourage Simultaneous Exploration and Exploitation

Lina Stålberg<sup>a</sup> and Anna Ericson Öberg<sup>1b</sup> <sup>a</sup>Volvo Construction Equipment, Mälardalen University <sup>b</sup>Volvo Construction Equipment, Karlstad University

Abstract. This paper identifies challenges and proposes enablers for simultaneous exploration and exploitation in Operations (the production part of a manufacturing company). It also contributes with an empirical example of organizing dual operating systems through behavioral ambidexterity during the digital transformation journey. The main challenges related to achieving simultaneous exploration and exploitation are communication, involved resources, innovation process, collaboration, and implementation. One of the proposed enablers is to develop a more supportive culture through awareness and competence development of managers about the competing cultures of exploration and exploitation. Further on, the diagnostic of opportunities model (the readiness and maturity evaluation model) is an overall enabler and can be used as a supportive dialogue tool to address several of the challenges identified. In addition to this, there also needs to be a strong focus on overall continuous communication and follow-up, especially of the proposed enablers, to support the overall change approach to reach strategic legitimacy in the organization.

Keywords. Industry 4.0, exploration, exploitation, organization, digital transformation

# 1. Introduction

The Fourth Industrial Revolution, also called Industry 4.0, is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres [1]. It encompasses end-to-end digitization and data integration of the value chain. Industry 4.0 is on the agenda of manufacturing companies around the globe. Yet most business leaders have still not come to terms with the challenges and opportunities of digital transformation [2]. Their survey [2], shows that companies rated as Digital Champions invest heavily in people development and training and cultivate multidisciplinary teams to foster innovation across functional boundaries.

The company in study, Volvo Construction Equipment (Volvo CE) is addressing Industry 4.0 in Operations (the production part of the company) by its initiative Factory 4 Tomorrow (F4T). The purpose is to accelerate the company's lean journey and adapt to the future by taking advantage of the digital transformation. The vision for the transformation is to reach smart and connected manufacturing, bringing benefits to employees, customers, shareholders, and the partners in the ecosystem.

<sup>&</sup>lt;sup>1</sup> Corresponding Author, anna.ericson.oberg@volvo.com

Related to the findings in [2] study, the company has organized the initiative inspired by Kotter's change management theory about dual operating systems [3], and the ambidextrous organization's theories of simultaneous exploration and exploitation for continuous innovation [4], [5], [6]. That includes a network setup with cross functional local teams, called Smart Factory Teams (SFT), as well as a global supportive cross functional core team. The people in the network belongs to the line organization. Though, when working in the network they are expected to take on an explorative way of working contributing to innovations and change. When working in the line organization the same people are expected to contribute to efficiency and performance of daily operations. In this way the exploration and exploitation tasks are not divided between different people, instead the same persons should do both.

There are of course many difficulties connected to an initiative of this magnitude, both in practice and in theory [2], [7]. Accordingly, the purpose of this paper is to provide an empirical example of how dual operating systems can be organized. In addition, also identify challenges and connected enablers to achieve simultaneous exploration and exploitation during a company's digitalization journey.

# 2. Theoretical framework

#### 2.1. Change management

To take on, drive, and implement a strategic initiative of this magnitude there needs to be a big focus on change management to prepare, support, and help individuals, teams, and organization in making changes. Elements such as communication, competence, motivational factors, and support structures are essential in the approaches for change [7]. Many previous theories on change management have seen change as a linear process assuming a stable environment before and after [8]. However, today many companies act in very dynamic environments since the external pace of change is very high, which requires companies to adapt to these circumstances and embrace continuous change.

Kotter with his very famous 8-step model for effective change [9], has revisited his model and promotes additional complements to support the need for change management in the 21st century [3]. His 8-step model for effective change including establishing a sense of urgency, creating a guiding coalition, developing a change vision, communicating the vision for buy-in, empowering broad-based action, generating short-term wins, consolidating gains and producing more change, and incorporating changes into the culture is still true, but these 8-steps are now called the accelerators for change [3].

In addition to this, the existing structures and processes need an additional element to address the challenges produced by mounting complexity and rapid change. The solution is according to [3], to have a dual operating system with five principles: "*many change agents, not just the usual few appointees*" - meaning to pull more people into the strategic change game to move faster and further, not on fulltime or even part time but volunteers; "*a want-to and a get-to, not just a have-to mind set*" - built on volunteerism; "*head and heart, not just head*" – it is not just about logics, change must appeal to emotions too; "*much more leadership, not just more management*" - the game is about vision, opportunity, agility, inspired action and celebration; "*two systems, one organization*" – the network and hierarchy is inseparable, with constant flow of information and activity between them [3].

# 2.2. Ambidextrous organizations

In relation to change management and especially Kotter's theory on dual operating systems there are other disciplines studying companies' adaptabilities to survive and compete in fast moving contexts. One important capability is organizational ambidexterity, which is defined as "the ability to simultaneously pursue both incremental and discontinuous innovation ... from hosting multiple contradictory structures, processes, and cultures within the same firm" [10].

The area of ambidextrous organizations uses the concepts of exploration and exploitation that originates from organizational learning to understand and explain how organizational ambidexterity can be achieved. Exploitation is about capabilities related to refinement, choice, production, efficiency, selection, implementation, and execution. Exploration, on the other hand, involve capabilities captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation [11]. Accordingly, exploitation is linked to a short-term and more specific perspective seeking to increase efficiency and reliability and establish standardized processes, exploration aims at achieving flexibility and creating new knowledge and new ways of doing things, often related to deep research and activities with greater risks for the company [4]. As can be seen exploration and exploitation have different objectives and therefore require different strategies, processes, capabilities, and structures [4]. This is very much aligned with Kotter's [3] dual operating systems: the hierarchical system in charge of efficiency and the strategy system/network in charge of change and future needs. As the definition of ambidexterity reveals there are challenges involved hosting both these systems which is related to the inherent logics of the two concepts being so different that there are tendencies of tensions and counteractions. And what has been observed is that in a context dominated by exploitation, exploration can be driven out, which is called the productivity dilemma [12], [6].

However, there are ways to achieve simultaneous ambidexterity (simultaneous exploration and exploitation): structurally, where autonomous explore and exploit subunits are structurally separated [13], or behavioral ambidexterity (also called contextual ambidexterity), implying to design features of the organization to allow individuals to divide their time between exploratory and exploitative activities [14], [15], [16]. Since the organization strives to have dual operating systems where people will work in both systems, only behavioral ambidexterity will be further elaborated.

Behavioral ambidexterity can be defined as "the behavioral capacity to simultaneously demonstrate alignment and adaptability across an entire business unit. Alignment refers to coherence among all the patterns of activities in the business unit; they are working together towards the same goals. Adaptability refers to the capacity to reconfigure activities in the business unit quickly to meet changing demands in the task environment" [14, p. 209]. To further achieve behavioral ambidexterity, processes and systems are needed that support and enable individuals to decide how to divide their time between alignment and adaptability. Therefore, the ability to balance exploration and exploitation is related to an organizational context characterized by an interaction of stretch, discipline, and trust. Behavioral ambidexterity assumes that ambidexterity is rooted in an individual's ability to explore and exploit [14]. However, support structures / parallel organizational structures that supports employees to switch between the two tasks need to exist as well as meta-routines, (routines applied for changing other routines; they facilitate the performance of non-routine tasks) [17]. These structures, also including the larger management system and a supportive culture, enable people from

the same unit to move back and forth between a bureaucratic structure for routine tasks and an organic structure for non-routine tasks.

A challenge related to behavioral ambidexterity is about the individuals taking on exploitative and explorative tasks. Since they rely on the same basic experiences, values, and capabilities to carry out both tasks, it can be difficult to explore fundamentally different knowledge areas. Other challenges are related to the individual dependency: those individuals who focus on creativity and exploration differ even in personality from those who emphasize implementation or exploitation activities [18], it is also challenging for an individual to excel at both exploitation and exploration [19]. Also, organizational factors affect individuals' ability to act ambidextrously [15].

Although there are different modes of ambidexterity, it has shown that over time companies may use combinations of these to balance exploration and exploitation [13]. And what have been seen is when exploratory efforts achieve strategy and customer legitimacy and are less vulnerable to being crowded out by the focus of exploitation in the company, the firm shifts to behavioral ambidexterity – where both exploration and exploitation and exploitation are executed throughout the same company or business unit [12].

# 3. Method

#### 3.1 Case company description

The company in study, Volvo CE, is offering heavy machinery, solutions and soft products like excavators, wheel loaders, road machinery, and articulated haulers worldwide. The production part of Volvo CE, called Operations, is addressing Industry 4.0 by its initiative F4T. The purpose is to accelerate the company's lean journey and adapt to the future by taking advantage of the digital transformation. The vision for the transformation is to reach smart and connected manufacturing, bringing benefits to employees, customers, shareholders, and the partners in the ecosystem. F4T has been implemented globally, at 14 different production sites.

Volvo CE has chosen a network setup for the implementation of the F4T initiative, see Figure 1. Each site has a cross functional local team, called SFT. The team consists of people from different functions, e.g., manufacturing engineering, IT, logistics, maintenance, and quality, with different roles in the line organization. Normally the team consists of 5-8 people and has an appointed leader, called the SFT leader, whose responsibility is to coordinate the SFT work. The SFT tasks include investigate new technology for production innovation, develop competence for future manufacturing technology, and share knowledge across communities and sites.

Each SFT has a local sponsor team at the site to support with resources, funding, high level direction, alignment, and communication. There is also a global supportive cross functional core team. The purpose of the core team is to be the overall change agents by inspiring the culture and sponsoring the transformation journey. The team members also support in their areas of expertise. The core team also develops and manage the diagnostic of opportunities model. There is also a meeting structure with forums supporting this network way of working.



Figure 1. The Smart Factory Teams and Core Team are manned with people from the line organization.

To support the way of working and help the sites to identify how to address this journey a diagnostic of opportunities model was created, see Figure 2, like a readiness and maturity evaluation model [20]. The purpose is to support all Volvo CE sites to evaluate their maturity and readiness regarding the digital transformation, to identify gaps, and guide how to prioritize F4T projects to add value. The model aims to create awareness and alignment, increase sharing and collaboration, and develop people. The intended deliverables from the model are clear current status and future wanted position for the plants including identified roadblocks and opportunities for the sites to prioritize. So far 10 of the 14 plants have conducted the diagnostic of opportunities. The model was created based on the input from the Smart PM research project [20].

The diagnostic of opportunities model consists of the four areas; Smart Governance and Digital Strategy, Connected Manufacturing, Virtual Manufacturing, and Autonomous Manufacturing. The areas are in turn broken down into 18 subthemes and 61 categories. An important part to notice, see Figure 2, is that almost half of the model, handles items related to governance and strategy, often considered as soft aspects. The items (subthemes) are Strategy, Leadership and Culture (innovation management), Customers and Society, Business Performance Management, Risk Management, Collaboration, Skills and Competence, and Communication.



Figure 2. The diagnostic of opportunities model shows the as-is and to-be state for the plant.

# 3.2 Data collection and analysis

The empirical data used to identify challenges related to this network way of working were collected through interviews and a comprehensive survey. The interviews were unstructured focusing on challenges related to digital transformation, and the interviewees were four people from the F4T core team (people representing manufacturing engineering, IT and quality).

The survey was divided into three parts to not make the respondents feel overwhelmed by the number of questions, and in that way increase the response rate. Part 1 of the survey mainly consists of questions about the SFT itself, for example: "How much dedicated time do you have for F4T activities (leader and members)? Strengths and weaknesses in the team? What investigations do you have ongoing?" Part 2 of the survey focus on the SFT's site and its relation to the SFT, example of questions: "Who was involved in the implementation? How does the site's management team support you? How do you share knowledge with your site?" Part 3 consist of questions: "Do the steps in the Innovation and Advanced Engineering process bring value? If yes, please describe? If not, what can be improved? Is the vision and future goal clear to you (F4T model)? If not, what is missing? What do you think of F4T communication approach?" The survey respondents were the SFT leaders, and the survey was distributed to the 14 SFT leaders using Forms. The response rate was 72% for Part 1, 50% for Part 2, and 64% for Part 3.

The data collected from the interviews and the survey were mainly qualitative, but some were also quantitative, like number of ongoing and completed investigations. The qualitative data were analyzed by the two researchers using category construction inspired by [21] to find categories of challenges. The empirical results were then further analyzed by comparing and elaborating on the challenges in relation to the theoretical framework. The empirical results that are the categories of challenges and their content, and the proposed enablers derived from the analysis were also shared and discussed with parts of the F4T core team to validate the findings and conclusions and to reduce bias.

# 4. Empirical results and analysis

# 4.1 Empirical results

The empirical results achieved from analyzing the data collected from the interviews and survey are presented and described as five categories of challenges.

#### Communication

The SFTs try to share their knowledge through different meetings (SFT meetings, sponsor team meetings, department meetings and more), but it is difficult for them to reach out to a broader community at the sites to create awareness. Some experience issues with language and that it is time consuming. They find it challenging to adjust the information to the audience e.g., detail level as well as to share something with others where their own knowledge is not yet very high.

# Involved resources

The SFTs are lacking dedicated time (leaders and members) for F4T activities (explorative activities). If there is not a dedicated team, it is difficult to find time, because they need to balance these activities with daily activities and the later are prioritized in the organization. It is hard for the SFT leader but even harder for the SFT members to find time to work on F4T activities. It also varies between different functions how affected they are by production emergencies. Most SFTs experience they have supportive sponsor teams, but the sponsor teams have not succeeded to protect exploration activities.

Some SFTs are missing participants from several functions, hence lacking the desired cross functionality that is important for exploration. If functions like quality and logistics are missing, important input and perspectives are lost. The F4T initiative has also been initiated from Operations and hence there is a lack of true end-to-end perspective. Some SFTs also mention there is not enough technical skills related to new technology. Some teams mention competence issues as a reason for low involvement from some SFT members.

#### Innovation process

Most SFTs have a balance between starting from internal pain points vs investigating new technology to understand what problem it can solve. However, some sites seem to focus more on internal pain points and might therefore miss good opportunities for disruptive innovations. There are different investigation processes for different SFTs, some very organized and detailed, and some more unstructured. In relation to this it is uncertain how the different investigation processes contribute to support explorative mindset and activities.

The current investment approval process is not fully supporting exploration since the return of investment (ROI) is an important criterion. Risk and uncertainty are a large part of exploration, hence measures like ROI can hinder these types of investigations.

# Collaboration

Several SFTs' co-development initiatives are working fine. However, there is a challenge with internal collaboration due to resource availability, to have everyone involved at the same time. There are also different maturity levels between the departments as well as the sites. They are at different stages on the journey and might even have different views of where they are heading. There could also be language barriers, cultural differences, problems to find right stakeholders/people and different time zones affecting the collaboration.

External collaborations with vendors/suppliers are working well for several sites. However, some sites mention there is a high cost involved that stops them from collaborating. Outside Sweden there are few external collaborations with universities. There is a long tradition in Sweden to collaborate with universities and similar partners that encourage this type of collaboration. Some sites are starting to collaborate with knowledge hubs. Other challenges related to external collaborations are to find the right forums, partners, and people. One respondent states "they don't have correct knowledge to approach correct projects to work on."

# Implementation

The implementation process is case-based, and the verified technology is implemented in collaboration with SFT, vendor and related department/team/people. Depending on its scale it can be implemented through an improvement project, continuous improvement activities, etc. During this phase, when moving from exploration to exploitation, many challenges have appeared. One concerns resource issues since support is needed from local and global IT for most projects. Due to resource availability project implementation can take a long time.

Another issue is related to technology. There is a need to integrate old equipment to new systems and there is also often an insufficient technology infrastructure at this stage. Competence issues also affect the implementation since there is a lack of knowledge in some areas, which makes it difficult to implement and scale up solutions. The plants are also part of a global manufacturing network, hence global solution issues appear. There might be requirements on the solution to be applicable for other sites around the world. Even though a site has found a proper local vendor, they must find a global vendor who can support all sites.

Also trust issues appear during implementation. If a solution is not working properly from the beginning, the trust from the organization in the technology might decrease. There are also funding issues related to implementation due to uncertainty of how to get the investments approved once pilot processes are completed.

# 4.2 Analysis

In this section the challenges, visualized with bold italic text, are analyzed in relation to the theoretical framework. Related enablers to overcome the challenges are proposed.

How the initiative is *communicated*, perceived, and accepted by the organization, is clearly critical for it's success. A common misconception can be that it is a technical initiative, of interest for the IT personnel and manufacturing engineers only. To make this successful it instead needs to involve the entire company and all functions [3], [7], [20]. To address this a lot of attention needs to be on change management, including continuous communication, readiness and maturity evaluation (diagnostic of opportunities model Figure 2), competence development to embrace the competence shift, as well as involving the different functions during the implementation, taking an end-to-end perspective in line with [7], [20].

To create awareness, opportunities to share and discuss in the organization about the dual operating systems and the competing cultures of exploration and exploitation need to be created, including discussing the risk of exploration being outcompeted in a strong culture of exploitation [3], [6]. The communication part can be very challenging for the SFT since it might not be their area of expertise. This is therefore an area where collaboration is necessary e.g., with communicators and managers to create a common communication plan, both internally within each site, but also globally. To jointly discuss and agree about the purpose when communicating. Is it to create awareness, buy-in or change of mindset? Certainly, the communication method needs to be altered depending on the purpose. A change of mindset will not happen by using one-way information but requires involvement and collaboration. At the same time keeping in mind how to balance administration versus necessary information.

Another reoccurring issue in the result as well as in the literature is to find a good workload balance between exploration and exploitation. Since most *involved resources* are working in a production environment, short term problem solving often gets prioritized before long term development. What can be discussed is if or when an organization is mature for behavioral ambidexterity with the dual operating systems? As mentioned by [13] companies usually shift from structural to behavioral ambidexterity when exploratory efforts achieve strategic legitimacy and are less vulnerable to being crowded out by the focus of exploitation. In the F4T case the sites have the freedom to put together the SFT themselves and assign suitable time for it. The desire is to build a culture of volunteer and commitment. Among the SFTs there is one team that is fully dedicated and the other SFTs divide their time between daily tasks and SFT activities. According to [3], a suitable way for us to move faster would be to involve more people. To have many change agents supporting the journey instead of few fully dedicated resources. Since the organization is in the starting phase of behavioral ambidexterity, and F4T might not have reached strategic legitimacy yet, there is a need to have even more support structures (more strict recommendations, e.g., that at least the SFT leader and members should be able to spend x% of their time on F4T activities) to enable the dual operating systems to work well together [14], [3]. Otherwise, there is a risk the network structure will be outcompeted by the focus of exploitation [12], [6].

Besides having the support structure with the parallel organizational network structure including guidelines, meeting structures etc., this could entail to create more tangible demand for result also for the exploration part, and to have the managers even more involved, to create a supportive culture [17]. Accordingly, important enablers are to increase competence and awareness of exploration versus exploitation, to help to protect exploration and support the dual operating system. Also, to use leading KPIs prioritizing long term development, to make the time needed for SFT work visible. Management can also support by not splitting people's time into too many different tasks, but instead give time for slack, since that is necessary for explorative mindset [18], [19]. To have the SFTs cross functionally composed also creates improved awareness and understanding in the organization since the participants act as information bearers and change agents.

The *innovation process* itself can be strengthened to help some SFTs to focus even more on exploration and develop a more explorative mindset. A too strict process for the purpose of an investigation (more of a project approach) can limit the exploration part and decrease creative "quick and dirty" investigations. By having the first steps in the innovation process defined helps us to collaborate and share information on a global level, also how to share something when our knowledge is not yet very high. The global core team can support in creating the structure for an explorative way of working, that is how to do an investigation in an agile way at the same time fulfilling its purpose. To make the exploration phase visible in comparison to exploitation, it helps to define clear activities and deliverables for each step in the process as well as support of how to visualize the investigation in the best way e.g., through a one-pager.

Another challenge is that some of the existing company processes do not fit very well in this new environment. As an example, the investment process can be mentioned. Exploration very much involves search, risk taking, experimentation, play, flexibility, discovery, and innovation [11]. It can therefore be a stopper if the SFT needs to create a business case with high return of investment to get funding for e.g., exploring a new

technology. This could lead to the focus being solely on exploitation. Instead, a part of the budget has been assigned to support exploration initiatives without profit requirements. The focus is instead on learning. Also, there should be possibilities for less mature sites to test "mature" technologies simultaneously as new technologies to develop their competence. The teams can have their own "pocket money" to reduce administration.

To find a suitable balance between exploration and exploitation for the site in question is necessary. The maturity level is different between the sites. One site can be ready to investigate a new technology while others first need to get more fundamental knowledge in place. Less digitally mature sites could focus more on pain points while mature sites should strive to investigate new technology. Accordingly, the innovation and funding process should be able to embrace different "levels" of innovation.

**Collaboration** across sites and functions increases the knowledge level and resources can be shared which supports simultaneous exploration and exploitation, it reduces double work and the speed in investigations can be increased. Co-development initiatives are encouraged by discussing ideas to find common topics to work on, having best practice and lessons learned sharing sessions to share knowledge and learn from each other. To better support the culture of "dare to try" the participants could also be asked to bring and share "failed" investigations. It is however necessary to get to know each other to build trust and see the common benefits to start a collaboration. Language barriers and cultural differences could be a challenge. However, if there is a common structure with supportive methods, like the innovation process with supporting forums, these can easier be overcome [17], [14].

When involved in external research projects the company gets access to knowledge as well as research resources. This can be a support when dividing the time for the employees between exploration and exploitation. University resources can be used for explorative tasks, doing pre-studies and to bring interesting perspectives. External collaborations currently often occur on an ad hoc basis and to overcome this challenge a plan for external collaborations could be developed, and sites unfamiliar to this type of collaborations are encouraged to learn from experienced sites.

In many SFTs it is in the *implementation* phase where the simultaneous exploration and exploitation is happening explicitly. The SFT member has been exploring new technology and solutions and is now part of making it work in an efficient way in the daily business. The SFT member becomes a boundary spanner and conveyer of competence [3].

A major enabler for the innovation process to work has been to put the IoT platform in place. This technical infrastructure is unquestionably necessary, otherwise often exploration will lead to dead ends. Such large projects should be decided top-down to avoid all sites trying to invent something by themselves. It is then very important to share the overall plan of e.g., system roll outs for the SFTs to know when they can count on that technology. An enabler for reaching the implementation phase is to do prioritization of such projects involving different functions from the beginning.

To get a better overview of the proposed enablers that are about how to overcome the challenges, the challenges and related enabler are summarized in Table 1.

Challenges	Enablers – proposed activities to overcome the challenges
Communication	Develop global and local communication plans for continuous communication supported by global/local communicators. Communicate e.g., vision and strategy for change, ongoing investigations, success stories, SFT and how to get involved.
Involved resources	Develop a supportive culture through awareness and competence development of managers regarding the competing cultures of exploration and exploitation. The parallel cross functional organizational structures including supportive processes and forum descriptions should be available in management system. Develop leading KPI's and other measures that prioritize long term development, visualizing overall progress for F4T change.
Innovation process	Use an innovation platform with defined investigation process including deliverables for each phase, supporting explorative mindset and cross functionality. The funding process should support exploration with limited focus on ROI. It should support different levels of innovation depending on the site's maturity level. Boost innovation culture through innovation ambassadors, involvement of a larger community, and supportive management.
Collaboration	<ul> <li>Expand co-development initiatives across sites, use common structure and forums for collaborations.</li> <li>Have best practice and lessons learned sharing sessions, include failures to promote dare to try culture, between sites, other functions, and business areas.</li> <li>Develop plan for external collaborations: Universities (increase master thesis students' and PhD students' involvement) and company collaborations (start-ups).</li> </ul>
Implementation	Implement technical infrastructure top-down and assure system roll-out plan is available for SFT. The SFT leaders and members are boundary spanners and conveyers of competence during implementation phase.

Table 1. Overview of the challenges and how to overcome them - the enablers.

#### 5. Discussion and conclusions

There are many challenges connected to a digital transformation like F4T. To capture and better understand those issues related to exploration and exploitation with the dual operating systems, interviews as well as an extensive survey have been conducted. The main challenges identified are communication, involved resources, innovation process, collaboration, and implementation, which are in line with change management and ambidexterity theories. The suggested enablers, summarized in Table 1, are almost covered by the subthemes (leadership and culture (innovation management), collaboration, skills and competence, and communication) in the diagnostic of opportunities model used by the company, see Figure 2. Accordingly, such a model (readiness and maturity evaluation model) is an important overall enabler and can be used as a supportive dialogue tool to address several of the issues both on plant and global level. However, the challenges and the specific enablers need to get bigger attention during these discussions. In addition to this, there also needs to be a strong focus on overall continuous communication and follow-up of especially the proposed enablers to support the overall change approach to reach strategic legitimacy in the organization.

The purpose with this paper is to provide an empirical example of how dual operating systems can be organized. In addition, also identify challenges and connected enablers to achieve simultaneous exploration and exploitation during a company's digitalization journey. In line with this, the paper contributes to both industry and academia with a concrete example of how to organize and overcome the challenges that could appear. Further, academically it also provides more in-depth understanding about specific challenges connected to especially behavioral ambidexterity in dual operating systems during digital transformations in manufacturing, which is a highly relevant research topic. Related to this future research could focus on validating the suggested enablers, including processes and systems for enabling behavioral ambidexterity, supporting dual operating systems.

When it comes to the methodological approach it includes one company which can limit the generalization of the research result. However, analytical generalization has been applied by comparing the empirical findings with theory. That implies the results are valid for other companies as well. Internal validity is strengthened by the methods used for data collection and analysis.

# Acknowledgement

Special thanks are given to Volvo CE for enabling time and resources to be spent in support of the research. The contribution from the SFT leaders is highly appreciated. Previous research was done in cooperation with participants in the research project SMART PM, granted by the Swedish Strategic Innovation Program Production 2030, financed by Vinnova. The support is gratefully acknowledged by the authors.

#### References

- Schwab, K. The Fourth Industrial Revolution: what it means, how to respond. World Economic Forum. 2016. Available at: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-itmeans-and-how-to-respond/. Latest access: 13/10/2021.
- [2] Geissbauer R, Lübben E, Schrauf S, Pillsbury S. Digital Champions: How industry leaders build integrated operations ecosystems to deliver end-to-end customer solutions - PWC 2018. Global Digital Operations Study 2018. 2018. Available at: https://www.strategyand.pwc.com/gx/en/insights/industry4-0/global-digital-operations-study-digital-champions.pdf Latest access: 13/10/2021.
- [3] Kotter, J. Accelerate!. Harvard business review. 2012; 90(11): 44-52.
- [4] March, J. G. Continuity and change in theories of organizational action. Administrative Science Quarterly. 1996; 41(2): 278-287.
- [5] Martini, A., Laugen, B. T., Gastaldi, L. & Corso, M. Continuous innovation: towards a paradoxical, ambidextrous combination of exploration and exploitation. International Journal of Technology Management. 2013; 61(1): 1-22.
- [6] Benner, M. J. & Tushman, M. L. Reflections on the 2013 Decade Award "Exploitation, exploration, and process management: the productivity dilemma revisited" ten years later. Academy of Management Review. 2015; 40(4): 497-514.
- [7] Innovationszentrum für Industrie 4.0. 2021. https://www.i40.de/en Latest access: 14/11/2021.
- [8] Jacobsen, D. I. & Thorsvik, J. Hur moderna organisationer fungerar, 4th ed. [in swedish], Studentlitteratur, Lund, Sweden. 2014.
- [9] Kotter, J.P. Leading Change. Harvard Business School Press:Boston. 1996.
- [10] Tushman, M. & O'Reilly, C. Ambidextrous organizations: Managing evolutionary and revolutionary change. California Management Review. 1996; 38(4): 8-29.
- [11] March, J. G. Exploration and exploitation in organizational learning. Organization Science. 1991; 2(1): 71-87.
- [12] Benner, M. J. & Tushman, M. L. Exploitation, exploration, and process management: The productivity dilemma revisited. Academy of Management Review. 2003; 28(2): 238-256.
- [13] O'Reilly, C. A. & Tushman, M. L. Organizational ambidexterity: past, present and future. Academy of Management Perspectives. 2013; 27(4): 324-338.
- [14] Gibson, C. A. B. & Birkinshaw, J. The antecedents, consequences, and mediating role of organizational ambidexterity. Academy of Management Journal. 2004; 47(2): 209-226.
- [15] Raisch, S., Birkinshaw, J., Probst, G. & Tushman, M. L. Organizational ambidexterity: Balancing exploitation and exploration for sustained performance. Organization Science. 2009; 20(4): 685-695.

- [16] Birkinshaw, J., Zimmermann, A. & Raisch, S. How do firms adapt to discontinuous change? Bridging the dynamic capabilities and ambidexterity perspectives. California Management Review. 2016; 58(4): 36-58.
- [17] Adler, P. S., Goldoftas, B. & Levine, D. I. Flexibility versus efficiency? A case study of model changeovers in the Toyota production system. Organization Science. 1999; 10(1): 43-68.
- [18] Amabile, T. M. Creativity in Context: Update to the Scocial Psychology of Creativity, Westview Press, Boulder, CO. 1996.
- [19] Gupta, A. K., Smith, K. G. & Shalley, C. E. The interplay between exploration and exploitation. Academy of Management Journal. 2006; 49(4): 693-706.
- [20] Machado, C.G., Winroth, M., Almström, P., Ericson Öberg, A., Kurdve, M. and AlMashalah, S. Digital organisational readiness: experiences from manufacturing companies. Journal of Manufacturing Technology Management. 2021; 32(9): 167-182. https://doi.org/10.1108/JMTM-05-2019-0188.
- [21] Merriam, S. Qualitative Research: a guide to design and implementation, Jossey-Bass, San Francisco, USA. 2009.