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RESEARCH

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Stakeholder interdependencies in a collaborative innovation project

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Abstract
Industry 4.0—also known as the modern industrial revolution—nurtures close collaboration between various organizations so that they can come together for innovation. While aiming for digital transformation through such innovation, these organizations form certain interdependencies due to the pool of resources and tasks they agree to share to reach both common and independent goals. To understand those interdependencies, we studied a national innovation project in Finland called "Reboot IoT Factory," which leveraged several resources, processes, and practices to successfully combine modern technologies in manufacturing in a competitive and sustainable way. The participants included in the project were factories, research organizations, and small and medium enterprises (SMEs). An actor dependency model was used to analyze the observed interdependencies through survey and interview data. The results showed strong goal, task, and resource dependencies between the participants. A conventional understanding of advantages and opportunities, such as increased experience sharing and possible long-term synergies, is elaborated; moreover, an analysis of the disadvantages and risks caused by interdependencies, such as delays in tasks and possible inefficiency through unnecessary complexity, is also conducted.

Keywords: Interdependencies, Collaboration, Innovation, Actor dependency, Industry 4.0

Introduction

Due to the technological developments and disruptive innovations accompanying Industry 4.0, it has brought about a drastic change in the industrial landscape (Pereira & Romero, 2017). A key characteristic of Industry 4.0 is that it accelerates industrial advancements based on technological dynamism, which drives the industry as a whole to modify and innovate its working patterns and management structures (Li, 2018; Reischauer, 2018; Sung, 2018); this creates a challenging competitive environment based on innovations, enhanced processes, and respective competencies from participating entities (Camarinha-Matos et al., 2009). These changes demand the re-consideration of the role of companies, universities, and government institutions as key actors in this competitive environment to understand the individual and aligned systems for collaboration (Camarinha-Matos et al., 2017) and the co-existence of multiple formal and informal collaborations and networks that are willing to co-innovate.

In this case, collaborative innovation is considered the key to the development of new offerings (Crosby et al., 2017). However, sustainable innovation calls for major redesigning (Boons & Ludeke-Freund, 2013) in innovation processes and necessitates the positing of various new viewpoints on value and stakeholders (Ludeke-Freund & Dembek, 2017), which can signify the role of the network partners (Boons & Ludeke-Freund, 2013). Due to the changing nature of Industry 4.0, it is important to understand the challenges of collaboration, innovation, and allocation of resources in the context of an open and dynamic system of networks, capabilities, and ever-changing social, economic, and environmental factors (Gjedrding & Kringelum, 2018) that lead to organizational transformations and thereby build the entire innovation ecosystem (Kim, 2017).

Within the ecosystem—where multiple stakeholders interact to give rise to innovation—knowledge is continuously produced, integrated, and re-produced. This creates managerial and strategic contradictions in terms of different context dependencies between actors, technologies, and dynamic capabilities (Teece, 2018). The necessary skills and capabilities keep changing according to predicted variations in future stakeholder collaborations, which presents yet another challenge. With the involvement of new actors as partners, the process of innovation turns into a new multilayered structure of interorganizational engagement and network activities, resulting in multifaceted dependencies (Rossignoli & Lionzo, 2018). However, understanding these interdependencies in relation to changes in the required collaborative networks, collaborative capabilities, stakeholder relationships, and resulting innovation processes within the industry 4.0 paradigm can strengthen the practical applicability of the theoretical aspects of the topic and requires further attention (Bocken et al., 2019; Teece, 2018). Previous literature on interdependencies has focused on methodological considerations, such as experimentation (Bocken et al., 2018; Schuit et al., 2017) in literature, such as management (Pfeffer & Salancik, 1978) and business models (Boons & Bocken, 2018), and specific industry domains, such as tourism (Baggio & Baggio, 2020), agriculture (Ravnborg & Westermann, 2002), and construction (Ju et al., 2016). However, little theoretical discussion on collaborating partners and their interdependencies in technology-driven projects has been initiated in recent past, which originates the need to inquire particular patterns of collaboration (Bocken et al., 2019) in other fields using qualitative analysis (Cehan, et al., 2021). In addition, the prevailing stakeholder analysis literature has overlooked collaborations-based resulting interdependencies and their proliferating effects (Mok et al., 2017). Therefore, it is significant to understand stakeholder relationships with respect to their types and interdependencies in distinct circumstances (Windsor, 2002). In this regard, this research aims to develop a synchronized understanding of collaboration among participating organizations and resulting interdependencies in a Finnish technology-based innovation project called "Reboot IoT Factory." The paper analyses key stakeholders, their forms of collaboration (Camarinha-Matos et al., 2009, 2017) that lead to different types of interdependencies (Bocken et al., 2019; Teece, 2018), with the perspective of advantages, disadvantages, risks, and opportunities therein. In the stated scenario, we aim to build our paper around the following research questions:

RQ1: What types of interdependencies exist among stakeholders in collaborative innovation?

RQ2: What are the advantages, disadvantages, opportunities, and risks related to these interdependencies?

The rest of this paper is structured in five sections. In Sect. 2, the concepts of Industry 4.0-based collaborations and innovation ecosystems leading to interdependencies are characterized utilizing the existing literature. This is followed by the research methodology and materials presented in Sect. 3 as well as a brief introduction to the case study. Section 4 describes the key results of the case study. Section 5 presents a discussion of the results, including a conception of the sustainable ways required in practice for Industry 4.0-based collaborative innovations. The paper closes with Sect. 6, which contains a brief conclusion of the paper and implications for future research.

Literature review

Collaborative innovation

The functionality and development of today's working environment has evolved to be fully dependent on new technologies and respective innovations (Borowski, 2021; Sadyrova et al., 2021). Not only has innovation been regarded as a key driver for growth and development, but it has also been viewed as an excellent solution to the old problem-solving attempts that failed (Torfing, 2019). The pursuit of considering innovation as a solution only may lead to undesirable negative outcomes, which is why innovation should not be considered a "normative good" (Osborne & Brown, 2011). Normative good means understanding innovation only as an evaluation standard, which limits its application to only being an alternative to failed solutions and creates uncertainty regarding its various other implications. Collaboration among different actors can be one way to minimize this kind of uncertainty. Collaboration entails the constructive management of differences to find a proper solution by selecting the promising alternatives proposed, testing and prototyping, conducting respective risk assessments, mobilizing resources, and undertaking a joint commitment to reach the goal (Hartley et al., 2013; Sørensen & Torfing, 2011; Torfing, 2016, 2019). Collaboration in this paper is defined as "a temporary social arrangement in which two or more social actors work together towards a singular common end requiring the transmutation of materials, ideas, and/or social relations to achieve that end (Roberts and Bradley, 1991, pp. 212)". In the process of collaboration, the entities forming the group can engage with one another through mutual trust, positive competition, commitment, shared risks and rewards, problem solving, and the overall enhancement of collaborative capabilities (Camarinha-Matos et al., 2017), which can lead to effective collaborative innovation.

Collaborative innovation is a term coined by a diverse stream of scholars aiming to explore collaborative governance (McGuire, 2006; Emerson et al., 2012; Ansell & Torfing, 2014) from the perspective of new theories of innovation (Borins, 2001; Eggers & Singh, 2009; Hartley et al., 2013; Hartley et al., 2013; Sørensen & Torfing, 2011). The discourse on collaborative innovation is considered a result of the combined efforts of the operating actors in a stimulating environment, leading to value and motivation for further collaboration (Hartley et al., 2013). Collaborative strategies meant for innovation facilitate knowledge exchange and sharing of competencies between different actors, thus facilitating mutual learning, which in turn may contribute to the form of many creative voices for problem solving (Roberts, 2000).

Industry 4.0 and collaborative innovation

The fourth modern industrial revolution, or Industry 4.0, has caused extensive fluctuations in industrial production (Kagermann et al., 2013). Having begun from a strategic German initiative, Industry 4.0 is presently a major form of transformation in a few countries from North America (Manufacturing USA), Europe, and Asia (e.g., made in China 2025) (Kagermann et al., 2013; Ślusarczyk, 2018). It has worked efficiently in the rapid theorization and application of advanced ideas (Strandhagen et al., 2017), for instance, the Internet of things (IoT), big data, smart factory, cyber physical systems, and interoperability, all of which rely on a prompt change in the outlook of automated production. Thus, advances in digitalization and the rise of Industry 4.0, which are predicated on the growing interconnectedness and interdependence of technologies and business organizations, amplify the need for collaboration (Khan et al., 2021).

Furthermore, the widespread digitalization in the industrial and manufacturing contexts driven by the development and spread of the industry 4.0 concept is generating substantial opportunities for innovation and value creation (Fatorachian & Kazemi, 2018). Industry 4.0-based solutions are developed from complex interrelated IoT-based technologies. This complexity demands a wide set of capabilities that are otherwise difficult to derive from a single provider. Collaborations allow companies to integrate and share knowledge and resources to co-create Industry 4.0-based innovative solutions. Such innovations stem from an ecosystem built on trust and commitment and neutral coordination between different actors, where key technologies act as a driver to form relationships among companies toward value co-creation (Benitez et al., 2020). However, the complex system of Industry 4.0 requires higher interdependent competencies due to the interconnected nature of digital technologies and information systems (Dalenogare et al., 2018, Reischauer, 2018, Rübmann et al., 2015). Thus, Industry 4.0 serves as the most suitable configuration for technological advancement, which involves interdependencies and collaborative innovation for value co-creation (Rong et al., 2015).

Collaborative innovation-related interdependencies in Industry 4.0

In line with the disruptions caused by Industry 4.0, companies are becoming increasingly interested in the application of new technologies to ensure long-term competitiveness and the ability to adapt to dynamically changing environmental conditions, such as shortening product lifecycles, increasing diversity, and changing consumer expectations (Adolph et al., 2014; Bauer et al., 2015; Lasi et al., 2014; Spath et al., 2013). Exploring collaboration methods involved distinct research angles to understand business networks and their underlying dynamics (Möller & Halinen, 2017; Äyväri & Möller, 2008). The adoption of a network perspective, which in current work is described as a group of inter-dependent organizations linked to each other through non-hierarchical relationships (Möller & Rajala, 2007; Schroeder et al., 2019) provides an opportunity to establish a shared network view (Henneberg et al., 2010). Establishing this view requires the elicitation and integration of the dispersed cognitive pictures held by individuals participating in the emergent business network (Ford et al., 2003; Henneberg et al., 2006). This requires a shift to the exchange, collaboration, and adaptation of activities that enable firms to build, handle, and exploit their business networks (Vesalainen & Hakala, 2014).

Collaboration entails achieving an overall common or mutually beneficial goal. It implies that the activities must be performed in a way that helps achieve the common goal, making their performance interdependent (Malone & Crowston, 1990, p. 4). Interdependencies can be defined as the extent to which outcomes of one unit (activity) are directly controlled by or contingent upon the actions of another unit (activity) (Victor & Blackburn, 1987, p. 490; Malone & Crowston, 1990, p. 4). In the given context, collaboration is the act of managing interdependencies; if there is no interdependency, there is nothing on which the parties can collaborate (Malone & Crowston, 1990). Stakeholder interdependence in this paper is, therefore, defined as "a web of positive and negative impacts (or consequences) among individuals generated by interactions beginning with a focal firm, develops mutual engagement and responsibility" (Windsor, 2002, pp. 21). Dependency is explained as a relationship between two actors: one of them depends on another for the accomplishment of some internal intention (Johnson & Johnson, 1994). Dependency may be established at the level of actors (an actor depends on another) or at the level of intentional elements (an intentional element of any kind depends on another intentional element); moreover, mixed combinations are possible (Yu & Mylopoulos, 1993). These scholars categorized intentional elements as four types of dependencies: first, goal dependency, in which the dependee shall satisfy the goal and is free to choose how. The second is task dependency: the depender requires a dependee to execute a task in the prescribed way. It is also essential to emphasize the understanding of tasks in the transformation process of an organization. This is usually not identified, even though the management of organizational resistance and achieving cultural acceptance of innovations is generally a priority in Industry 4.0 projects. The third is resource dependency: the dependee must make a resource available to the depender, as the identification of resource dependency is important (Gulati & Sytch, 2007; Nagy, 2019). These different kinds of interdependencies can be both positive or negative resulting in development of helpful results or prevention of certain occurrences (Freytag et al., 2017). All organizations face collaboration problems arising from interdependencies (Malone & Crowston, 1994), which can be both internal (within organization) and external (across organizations). Therefore, the collaboration mechanisms must be chosen in such a way that effectively addresses the existing interdependencies (McCann & Ferry, 1979).

Methodology

Data source and analysis

A single case study is carried out to follow the qualitative research approach (Creswell, 2013; Yin, 2009). Qualitative research and data collection is advised when the research aims to observe and understand certain behaviors and interests (Bryman, 2016). The case chosen to reach the aim of this study is the Reboot IoT Factory project, which is a large national innovation project focused on the digitalization of the manufacturing industry in Finland. The case represents the studied phenomenon well as the focus of the project was on collaborative innovation for Industry 4.0 solutions building on close collaborations between partners. Due to the complex nature of the project and active collaboration between partners, it was assumed that project participants may entail several interdependencies. The key stakeholders in the project were: factories who provided a platform for co-innovation in their production environments, research organizations who facilitated the ecosystem-level co-operation and carried out research, SMEs who offered digitalization services and products to factories, and government as the funding body.

The empirical data are based on a survey, interviews, and secondary data sources, such as project reports, plans, and presentations. The application of using these different participatory methods was significant as it ensured the information analyses 'with the stakeholders' and 'about the stakeholders' as a community of people chasing and sharing a common goal and interest (Agrawal & Gibson, 1999; Mosse, 1994). A self-administered survey questionnaire was designed from an actor dependency model (Yu & Mylopoulos, 1993) to understand different types of interdependencies and the respective advantages and risks associated with the project. The questionnaire to understand the interdependencies in innovation-based projects was adopted from Tjosvold's (2004) work. The questionnaire and interview items were further developed to fit in the context of the current study with the help of two experienced researchers in the field and later validated using a pilot study. Finally, the survey was e-mailed to the participants of the Reboot IoT Factory project.

The survey included 15 questions on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) related to goal, task, and resource dependencies, three yes or no questions related to experienced dependencies, and two open-ended questions on the benefits and disadvantages of the experienced dependencies (Appendix I). The survey was sent to a sample of 116 participants, including factories, SMEs, and research partners. The participants were assured about confidentiality and informed consent. The results would be shared with the participants upon request.

There were 33 usable responses received between 19 August and 30 September 2019, thus reaching a response rate of 28%. Of the respondents, 49% (n = 16) were from research organizations, 33% (n = 11) from factories and 18% (n = 6) from SMEs. In the quantitative part of the analysis, the Kruskal–Wallis test was used to compare the mean dependency responses of the three groups, as the response distribution was skewed toward the "agree" end of the scale. The responses to questions G4–G7 (Appendix I) were reversed due to the wording used in the survey. This ensured full measurement of opinions through consistent answers and helped escape agreement bias. To analyze the homogeneity between the yes/no responses to the experienced dependency types by the different respondent groups, the Pearson's chi-squared test was used. The survey also included two open-ended questions related to the benefits and disadvantages of their perceived interdependencies.

Since the number of responses was limited, additional empirical data was collected by conducting further interviews (3) and analyzing the project documentation and reports. Each interview lasted for 1 h, and the interview questions included the following: "Do you feel dependency in Reboot IoT project?" "What kind of dependencies do you see within the project?" "Do you see those interdependencies as sustainable advantage or risk?" The interviewees were managers from each participating organization, i.e., the factories, SMEs, and research partners. The interview data were analyzed using qualitative content analysis. The answers were added to Table 2, thus complementing the survey data.

Case description

Our unit of analysis is the Reboot IoT Factory project, which is a national innovation project focused on the digitalization of the manufacturing industry in Finland. The Reboot model is a novel way to implement research projects that aim for competitive advantage through the digital transformation and innovation attained by integrating modern technologies, such as ICT (Information and Communication Technologies) and IoT into manufacturing. The focal issue in the project was to study the grand challenges. Grand challenges identified in the project were data-driven supply chain and production, robotics fusion and labour in the digital work environment. Broader aim of solving grand challenges was to enable significant business benefits in that they help factories to reimagine their operations through use of state-of-the-art technologies and introduction of new solutions and service models. These challenges cannot be solved by one partner alone but require a critical mass and variety of partners. The aim of sharing the risk of IoT based digitalization was, therefore, collectively addressed by a group of leading companies as well as leading research institutes and SME companies. The industry partners were ABB, GE Healthcare, Kongsberg Maritime, Nokia and Ponsse. The participating research organizations were VTT Research Institute of Finland, University of Oulu and Åbo Akademi. The project is funded by Business Finland, which implies strong support from the government in lowering the risk of trialing with new technology. The key element of Reboot IoT Factory, Finland, is the new operational model based on the co-creation and experience sharing between all the interdependent participating organizations. The starting point is a lean, sprint-based execution, where each stakeholder in the project network has specified roles and responsibilities. Instead of implementing a 2- or 3-year fixed project plan, the model uses a dynamic approach to closely follow digitalization trends aligned to the pace of the industry.

All activities start from actual factory needs. Factory personnel, researchers, and SMEs co-create a range of possible solutions for the problem. The solution idea is implemented in the factory as a proof-of-concept (PoC) to conduct real-life trials, which reveal the feasibility of the technology and viability of the business case. Learnings from each PoC are shared openly from factory to factory, allowing all stakeholders to quickly adopt the measures. The best solutions are commercialized by SMEs and spread to the project's partner global factory networks using a scale-up process, thus unleashing the full potential of benefits for the companies through collaborative work. Experience sharing with companies and factories outside Reboot allows them to follow and deploy solutions that have been proven by leading Reboot factories, thus saving time and resources that the other participating stakeholders would need for experimentation. As a result of effective collaboration in the studied case, key activities based on digital acceleration and innovation noted were successful cross-ecosystem disseminations, trust development, implementation of more than targeted PoCs resulting in significant productivity improvements. Another measure of the project's success was the Business Finland's decision to fund the project's continuation after the first phase had ended.

Results

Our study results are analyzed based on the actor dependency model by Yu and Malopoulos (1993), which embodies an innovation-based project comprising a network of dependencies among participating actors. The model helps understand different kinds of work patterns among the actors built upon varying interdependencies, which possess the ability to expand or restrict the end goal. The actors in our case of a joint innovation project clearly show that there are strong interdependencies in the project, as these actors depend on each other to achieve goals, perform tasks accordingly, and use a shared pool of resources. To determine how the participants perceive goal (GD), task (TD), and resource (RD) independencies, the quantitative part of the survey with the goal dependency questions (G1–G8), task dependency questions (T1–T6), and resource dependency questions (R1–R4) (Appendix 1) was analyzed. The results are summarized in Table 1.

We can see that the respondents perceived high levels of goal interdependency. The mean of the goal dependence section of the survey was 3.7, and 79% of the respondents answered "Yes" for the claim "Yours and other Reboot project members' goals are related." This suggests that the case project model resulted in a high level of goal dependence between the participants. Regarding task dependencies, the results suggest that, on average, this was on a lower level than goal dependence. The mean of the task dependence section of the questionnaire was 3.6, and 67% of the respondents agreed with the claim "Reboot members have to interact with each other to complete their tasks." For the means of task dependencies, a statistically significant difference was observed (Kruskal–Wallis, $H\ (2) = 9.04$, $p = 0.011$). The researchers viewed their task dependence to be higher than the other two respondent groups. Other statistically significant differences were not found. Out of the three dependency types, resource dependency was perceived to be the lowest by the project participants, with a mean of 3.2 and 61% responding "Yes" to the question "Reboot members have to share resources to achieve specific goals."

The results presented that the participants achieve mutually beneficial goals (digitalization, commercialization, innovation, and scaling-up solution) by carrying out various interdependent tasks (research and outsourcing) from a pool of shared resources (information, knowledge, skillsets, and physical objects). It is evident that factories need to outsource their needs and requirements first to the research organization to find the right solutions and then to the SMEs to implement those solutions. Similarly, research organizations will need the right information from the participating organization to accomplish their tasks. SMEs experience resource dependency due to lack of monetary support, knowledge, skills, and competencies, which can be attributed to their limited size of operations. A well-defined goal—in this case, active information and experience sharing, aligned tasks, and mutual availability of resources—is key to successful collaborative innovation.

Table 1 Summary of the survey results

Affiliation	N	GD (mean of G1–G7)	Experienced GD % (G8)	TD (mean of T1–T5)	Experienced TD % (T6)	RD (mean of R1–R3)	Experienced RD % (R4)
Factory	11	3.7	82%	3.2	73%	3.2	82%
Research	16	3.7	81%	3.9	69%	3.2	50%
SME	6	3.8	67%	3.5	50%	3.4	50%
Total	33	3.7	79%	3.6	67%	3.2	61%

Next, we analyzed the actor dependency model to assess the participating actors' dependencies and their structures in terms of either expanding their capabilities or becoming vulnerable in the pursuit of innovation-based goals. The participants showed both the advantageous and disadvantageous sides of interdependencies in the project (Table 2). On the one hand, all three networks of participating actors agreed on the benefits gained from interdependent relationships, such as the efficient use of resources and improved information sharing, leading to more successful and long-term collaboration opportunities. Some of the views shared by factory (F), research (R), and SME (S) actors are as follows:

> *F: "To not reinvent the wheel by sharing resources, have related targets and aligned resources makes the Reboot efficient. I already experienced them in planning phase." F: "When dependencies align, the collaboration is more active." R: "I think dependencies overall are good, since they force to have both formal and informal collaboration." S: "Shared goals and constant co-operation with Reboot-member sets targets and fluent workflow for the project."*

SME and research partners outlined the advantages of finding high-quality solutions by proposing multiple unique approaches, such as efficient communication, hence creating opportunities for not only competency and expertise development but also new knowledge creation. In this regard, the participants responded as follows:

> *R: "To match goals, there is need for multidisciplinary competencies working with one another. It makes us eager to learn what others do best and get them on board. Not only to promote one's own ideas or look at resources inside own research organization, i.e., encounter when resourcing, initiating publications, deciding project level matters." S: "The dependencies are often two-way and provide a natural incentive for better communication."*

While examining the interdependent configuration of the Reboot project, the participants also stated some disadvantages and risks associated with network collaborations.

Table 2 Advantages, disadvantages, opportunities, and risks of interdependencies in the studied project

Advantages and opportunities of interdependencies	Disadvantages and risks of interdependencies
Advantages	**Disadvantages**
• Productive use of resources • Improved information sharing • Increased experience sharing • Closer collaboration • New approaches for solution creation • Faster development • Higher quality of solutions	• Decreased independence in the development work • Delays in certain tasks due to dependencies • More complex scheduling • Narrow focus in solution creation (only specific use cases) • Additional costs for external collaboration
Opportunities	**Risks**
• Creation of new knowledge • Growing network of expertise • Finding new synergies among partners • Deeper and more successful collaboration • Competence development through diversity and multi-disciplinarity	• Delays due to sharing of research resources • Misalignment of goals • Inefficiencies and unnecessary complexity • Information sharing delays among multiple partners • Conflicts in individual and shared goals

The most common disadvantage identified was delay in certain tasks due to a dependent task assigned to any other actor remaining incomplete, which gives rise to the risk of unnecessary complexity, as one of the actors reported. R: "Sometimes you need to wait for information or somebody to get something done before you can proceed with your own task." Factories with a larger pool of resources may be too focused on their own solution, which may risk misaligning goals for all participating actors. On the other hand, SMEs are burdened by the lack of resources, which hinders their growth in external collaborations. Interdependent relationships also make the scheduling of tasks and resources more complex, which may delay the sharing of mutual resources and increase risks, such as conflicts related to individual and shared goals. Our results are supported by the statements of the participants.

> *F: "Resources can be wasted in extreme situations. In addition, if another project's goal is related, it might require both of the goals or even tasks to lack something, if another one is not completed." S: "Scheduling of shared resources is sometimes challenging." R: "It makes things move slower. Especially if the task is an outlier and not a core function."*

Discussion

Reflecting on the RQ1, what types of interdependencies exist among stakeholders in collaborative innovation?, the results show that several interdependencies exist in the studied collaborative innovation model. The stakeholders participating in the joint innovation project report goal-, task-, and resource-based interdependencies. Based on these results, interdependencies have several positive effects (advantages and opportunities). Similar findings have been reported in earlier studies depicting the existence of several types of interdependency types, such as actor and resource dependencies between governmental, educational, and private organizations (Helmke, 2021). While theorizing the impact, other studies (Tjosvold, 2004; West, 2002) report that cooperation and collaboration is undertaken to reach a collective goal of performing tasks successfully using a pool of shared resources, knowledge, and skills. However, our results report some new positive outcomes of interdependencies, such as the efficient use of resources through experience sharing. Active experience sharing can help save time and energy a company would have to invest in testing the necessary resources. This means that when a set of stakeholders are in a goal-dependent situation, they try to strive toward the same results. For example, in successful cooperation between a company and a research organization, the company needs more knowledge in the field, where the research organization is active. Knowledge transfer in the literature is seen as a resource for competitive advantage and a significant mechanism for interaction among stakeholders (Bruciu & Kicsi, 2015; Miśkiewicz, 2018). The common goal in this regard is reached by both organizations sharing knowledge and experience and pursuing their own interests through close collaboration, aiming for customized solutions and faster development. The joint actions of stakeholders increase the relational orientation, resulting in increased beneficial exchange on information and trust development (Gulati & Sytch, 2007). These positive interdependent outcomes are in line with the basic premise of the social interdependence theory, which states that all the individual actors consider their goals to be linked to the other actor's goals, and subsequently, they put effort into maximizing each other's success (Johnson & Johnson, 1994). These interdependencies not only provide in-project advantages but also long-term future opportunities. Our findings related to RQ2, what are the advantages, disadvantages, opportunities, and risks related to these interdependencies?, show that the co-innovation model platform provides a basis for interaction between people with multidisciplinary competencies. This results in the project members' eagerness to learn what the others do best and get them on board for future collaborations (Barrick et al., 1998; Carter & West, 1998; Tjosvold, 2004). The objective is to not only promote one's own ideas but also support important decisions about future resourcing, build synergies, and extend networks.

On the other hand, our results may appear contrary to the conventional findings that state only the advantages and opportunities. The results present some unique disadvantages caused by interdependencies. For example, the success of a project directly contingent on interdependent work might cause delays in other independent tasks due to its complex structure with multiple partners who have their own interests separate from the project (Berker & Bharathi, 2012; Ju et al., 2016). Consideration of time frame in projects with stakeholder interdependencies is crucial, as the knowledge and learning effects of the players keep evolving and changing over time (Freytag et al., 2017). Complex scheduling in terms of time and resource sharing may also be a downside for the small-scale participating organizations, as they may not be able to demand more suitable options or raise questions due to their insignificant voice in the collaborative structure. Inclusion of new partners to the ecosystem during the process of networking and collaboration can stimulate costs related problems (Windsor, 2002) which limit their options to a few specific use-case solutions only. These factors may result in the risk of misalignment of ultimate goals, leading to inefficiency and unnecessary complexity between participating organizations at a higher level. At the individual level, participants may seek a lower level of information sharing and delays in resource sharing, causing discrepancies in the overall innovation process.

Planning for selection of partners and provision of clear interdependency strategies (Jarimo et al, 2006) at the beginning of a project can be one way to avoid the stated risks. Therefore, we recommend that organizations that plan and participate in collaborative innovation projects should invest time to identify project-specific interdependencies and plan how to utilize and manage them to exploit their advantages and opportunities as well as to mitigate the disadvantages and risks. For instance, if complexity of a task is identified as low, lowering the interdependence may result in limiting the boundary spanning of a collaborating project and its contingent nature (Gulati & Sytch, 2007). Another important question to consider is what the right level of interdependencies are, as strong interdependencies can improve collaboration and result in more productive innovation work, but those that are too strong can also increase complexities and inefficiency. For instance, existing research has recognized strong interdependence may result in extreme over-embeddedness which unnecessarily strengthens dysfunctional ties (Gargiulo & Benassi, 1999), accelerates power issues and conflicts (Gulati & Sytch, 2007; Uzzi, 1997) and restrains advantageous feedback and innovation potential (Mizruchi & Stearns, 2001; Uzzi, 1996). Interdependency strategies should, therefore, focus on system-level thinking, which not only points out companies' internal operations but also the whole supply chain and lifecycle impact of products and services across chain of participating stakeholders. This will boost further collaborations, as the process can easily help organizations access people, with the new skills and a variety of competencies that will be needed, from the partner organizations. SMEs will get better visibility from the planning phase, which will help them overcome some unique challenges, such as the lack of resources, knowledge, competences, and awareness of changing regulations.

In addition to digitalization, which was the focus of the studied collaborative innovation project, the twin transition focuses on sustainability and digitalization trends simultaneously, which are significant to the industry. This twin transition of digitalization and sustainability creates a need to consider how the studied collaborative innovation model should be developed in the future to address this change. Sustainability has a wide definition, which includes environmental, social, and economic aspects. Companies, especially SMEs, are trying to develop new ways to measure and increase their environmental sustainability which in turn contribute positively to firm's innovation (Masocha, 2018). However, defining and measuring sustainability is difficult and brings up a need for systemic thinking (Foley et al., 2003) including new types of capabilities. Understanding interdependencies considering these new capabilities will add new dimensions to the collaborative innovation process.

Conclusions

As a significant characteristic of collaboration, interdependencies have given rise to interactive dynamics among the project participants during the innovation process. Our study aimed to investigate different kinds of interdependencies at the project level using a descriptive single case study analysis and qualitative research approach. The participants in the project were leading Finnish companies, research organizations, and SMEs seeking digital transformation for innovation and a competitive edge. The study evidenced interdependencies as an important variable to be considered and understood in the collaboration and innovation process. The results show three key interdependencies, namely, goal, task, and resource dependencies within the Reboot IoT Factory model.

Our study further analyzed the advantages, disadvantages, risks, and opportunities associated with the interdependencies between partner organizations in the collaborative innovation process. It outlines the advantages in terms of new knowledge creation, closer collaborations, customized solutions, and increased information and experience sharing, which provides opportunities to form a network of expertise, develop competencies, and realize active learning and new knowledge creation. On the other hand, interdependencies may cause certain delays in the tasks and lead to complex scheduling and extra costs for external collaborations, which increase the future risk of misalignment of goals, delays in information sharing, and conflicts of interests.

Our study has several limitations with respect to the sample and operations. One major limitation is the single case study analysis, which disallows generalizability. The methodological weakness can be overcome in further studies by testing the ideas with different methods, such as quantitative and experimental verification. For instance, the effectiveness of the structure of the collaboration network and resulting interdependencies on innovation results could be further validated quantitively. Furthermore, apart from adopting a more holistic approach for collaborative innovation, combining expertise among large companies, SMEs, and research organizations for twin transition can bring further sustainable business opportunities, which is another recommendation for future studies.

Appendix 1

The dependency survey questions

Goal dependency perceptions (G).

G1. Reboot project members "swim or sink" together.

G2. Reboot project members want each other to succeed.

G3. The goals of the Reboot project members are aligned.

G4. Reboot project members structure things in ways that favor their own goals rather than the goals of other project members.

G5. Reboot project members have a "win-lose" relationship.

G6. Reboot project members like to show that they are superior to each other.

G7. Reboot project members' goals are incompatible with each other.

Task dependency perceptions (T).

T1. I have information and help from the Reboot project members to do my task well.

T2. I have to work together and consult with Reboot project members to do my task well.

T3. I have to meet regularly with Reboot project members to communicate about work-related matters.

T4. Reboot project participants consider the nature of the tasks, individual resources, and fields of expertise when they negotiate about task division.

T5. Reboot project members discuss sharing regular routine tasks, which include taking meeting minutes, scheduling next meeting, saving notes, and writing weekly progress reports.

Resource dependency perceptions (R).

R1. Key resources such as knowledge, technologies, and competencies are readily available to the SMEs.

R2. Key resources such as knowledge, technologies, and competencies are under factory partners' control.

R3. Key resources such as knowledge, technologies, and competencies are already "installed" as part of the project's asset base.

A dependency relationship is a relationship in which one element, the client, uses or depends on another element, the supplier. What kind of dependency have you experienced during the Reboot project? (Not experienced = 0, Experienced = 1).

G8. Goal dependency (Yours and other Reboot project members' goals are related.)

T6. Task dependency (Reboot members have to interact with each other to complete their tasks.)

R4. Resource dependency (Reboot members have to share resources to achieve specific goals.)

What do you think are the benefits of your selected dependencies within the project and when do you experience them?

What do you think are the disadvantages of your selected dependencies within the project and when do you experience them?

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Availability of data and materials
The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests
The authors declare that they have no competing interests.

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